UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLIED MATERIALS, INC.

Petitioner

v.

DEMARAY LLC

Patent Owner

Patent No. 7,544,276

DECLARATION OF INGRID HSIEH-YEE, PH.D.

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I, Ingrid Hsieh-Yee, Ph.D., do hereby declare as follows:

1. I have been retained as an independent expert witness on behalf of Applied Materials, Inc. ("APPLIED") for *Inter Partes* Review ("IPR") proceedings before the United States Patent and Trademark Office ("PTO") regarding U.S. Patent Nos. 7,381,657 and 7,544,276.

2. I am being compensated for my work in this matter at my customary hourly rate. I am also being reimbursed for any reasonable expenses associated with my work and testimony in this investigation. My compensation is not contingent on the results of my study, the substance of my opinions, or the outcome of the above matter(s).

I. INTRODUCTION

A. Qualifications and Professional Experience

3. My complete qualifications and professional experience are described in my academic curriculum vitae (**Appendix A**). The following is a brief summary of my relevant qualifications and professional experience.

4. I am currently a Professor in the Department of Library and Information Science at the Catholic University of America. I have experience working in an academic library, a medical library, and a legislative library and have been a professor for more than 25 years. I hold a Ph.D. in Library and Information Studies

from the University of Wisconsin-Madison and a Masters in Library and Information Studies from the University of Wisconsin-Madison.

5. I am an expert on library cataloging and classification and have published two editions on this subject, *Organizing Audiovisual and Electronic Resources for Access*: *A Cataloging Guide* (2000 and 2006). I teach a variety of courses, including Cataloging and Classification, Advanced Cataloging and Classification, Organization of Internet Resources, Organization of Information, Digital Content Creation and Management, Internet Searches and Web Design, Information Literacy Instruction, Advanced Information Retrieval and Analysis Strategies, and The Information Professions in Society. I am familiar with metadata schema design and implementation. In my teaching I have covered cataloging and classification standards and tools, the design and implementation of metadata in databases, search engines, digital repositories, digital libraries, and digital archives. I have also covered how information organization affects the discovery and access to digital resources on the Internet. My research interests cover cataloging and classification, information organization, metadata, information retrieval, information architecture, digital collections, scholarly communication, user interaction with information systems, and others.

6. I am very familiar with a library cataloging encoding standard known

as the "Machine-Readable Cataloging" standard, also known as "MARC," which became the national standard for sharing bibliographic data in the United States by 1971 and the international standard by 1973. MARC is the primary communications protocol for the transfer and storage of bibliographic metadata in libraries. Experts in my field reasonably rely upon MARC records when forming their opinions. My understanding of MARC is based in part on my personal experience as a cataloger and as a cataloging instructor over the years, extending back to the 1984 timeframe.

7. A MARC record consists of several fields, each of which contains specific data about the work. Each field is identified by a standardized, unique, three-digit code corresponding to the type of data that follows. **Appendix B** is a true and correct copy of Parts 7 to 10 of "Understanding MARC Bibliographic: Machine-Readable Cataloging" (https://www.loc.gov/marc/umb/um07to10.html) from the Library of Congress that explains commonly used MARC fields. For example, the personal author of the work is recorded in Field 100, the title is recorded in Field 245, publisher information is recorded in Field 260, the physical volume and characteristics of a publication are recorded in Field 300, and topical subjects are recorded in the 650 fields.

8. The Online Computer Library Center (OCLC) is the largest bibliographic network of the world, with more than 473 million records and

thousands of member institutions (many of which are libraries of some type) in more than 100 countries. OCLC was founded in 1967 to promote and support library cooperation. According to the "Third Article, Amended Articles of Incorporation of OCLC Online Computer Library Center, Inc.," OCLC was created "to establish, maintain and operate a computerized library network and to promote the evolution of library use, of libraries themselves, and of librarianship, and to provide processes and products for the benefit of library users and libraries, including such objectives as increasing availability of library resources to individual library patrons and reducing the rate of rise of library per-unit costs, all for the fundamental public purpose of furthering ease of access to and use of the ever-expanding body of worldwide scientific, literary and educational knowledge and information" (source: https://www.oclc.org/content/dam/oclc/membership/articles-of-incorporation.pdf).

9. OCLC members can contribute original cataloging records in MARC to the system or derive cataloging records from existing records, an activity referred to as "copy cataloging." When an OCLC participating institution acquires a work, it can create an original MARC record for the work in OCLC's Connexion system (a system for catalogers to create and share MARC records), and the system will automatically generate a code for the date of record creation in the yymmdd format, and the creating library's OCLC symbol is recorded in subfield "a" of the 040 field.

Once the MARC record is in Connexion, it becomes available to other OCLC members for adoption to their local online catalogs (*i.e.*, copy cataloging). This process of cooperative cataloging has been in place since OCLC began operation in the 1960s.

10. After a MARC record is created in Connexion, it also becomes searchable and viewable on WorldCat, which is a free web portal for users to explore more than 10,000 libraries worldwide. The record in WorldCat, however, is not presented in MARC fields. Instead, the data elements are labeled to help users interpret the record. Thus, the information stored in MARC records in Connexion is available to the interested public through the user-friendly WorldCat web portal.

11. WorldCat (http://www.worldcat.org) is "the world's largest network of library content and services" and its features are summarized in "What is WorldCat" (http://www.worldcat.org/whatis/default.jsp). WorldCat began operation in January 1998 as a free web portal to more than 10,000 library collections worldwide. Through WorldCat, users can search for information in their local libraries and libraries around the world. WorldCat allows users to search for books, CDs, videos, and many new types of digital content, such as audiobooks, in many languages. Users can also retrieve research materials and article citations with links to their full text. After an item is retrieved, WorldCat helps users identify a library nearby that

holds the item or all the libraries that hold the item. WorldCat is an efficient way to explore the content held by more than 10,000 libraries around the world. WorldCat is publicly accessible, and there is no fee to perform a search on WorldCat.

12. Library online catalogs gained acceptance in the early 1980s and many libraries migrated their systems to the World Wide Web in the mid-1990s. Library online catalogs are based on MARC records that represent their collections in order to help the public understand what materials are publicly accessible in those libraries. Most libraries with online catalogs have made their catalogs freely available on the Web. These online catalogs offer user-friendly search interfaces. Strong user interest in keyword searches and the popularity of Google have led to the "googlization" of library search systems. As a result, many library catalogs now provide a single search box for users to conduct keyword searches, with additional support for searches by author, title, subject terms, and other data elements such as ISBN (International Standard Book Number). Library catalogs these days also offer features for users to narrow their search results by language, year, format, and other elements. Many libraries display MARC records on their online catalogs with labels for the data elements to help the public interpret MARC records. Many libraries also offer the option to display MARC records in MARC fields.

13. Libraries create MARC records for works they acquire, including

books, serials, motion pictures, and publications in other formats. Monograph cataloging is fairly common in libraries, and most libraries make a newly cataloged monograph available to the public soon after the cataloging work is completed, usually within a week. Libraries can create original cataloging records or use an existing record in OCLC to create a copy cataloging record. As soon as the cataloging record is completed, it is added to the library's online catalog for users. If the record is an original record, it is also entered into OCLC WorldCat. If it is a copy cataloging record, the library's holding symbol is attached to the existing original record in OCLC WorldCat to facilitate searching and interlibrary loan. This practice is designed to facilitate resource discovery and sharing and has been in place since OCLC began operation in the 1960s.

14. The cataloging of serials and the serial check-in process are discussed here to show how libraries usually provide access to newly received serial issues. According to the glossary of the *RDA: Resource Description and Access* cataloging standard, a serial is "a mode of issuance of a manifestation issued in successive parts, usually bearing numbering, that has no predetermined conclusion. A serial includes a periodical, monographic series, newspaper, etc." Because the publisher of a serial makes new issues of the serial available successively, a customary cataloging practice is to create one bibliographic record for the serial, and the MARC serial

record typically provides information on the beginning date and frequency of the serial, not the dates of individual issues. In other words, libraries typically do not create MARC records for individual issues of a serial. Instead, they rely on a serial check-in system to track the receipt of new issues. A common check-in practice is to date stamp a new issue when it arrives. This practice has become automated since the late 1990s, and libraries now vary in how they share the receipt date of a new serial issue with the public. Some libraries use a date stamp, some affix a label to indicate the receipt date, some pencil in the receipt date, and some do not provide the information to the public. I am familiar with all of these processes based on my years of personal experience, as a cataloger and as a cataloging instructor and researcher, interacting with many different libraries and their systems, including during the 1990s and 2000s.

15. The serial check-in process usually takes less than an hour, and one of the steps involves placing a date stamp on the new issue to document the date the issue is checked in. After that, the holdings information of the serial is updated in the library's catalog so that users know which issues are available for request or access. After serial check-in is completed, the new issue is placed on the shelf with the previous issues of the serial. Libraries with a public periodical room typically place new issues in the periodical room for easy user access. Because information

presented in serials often reflects latest discovery, a general practice of libraries is to make new issues of serials available for user access soon after they are checked in, usually within a week. I am familiar with all of these processes based on my years of personal experience as a cataloger and a cataloging instructor interacting with many different libraries and their systems, including during the 1990s and 2000s.

16. There are two ways to catalog conference proceedings. One approach is to catalog each conference proceedings as a book to make the proceedings easily discoverable. This means that once a volume of conference proceedings is cataloged as a book, the book is processed quickly to make it available for public access, usually within a week. Another approach is to catalog conference proceedings as a serial when the conference takes place fairly regularly and the title of the conference remain largely the same. In such a case, a serial record is created, and no individual record is created for each conference proceedings, but the proceedings received are noted in the holdings record to let the public know which year's proceedings are available. The physical copy of the proceedings is checked in through the serial check-in process, and made available for public access soon after the serial check-in is completed, usually on the same day or within a week. This was true in the 1990s and 2000s and I am familiar with all of these processes based on my years of personal experience interacting with many different libraries and their systems, including

during the 1990s and 2000s.

17. I am personally familiar with many online catalogs, databases, and search engines. In preparing for this declaration I used the following authoritative information systems to search for records:

- Google Scholar (https://scholar.google.com)
- Online catalog of the British Library (http://explore.bl.uk/primo_library/libweb/action/search.do?vid=BLVU1)
- Online catalog of the Library of Congress (https://catalog.loc.gov)
- Online catalog of the Linda Hall Library (https://catalog.lindahall.org/)
- WorldCat (https://www.worldcat.org)

These records are identified and discussed in this declaration. Experts in the field of library and information science (like myself) reasonably rely on the data described herein to form their opinions. My opinions in this Declarations are based on my years of experience working with many libraries and library-based systems, and my work experience as a cataloging expert in the field of library and information sciences.

B. Scope of This Declaration

18. I have been asked to offer an opinion on the authenticity and public

availability date of the following documents, which I understand have been labeled with the following exhibit numbers:

(1) Belkind, A., Zhao, Z., Carter, D., Mahoney, L., McDonough, G., Roche, G., ... & Walde, H. (2000, April), Pulsed-DC reactive sputtering of dielectrics: pulsing parameter effects, in the 43rd Proceedings of Annual Technical Conference, Society of Vacuum Coaters, pp. 86-90, obtained from Linda Hall Library, **Ex. 1008**;

(2) Dogheche, E., Rémiens, D., Boudrioua, A., & Loulergue, J. C. (1999), Growth and optical characterization of aluminum nitride thin films deposited on silicon by radio-frequency sputtering, in *Applied Physics Letters*, vol. 74, no. 9, pp. 1209-1211, obtained from the publisher The American Institute of Physics, **Ex. 1029**;

(3) Sproul, W. D. (1998), High-rate reactive DC magnetron sputtering of oxide and nitride superlattice coatings, in *Vacuum*, vol. 51, no. 4, pp. 641-646, obtained from the publisher Elsevier, **Ex. 1036**;

(4) Safi, I. (2000), A novel reactive magnetron sputtering technique for producing insulating oxides of metal alloys and other compound

thin films, in *Surface and Coatings Technology*, vol. 135, no. 1, pp. 48-59, obtained from the publisher Elsevier, **Ex. 1039**;

(5) Kelly, P. J., Henderson, P. S., Arnell, R. D., Roche, G. A., & Carter, D. (2000), Reactive pulsed magnetron sputtering process for alumina films, in *Journal of Vacuum Science & Technology A: Vacuum, Surfaces, and Films*, vol. 18, no. 6, pp. 2890-2896, obtained from the publisher American Institute of Physics, **Ex. 1059**.

C. Evidence Considered in Forming My Opinions

19. In the preparation of this declaration, I have reviewed the documents and information listed below and any other documents and information that I reference in this Declaration. Such information and documents are types of materials that experts in my field would reasonably rely upon when forming their opinions on the authenticity and public availability of publications such as the exhibits identified above:

a) The documents (exhibits) referenced above in Section I.B, and corresponding copies of those references identified herein as **Appendices**

1008, 1029, 1036, 1039, and 1059;[1]

b) Bibliographic and MARC records for *Proceedings of the Annual Technical Conference, Society of Vacuum Coaters*, that contains *Belkind*, available from the online catalog of the Linda Hall Library at https://lindahall.primo.exlibrisgroup.com/permalink/01LINDAHALL_INST/19lda7s/alma992834813405961, accessed and obtained on September 17, 2020, **Appendix 1008-A**;

c) MARC record for *Proceedings of the Annual Technical Conference, Society of Vacuum Coaters*, that contains *Belkind*, available from the online catalog of the British Library at http://explore.bl.uk/BLVU1:LSCOP-ALL:BLL01007873885, accessed and obtained on September 17, 2020, **Appendix 1008-B**;

d) Library copy of *Dogheche*, obtained from the Linda Hall Library, **Appendix 1029-A**;

[1] I have reviewed the references associated with **Exhibits 1008, 1029, 1036, 1039, and 1059** and confirm that the copies of those references included herein as **Appendices 1008, 1029, 1036, 1039, and 1059** are respectively the same**.**

e) Bibliographic and MARC records for *Applied Physics Letters*, whose vol. 74, no. 9 contains *Dogheche*, available from the online catalog of the Linda Hall Library at https://catalog.lindahall.org/permalink/01LINDAHALL_INST/1jnv6m8/alma992785733405961, accessed and obtained on September 15, 2020, **Appendix 1029-B**;

f) MARC record for *Applied Physics Letters*, whose vol. 74, no. 9 contains *Dogheche*, available from the online catalog of the British Library at http://explore.bl.uk/BLVU1:LSCOP-ALL:BLL01014532647 (select MARC display), accessed and obtained on September 28, 2020, **Appendix 1029-C**;

g) Full text of documents citing *Dogheche* and publisher webpages with publication dates, **Appendix 1029-D**;

h) Library copy of *Sproul*, obtained from the Linda Hall Library, **Appendix 1036-A**;

i) Bibliographic and MARC records for *Vacuum*, whose vol. 51, no. 4, contains *Sproul*, available at the online catalog of the Linda Hall Library at

https://catalog.lindahall.org/permalink/01LINDAHALL_INST/1jnv6m8/alma992818493405961, accessed and obtained on September 14, 2020, **Appendix 1036-B**;

j) Copy of Kelly, P. J., Arnell, R.D, (2000), Magnetron sputtering: a review of recent developments and applications, *Vacuum* vol. 56, pp. 159-172 (manuscript received by the publisher on September 20, 1999), as an early citing article of *Sproul*, **Appendix 1036-C**;

k) Library copy of *Safi*, obtained from the Linda Hall Library, **Appendix 1039-A**;

l) Bibliographic and MARC record for *Surface and Coatings Technology*, whose vol. 135, issue 1, contains *Safi*, available from the online catalog of the Linda Hall Library at https://catalog.lindahall.org/permalink/01LINDAHALL_INST/1jnv6m8/alma993036823405961, accessed and obtained on September 14, 2020, **Appendix 1039-B**;

m) MARC record for *Surface and Coatings Technology*, whose vol. 135, issue 1 contains *Safi*, available from the online catalog of the British Library at http://explore.bl.uk/BLVU1:LSCOP-ALL:BLL01007514620 (select

MARC display), accessed and obtained on September 28, 2020, **Appendix 1039-C**;

n) Copy of Blondeel, A., & De Bosscher, W. (2001), Arc handling in Reactive DC magnetron sputter deposition, in *Proceedings of the Annual Technical Conference*, Society of Vacuum Coaters, pp. 240-245, as an early citing article of *Safi*, **Appendix 1039-D**;

o) Library copy of *Kelly*, obtained from the Linda Hall Library, **Appendix 1059-A**;

p) Bibliographic and MARC records for Journal of *Vacuum Science & Technology A: Vacuum, Surfaces, and Films* that contains *Kelly*, available at the online catalog of the Linda Hall Library at https://catalog.lindahall.org/permalink/01LINDAHALL_INST/19lda7s/alma992759783405961, accessed and obtained on September 19, 2020, **Appendix 1059-B**.

20. The Library of Congress holds several exhibit items but it is closed due to the COVID pandemic, so I could not obtain physical copies from the Library of Congress to include with this declaration. I reserve the right to submit physical library copies of any available documents when the library reopens and will do so if asked when I am capable of doing so.

II. AUTHENTICATION AND PUBLIC AVAILABILITY OF *BELKIND* (APPENDIX 1008)

A. Authentication

21. **Appendix 1008** is a true and correct copy of "Pulsed-DC reactive sputtering of dielectrics: pulsing parameter effects," ("*Belkind*"), by Belkind et al. in the *2000 Technical Conference Proceedings* of the Society of Vacuum Coaters, pp. 86-90, that I obtained from the Linda Hall Library. When I began preparing this declaration I searched WorldCat by the title of *Belkind* for records, and the search results informed me that Linda Hall Library held this conference proceedings. I then requested a copy of *Belkind* from the Linda Hall Library Document Delivery Service and received the copy on September 21, 2020. This library copy is presented as **Appendix 1008** in this declaration.

22. **Appendix 1008** is a true and correct copy of *Belkind* that I obtained from the Linda Hall Library. It includes the front matter (cover, title page, copyright

page, and table of contents) and the Belkind article. Page 1 is the cover that shows Society of Vacuum Coaters, "43rd Annual Technical Conference Proceedings, April 15-20, 2000, Denver, Colorado USA" and a faint library date stamp. Page 2 is the title page that shows the same conference information and also shows the conference proceedings has a "2000" copyright date with the Society of Vacuum Coaters as the copyright holder. Page 3 is the copyright page that shows the Society of Vacuum Coaters' annual technical conference proceedings are available in print and CD-RM, the ISSN of this series of conference proceedings is "0737-5921," and the Society is the publisher. Pages 4 to 9 are the table of contents and page 5 (internal page iv) shows *Belkind* is included in the "Emerging Technologies" session and appears from pages 86 to 90. Page 10 begins the Plenary session and carries a library date stamp of "LINDA HALL LIBRARY SEP 12 2000." Pages 11 to 15 are the *Belkind* article. Page 11 (internal page 86) shows the title, authors, four key words, and an abstract of *Belkind*. The footer shows *Belkind* has a "2000" copyright date with the Society of Vacuum Coaters as the copyright holder, and its ISSN is "0737-5921." It also shows *Belkind* is included in the "43rd Annual Technical Conference Proceedings—Denver, April 15-20, 2000." *Belkind* is five pages long, including seven figures and 20 references.

B. Linda Hall Library Records

23. **Appendix 1008-A** is a true and correct copy of the bibliographic and MARC records for *Proceedings of the Annual Technical Conference, Society of Vacuum Coaters* that contains *Belkind*. I personally located, identified and obtained these records from the online catalog of the Linda Hall Library by searching for the ISSN "0737-5921" for records. This is the type of records experts in my field would reasonably rely upon when forming their opinions. I captured images of the bibliographic and MARC records to produce **Appendix 1008-A**.

24. Page 1 of **Appendix 1008-A** identifies the publication as a journal with the title of *"Proceedings of the ... Annual Technical Conference*" and the Society of Vacuum Coaters, Technical Conference as the creator. The record shows that this journal is "Available at Linda Hall Library Closed Stacks – Serials (Society of Vacuum Coaters. Proceedings [of the annual technical conference])" and other locations and "25 (1982) – 51 (2008)", meaning it has the 43rd conference proceedings (2000) that contains *Belkind*. Page 2 is the detailed bibliographic record that shows the title, creators, subjects, identifiers, other titles, related title, publisher, creation date, frequency, and citation/References notes.

25. Page 3 is the MARC record for *Proceedings of the Annual Technical Conference, Society of Vacuum Coaters* that shows the creation date and creator of

this MARC record. The first six digits of Field 008 show the MARC record was created on "830411" (*i.e.*, April 11, 1983), and the "c19829999" code following this creation date indicates that the journal is a continuing resource that began publication in 1982 and is an ongoing publication. Subfield "a" of Field 040 shows that "DLC" created this record, and Filed 049 shows "LHLA" as the holding library. According to the Directory of OCLC Members (https://www.oclc.org/en/contacts/libraries.html), "DLC" is the OCLC library symbol for the Library of Congress and "LHL" is the symbol for the Linda Hall Library. "LHL" is not included in Field 040 subfield "d" because the library added its holdings symbol to the record and did not modify the original MARC record, a practice documented by the MARC Bibliographic Standard (https://www.loc.gov/marc/bibliographic/). As discussed earlier, a customary library practice is to create a serial record for a serial, without creating records for individual issues of the serial. When individual issues are received, they go through the serial check-in process, which usually takes less than an hour. After that, the newly received issues are placed on the shelf or a periodical reading room for user access, usually on the same date of serial check-in or within a week after serial check-in. These procedures are what would have been followed in 2000 and are consistent with my experience with the Linda Hall library. I know this is a

customary library practice from personal experience as a cataloging instructor and researcher that provided me with many opportunities to interact with catalogers, and many different libraries and their systems. The library date stamp of "SEP 12 2000" on the Plenary session page (page 10) of the Linda Hall Library copy (**Appendix 1008**) means that the 43rd *Proceedings of the Annual Technical Conference* (2000) of the Society of Vacuum Coaters (and *Belkind* contained therein) was received by the library on September 12, 2000. It is therefore my opinion that this volume would have been available for public access on September 12, 2000, or no later than September 19, 2000, at the Linda Hall Library, and certainly no later than the end of 2000.

26. Field 022 of the MARC record (**Appendix 1008-A**) shows the journal's ISSN is "0737-5921." Following cataloging standards, the conference name is used as the author in Field 110 and the conference name is presented as "Society of Vacuum Coaters. Technical Conference." Field 245 shows "Proceedings of the … Annual Technical Conference" as the title and the Society of Vacuum Coaters is included in the statement of responsibility (encoded in subfield "c"). Field 246 show two variant titles are included to help users discover this journal. Field 260 shows the Society of Vacuum Coaters as the publisher since 1982. Field 362 shows the journal began with "25th (1982)" and Field 310 shows the publication is "Annual."

Four 510 fields show this journal is selectively indexed by four abstracting and indexing services, making articles in this journal easier for users to discover. The ISSN, journal title and publisher match the information presented in the Linda Hall Library copy (**Appendix 1008**).

27. The original MARC record by the Library of Congress uses a Library of Congress Classification (LCC) number "TS695" in Field 050 to represent the subject of this journal. Because Linda Hall Library does not assign classification numbers to their journals, this field is retained but not used by the Linda Hall Library for retrieval purposes. Instead, the Linda Hall Library record represents the journal's subject with a Library of Congress subject heading in Field 650, using "Vapor-plating" as the main heading, followed by "Congresses" encoded in subfield "v" to show the topic is treated in a conference.

28. This MARC record (**Appendix 1008-A**) shows that *Proceedings of the Annual Technical Conference* of the Society of Vacuum Coaters is a long-running journal and this MARC record has made this journal searchable in the catalog of the Linda Hall Library. Because *Belkind* was received and processed on September 12, 2000, it is my opinion that *Proceedings of the Annual Technical Conference* of the Society of Vacuum Coaters that contains *Belkind* would have been searchable in the online catalog of the Linda Hall Library at least by September 2000. Users interested

in *Belkind* would have been able to search for this journal by its title, variant titles, ISSN, the Library of Congress subject heading, which are provided as access points in this MARC record. Linda Hall Library was established in 1946 and is the largest independently funded public library of science, engineering and technology in North America. Based on my experience and knowledge of the Linda Hall Library and research libraries like it, it is my opinion that persons interested in locating *Belkind* in 2000 would have been able to use the access points provided in the MARC record to locate and access *Belkin*d by the end of September 2000, and certainly no later than the end of 2000.

C. British Library MARC Record

29. To further demonstrate public availability of *Belkind*, I searched WorldCat for holding libraries and identified the British Library as another holding library. I searched their online catalog to obtain their MARC record and holdings information. **Appendix 1008-B** is a true and correct copy of the MARC record for *Proceedings of the Annual Technical Conference* of the Society of Vacuum Coaters. I personally located, identified and obtained this record from the online catalog of the British Library. This is the type of record experts in my field would reasonably rely upon when forming their opinions relating to the public availability of a published document in such a library.

30. The FMT field of the British Library MARC record (**Appendix 1008-B**) identifies this publication as "SE" (meaning serial). The first six digits of Field 008 shows this MARC record was created on "840327" (*i.e.*, March 27, 1984) and the "c19829999" code following this creation date indicates that the journal is a continuing resource that began publication in 1982 and is an ongoing publication. Subfield "a" of Field 040 shows that "Uk" created this record. According to the MARC codes for organizations in the UK and its dependencies (https://www.bl.uk/britishlibrary/~/media/bl/global/services/collection%20metadata/pdfs/marc-codes-directory.pdf?la=en&hash=95F3854F9268E590E81C13357506F393), "Uk" is the code for the British Library.

31. Field 022 of the MARC record (**Appendix 1008-B**) shows the journal's ISSN is "0737-5921." Following cataloging standards, the conference name is used as the author in Field 110 and the conference name is presented as "Society of Vacuum Coaters. Technical Conference." Field 245 shows "Proceedings of the … Annual Technical Conference" as the title and the Society of Vacuum Coaters is included in the statement of responsibility (encoded in subfield "c"). Fields 246 show two variant titles are included to help users discover this journal. Field 260 shows the Society of Vacuum Coaters as the publisher. Field 310 shows the

publication frequency is "Annual." The ISSN, journal title and publisher match the information presented in the Linda Hall Library copy (**Appendix 1008**). Field 852 shows the Document Supply Center of the British Library has "6842.380000" as the shelfmark for this serial and Field 866 shows it holds proceedings from "21, 1978" on, meaning from the 21st Technical Conference proceedings (1978) on, including the 43rd proceedings (2000) that contains *Belkind*. The British Library assigns two classification numbers to this serial to represent the subjects. Field 082 shows a Dewey Decimal Classification number of "671.73505," which represents the class number for periodicals on "Vapor plating (Vacuum deposition)"; and Field 084 shows a British Library Science reference information service subject classification number of "TJ 74." No subject headings or keywords are included in this MARC record.

32. This MARC record has made *Proceedings of the Annual Technical Conference*, of the Society of Vacuum Coaters searchable in the catalog of the British Library since 1984 when the serial MARC record was created by the British Library. Users interested in the subject of this publication would have been able to find it through the DDC number and the British Library's own classification number. In addition, they would have been able to find the serial through the ISSN, the conference name, title, and variant titles, all of them provided as access points in the

MARC record. The physical copy of the *Proceedings of the Annual Technical Conference*, of the Society of Vacuum Coaters (and *Belkind* contained therein) would have been available for public access soon after the 43rd conference proceedings (2000) was received. Based on my experience and knowledge of the British Library procedures, it is my expert opinion this would have likely occurred within a week or so after serial check in was completed, and so in my opinion, *Belkind* would have been publicly available by the British Library at least by the end of September 2000, and certainly no later than of end of 2000.

33. The British Library is closed due to the COVID pandemic, so I was unable to a physical copy from the British Library to include with my declaration and further support my opinion. Therefore, I reserve the right to submit the physical library copy of *Belkind* once the library reopens, and will do so if asked and I am capable of doing so.

D. Summary of My Opinion on *Belkind*

34. Taken together, the "SEP 12 2000" date stamp in the Linda Hall Library copy of *Belkind* (**Appendix 1008**), the Linda Hall Library records (**Appendix 1008-A**), and the British Library MARC record (**Appendix 1008-B**), together with my knowledge and experience with library cataloging and processing practices and procedures as an expert in the field, inform my opinion that the 43rd *Proceedings of*

the Annual Technical Conference of the Society of Vacuum Coaters (and *Belkind* contained therein) was received by the Linda Hall Library on September 12, 2000, and would have been available for public access on September 12, 2000, or no later than September 19, 2000, and certainly no later than of end of 2000. It is also my opinion that the British Library holds this serial, and the 43rd conference proceedings that contains *Belkind* would have been made available to the public soon after the serial check in process was completed. Based on my experience as an expert and my previous experience working with librarians and collections of the British Library, it is my opinion that *Belkind* would have been available to the public through the British Library no later than the end of 2000 if not earlier. I reserve the right to expand on the basis for my opinion regarding *Belkind* if asked to do so.

III. AUTHENTICATION AND PUBLIC AVAILABILITY OF *DOGHECHE* (APPENDIX 1029)

A. Authentication

35. **Appendix 1029** is a true and correct copy of "Growth and optical characterization of aluminum nitride thin films deposited on silicon by radio-frequency sputtering," ("*Dogheche*"), by Dogheche et al., in *Applied Physics Letters*, vol. *74*, no. 9 (1999), pp. 1209-1211, that I obtained from the publisher The American Institute of Physics. When I began preparing this declaration I searched Google Scholar by the title of *Dogheche* for records, and the search results informed me that *Dogheche* was available online at the *Applied Physics Letters* website of the American Institute of Physics (https://aip.scitation.org/doi/abs/10.1063/1.123501). I then used the PDF link to purchase *Dogheche*. This copy from the publisher is presented as **Appendix 1029** in this declaration.

36. **Appendix 1029** is a true and correct copy of *Dogheche*. Page 1 is the cover sheet that shows Dogheche et al. published "Growth and optical characterization of aluminum nitride thin films deposited on silicon by radio-frequency sputtering" in *Applied Physics Letters*. It also shows the article history as "Submitted: 24 July 1998. Accepted: 05 January 1999. Published online: 23 February 1999" and informs users to cite *Dogheche* as "Appl. Phys. Lett. 74, 1209 (1999): https://doi.org/10.1063/1.123501." The bottom of the page shows *Dogheche*

has a "1999" copyright date with the American Institute of Physics as the copyright holder. Page 2 of **Appendix 1029** is the first page of the Dogheche article. It shows the title, authors, article history, and an abstract that has a "1999" copyright date with the American Institute of Physics as the copyright holder. The footer of page 2 (internal page 1209) shows *Dogheche* was published in "0003-6951," which is the International Standard Serial Number (ISSN) of *Applied Physics Letters*, in "99/74(9)," meaning vol. 74, no. 9 in 1999. **Appendix 1029** shows that *Dogheche* runs from page 1209 to page 1211, including one table, four figures, and 14 references.

37. To demonstrate public availability of *Dogheche*, I searched WorldCat by the title of *Dogheche* and the search results informed me that the Linda Hall Library was one of the holding libraries. I then requested a copy of *Dogheche* from the Linda Hall Library Document Delivery Service and received the copy on September 15, 2020 (**Appendix 1029-A**). I have closely compared the publisher's copy of *Dogheche* (**Appendix 1029**) with the Linda Hall Library copy (**Appendix 1029-A**) and concluded that the two copies contain the same Dogheche article. Differences between the two copies are that the publisher's copy includes a colored cover sheet, and the Linda Hall Library copy includes front matter.

38. **Appendix 1029-A** is a true and correct copy of *Dogheche* that I

obtained from the Linda Hall Library. It includes the front matter (cover, copyright page, and table of contents) and the Dogheche article. Page 1 is the cover that shows "Applied Physics Letters" as the journal title and identifies the issue as "Volume 74 Number 9" published on "1 March 1999" by the American Institute of Physics. It also shows the issue is "Available online—See www.aip.org." Page 2 is the copyright page that shows this journal's website is at http://ojps.aip.org/apl, the journal's ISSN is "0003-6951" and its CODEN (a six-character unique identifier of serial) is "APPLAB." This page also shows that *Applied Physics Letters* "is published weekly by the American Institute of Physics" and this issue carries a "1999" copyright date with the American Institute of Physics as the copyright holder. Page 3 begins the table of contents of vol. 74, no. 9. It shows the Dogheche article appears on page 1209 and ends on page 1211. It also shows a Linda Hall Library date stamp of "AUG 04 1999."

B. Linda Hall Library Records

39. Appendix 1029-B is a true and correct copy of the bibliographic and MARC records for *Applied Physics Letters* that contains *Dogheche*. I personally located, identified and obtained these records from the online catalog of the Linda Hall Library by searching for the ISSN "0003-6951" for records. These are the type of records experts in my field would reasonably rely upon when forming their

opinions on the public availability of a document. I captured images of the bibliographic and MARC records to produce **Appendix 1029-B**.

40. Page 1 of **Appendix 1029-B** identifies *"Applied physics letters"* as a journal and shows that it is "Available at Linda Hall Library Closed Stacks – Serials (Applied physics letters.)" It also shows the library holds "v.1:no.1(1962:Sep.)-v.107:no.26(2015:Dec.28), meaning it holds vol. 74, no. 9 that contains *Dogheche*. Page 2 is the detailed bibliographic record that shows the journal title, contributor, subjects, identifiers, other titles, publisher, journal creation date, format, publication frequency and general notes.

41. Page 3 is the MARC record for *Applied Physics Letters* that shows the creation date and creator of this MARC record. The first six digits of Field 008 show the MARC record was created on "750829" (*i.e.*, August 29, 1975), and the "c19629999" code following this creation date indicates that the journal is a continuing resource that began publication in 1962 and is an ongoing publication. Subfield "a" of Field 040 shows that "DLC" created this record. According to the Directory of OCLC Members (https://www.oclc.org/en/contacts/libraries.html), "DLC" is the OCLC library symbol for the Library of Congress. Data from Field 008 and Field 040 inform my opinion that the Linda Hall Library used the record originally created by the Library of Congress in 1975 to catalog *Applied Physics*

Letters as a serial. As discussed earlier, a common library practice is to create a serial record for a serial, without creating records for individual issues of the serial. When individual issues are received, they go through the serial check-in process, which usually takes less than an hour. After that, the newly received issues are placed on the shelf or in a periodical reading room for user access, usually on the same date of serial check-in or within a week after serial check-in. The library date stamp on page 3 of the Linda Hall Library copy (**Appendix 1029-A**) shows that vol. 74, no. 9 (March 1999) of *Applied Physics Letters* (and *Dogheche* contained therein) was received by the library on August 4, 1999. These procedures are what would have been followed in 1999 and are consistent with my experience with the Linda Hall library. I know this is the customary library practice from personal experience as a cataloging instructor and researcher that provided me with many opportunities to interact with catalogers, and many different libraries and their systems. The Library date stamp of "AUG 04 1999" (**Appendix 1029-A**) informs my opinion that this issue would have been available for public access on August 4, 1999, or no later than August 11, 1999, at the Linda Hall Library, and certainly no later than the end of 1999.

42. Field 022 of the MARC record (**Appendix 1029-B**) shows "0003-6951" as the journal's ISSN and Field 030 shows "APPLAB" as its CODEN. Field

245 shows "Applied physics letters" as the journal title, Field 260 shows the American Institute of Physics of New York is the publisher. Field 362 shows the journal began with "v. 1- Sept. 1962" and Field 310 shows the publication frequency has been "Weekly" since 1986. 16 Fields 510 show this journal is selectively indexed by indexing and abstracting services, making some of the journal articles easier to discover. Field 710 shows the publisher is included as an additional access point to help users discover this journal. The ISSN, title, publisher, publication frequency match the information presented in the Linda Hall copy of *Dogheche* (**Appendix 1029-A**).

43. Field 050 shows a Library of Congress Classification (LCC) number of "QC1," which is the class number for periodicals in the field of physics, is included in the MARC record. The Linda Hall Library retains this field in its MARC record but does not used it for retrieval purposes because the library shelves journals by title, not subject. To represent the subject of this journal, the Linda Hall Library MARC record uses a Library of Congress subject heading in Field 650 with "Physics" as the main heading followed by "Periodicals," a form subdivision encoded in subfield "v" to show the topic was treated in a journal.

44. This MARC record (**Appendix 1029-B**) shows that *Applied Physics Letter* is a long-running journal and this MARC record has made it searchable in the

online catalog of the Linda Hall Library. Because *Dogheche* was received and processed by the Linda Hall Library on "AUG 04 1999," it is my opinion that *Applied Physics Letters* that contains *Dogheche* would have been searchable no later than August 1999 in the online catalog of the Linda Hall Library. Users interested in the subject of *Applied Physics Letters*, which contains *Dogheche*, in 1999 would have been able to do a subject search for the journal by the Library of Congress subject heading assigned to it. Interested users would also have been able to search by the journal, title, ISSN, CODEN, and the publisher, which are provided as access points in the MARC record. In short, the issue containing *Dogheche* was available at the Linda Hall Library on August 4, 1999, and persons interested in locating *Dogheche* in 1999 would have been able to search for the journal by the access points provided by the MARC record in 1999, and obtain access to *Dogheche* at least in August 1999 and certainly no later than the end of 1999.

C. British Library MARC Record

45. To further demonstrate public availability of *Dogheche*, I searched WorldCat for holding libraries and identified the British Library as another holding library. I searched their online catalog to obtain their MARC record and holdings information. **Appendix 1029-C** is a true and correct copy of the MARC record for *Applied Physics Letters*. I personally located, identified and obtained this record

from the online catalog of the British Library. This is the type of record experts in my field would reasonably rely upon when forming their opinions.

46. The FMT field of the British Library MARC record (**Appendix 1029-C**) identifies this publication as "SE" (meaning serial). The first six digits of Field 008 shows this MARC record was created on "840320" (*i.e.*, March 20, 1984) and the "c19629999" code following this creation date indicates that the journal is a continuing resource that began publication in 1962 and is an ongoing publication. Subfield "a" of Field 040 shows that "Uk" created this record. According to the MARC codes for organizations in the UK and its dependencies (https://www.bl.uk/britishlibrary/~/media/bl/global/services/collection%20metadata/pdfs/marc-codes-directory.pdf?la=en&hash=95F3854F9268E590E81C13357506F393), "Uk" is the code for the British Library.

47. Field 022 of the MARC record (**Appendix 1029-C**) shows the journal's ISSN is "0003-6951." Field 245 shows "Applied physics letters" as the title and Field 260 shows the American Institute of Physics of New York has been the publisher since 1962. Field 310 shows the journal publication frequency is "Fortnightly" and the publisher is included in Field 710 as an additional access point to help users discover this journal. The British Library assigns two classification

numbers to this journal to represent the subjects. Field 082 shows a Dewey Decimal Classification (DDC) number of "621," which represents the class number for "Applied physics" and Field 084 shows a British Library Science reference information service subject classification (blsrissc) number of "PQ 00." No subject headings or keywords are included in this MARC record. The British Library holds two sets of this journal. Field 852 shows "STI" (*i.e.*, the Science, Technology & Business) has "(P) PQ 00 -E(12)" as the classification number for this journal and Field 866 shows STI holds "volume 1 (1962)- ". A second Field 852 shows "DSC" (*i.e.*, the Document Supply Center) holds another set with "1576.400000" as the shelfmark for this journal and Field 866 shows it holds "Volume 1 (1962)- "

48. This MARC record has made *Applied Physics Letters* searchable in the catalog of the British Library since March 20, 1984. Users interested in *Dogheche* in 1999 would have been able to search for this journal by conducting subject searches by the DDC number and the British Library's own classification number. They would also have been able to find the journal through the ISSN, title, and publisher, which are provided as access points in the MARC record. Based on my experience and usage of the British Library, it is my opinion that persons interested in locating *Dogheche* in 1999 would have been able to locate and access *Dogheche* soon after vol. 74, no. 9 (March 1999) of *Applied Physics Letter* (and *Dogheche*

contained therein) was received, typically on the same day of serial check in or within a week after serial check in was completed. Based on my experience as an expert and my previous experience working with articles from *Applied Physical Letters* from the British Library, it is my opinion that *Dogheche* would have been publicly available by the British Library no later than of end of 1999.

49. The British Library is closed due to the pandemic, so I was not able to obtain a physical copy from the British Library for this declaration. In case the copyright owner raises questions about library copies, I reserve the right to submit a library copy of *Dogheche* when the British Library reopens.

D. Actual Usage Record

50. Actual usage of a publication is reflected by the papers that make reference to it. The citation history on Google Scholar shows *Dogheche* has been cited at least 38 times. Three citing articles are provided in **Appendix 1029-D** to show that *Dogheche* was used by other researchers soon after its availability at the Linda Hall Library in September 1999. These citing papers support my additional opinion that *Dogheche* was used by other researchers in 1999 and 2000 and was available for public access at least at these times. The three citing papers are

(1) Ren, Z. M., Lu, Y. F., Goh, Y. W., Chong, T. C., Ng, M. L., Wang, J. P., ... & Liew, Y. F. (2000, May). Deposition of AlN thin films with cubic

crystal structures on silicon substrates at room temperature. *Japanese Journal of Applied Physics*, *39*(5A), L423. (Manuscript "received September 20, 1999; accepted for publication March 6, 2000." *Dogheche* is Reference 9. Copy obtained from the Copyright Clearance Center. The Table of Contents of Issue 5A at https://iopscience.iop.org/issue/1347-4065/39/5A shows Ren et al. was published in May 2000 (see pages 18 of **Appendix 1029-D**).) This article cites to *Dogheche* on page 3 of **Appendix 1029-D**. (**Appendix 1029-D** at 3 (citing reference no. 9 "E. Dogheche, D. Remiens, A. Boudrioua and J. C. Loulergue: Appl. Phys. Lett. 74 (1999) 1209").) That reference to "E. Dogheche" is a reference to the same *Dogheche* reference I discuss above (**Appendix 1029**) because it references the authors, volume and date as **Appendix 1029**. (*See e.g.,* **Appendix 1029** at 1 "Appl. Phys. Lett. 74, 1209 (1999)", 2 (E. Dogheche, D. Rémiens, A. Boudrioua, and J. C. Loulergue).)

(2) Ren, Z. M., Lu, Y. F., Ni, H. Q., Liew, T. Y. F., Cheong, B. A., Chow, S. K., ... & Wang, J. P. (2000, November). Room temperature synthesis of c-AlN thin films by nitrogen-ion-assisted pulsed laser deposition. *Journal of Applied Physics*, *88* (12), 7346-7350. (Manuscript submitted on April 10, 2000, accepted on August 28, 2000, and published online on November 28, 2000. *Dogheche* is Reference 9. Copy obtained from the publisher.) This

article cites to *Dogheche* on page 9 of **Appendix 1029-D**. (**Appendix 1029-D** at 9 (citing reference no. 9 "E. Dogheche, D. Remiens, A. Boudrioua, and J. C. Loulergue, Appl. Phys. Lett. 74, 1209 (1999)".) That reference to "E. Dogheche" is a reference to the same *Dogheche* reference I discuss above (**Appendix 1029**) because it references the authors, volume and date as **Appendix 1029**. (*See e.g.,* **Appendix 1029** at 1 "Appl. Phys. Lett. 74, 1209 (1999)", 2 (E. Dogheche, D. Rémiens A. Boudrioua, and J. C. Loulergue).)

(3) Lim, W. T., Son, B. K., Kang, D. H., & Lee, C. H. (2001, February). Structural properties of AlN films grown on Si, Ru/Si and ZnO/Si substrates. *Thin Solid Films*, *382*(1-2), 56-60. (Manuscript received on February 3, 2000, received in revised form on August 3, 2000, and accepted on September 27, 2000. *Dogheche* is Reference 6. Copy obtained from the publisher. The publisher's webpage for Lim et al. shows this article was published in the "February 2001" issue (see pages 15 of **Appendix 1029-D**).) This article cites to *Dogheche* on page 14 of **Appendix 1029-D**. (**Appendix 1029-D** at 14 (citing reference no. 6 "E. Dogheche, D. Remiens, A. Boudrioua, J.C. Loulergue, Appl. Phys. Lett. 74 (1999) 1209").) That reference to "E. Dogheche" is a reference to the same *Dogheche* reference I discuss above (**Appendix 1029**) because it references the authors, volume and date as

Appendix 1029. (*See e.g.,* **Appendix 1029** at 1 "Appl. Phys. Lett. 74, 1209 (1999)", 2 (E. Dogheche, D. Rémiens, A. Boudrioua, and J. C. Loulergue).)

Based on my experience in the field of library science, and as an expert in the field, it is my opinion that each of these three citing references by Ren and Lim would themselves have been available at the time of the publication dates identified on each of those respective documents.

E. Summary of My Opinion on *Dogheche*

51. Based on the "Aug 04 1999" date stamp in the Linda Hall Library copy of *Dogheche* (**Appendix 1029-A**), the Linda Hall Library records (**Appendix 1029-B**), my knowledge and experience with library cataloging and processing practices and procedures, my experience with many libraries and cataloging systems, and my experience interacting with the Linda Hall Library, it is my opinion that the *Applied Physics Letters* issue containing *Dogheche* was received by the Linda Hall Library on August 4, 1999, and this issue would have become available to the public by at least August 4, 1999, or no later than August 11, 1999, and certainly no later than the end of 1999. It is also my opinion that the British Library holds this journal, and vol. 74, no. 9 (March 1999) containing *Dogheche* would have been made available to the public soon after the serial check in process was completed. Based on my experience as an expert and my previous experience working with articles in *Applied*

Physical Letters held by the British Library, it is my opinion that *Dogheche* would have been available to the public through the British Library no later than the end of 1999. I reserve the right to expand on the basis for my opinion regarding *Dogheche* if asked to do so.

IV. AUTHENTICATION AND PUBLIC AVAILABILITY OF *SPROUL* (APPENDIX 1036)

A. Authentication

52. **Appendix 1036** is a true and correct copy of "High-rate reactive DC magnetron sputtering of oxide and nitride superlattice coatings," ("*Sproul*"), by Sproul in *Vacuum*, vol. 51, no. 4 (1998), pp. 641-646, that I obtained from the publisher Elsevier. When I began preparing this declaration I searched Google Scholar by the title of *Sproul* for records, and the search results informed me that *Sproul* was available online at ScienceDirect at https://www.sciencedirect.com/science/article/abs/pii/S0042207X98002656. ScienceDirect is a website that provides full text access to books and journals on science and medical research, and most items on this site are published by Elsevier. I then used the "Get Access" link to purchase *Sproul*. This copy from the publisher is presented as **Appendix 1036** in this declaration.

53. **Appendix 1036** is a true and correct copy of *Sproul* obtained from Elsevier. Page 1 is the first page of *Sproul* that shows Sproul published "High-rate reactive DC magnetron sputtering of oxide and nitride superlattice coatings" in "Vacuum/volume 51/number 4/pages 641 to 646/1998" and the article has a "1998" copyright date with Elsevier Science Ltd. as the copyright holder. It also shows the journal's ISS is "0042-207X. Page 1 includes an abstract that has a "1998" copyright

date with Elsevier Science Ltd. as the copyright holder. *Sproul* is six pages long, including eight figures and 21 references.

54. To demonstrate public availability of *Sproul* at libraries, I searched WorldCat by the title of *Sproul* and the search results informed me that the Linda Hall Library was one of the holding libraries. I then requested a copy of *Sproul* from the Linda Hall Library Document Delivery Service and received the copy on September 15, 2020 (**Appendix 1036-A**). I have closely compared the publisher's copy of *Sproul* (**Appendix 1036**) with the Linda Hall Library copy (**Appendix 1036-A**) and concluded that the two copies contain the same *Sproul* article. The difference between the two copies is that the Linda Hall Library copy includes front matter.

55. **Appendix 1036-A** is a true and correct copy of *Sproul* that I obtained from the Linda Hall Library. It includes the front matter (cover, copyright page, and table of contents) and the Sproul article. Page 1 is the cover that shows "Vacuum" as the journal title and a tag line of "surface engineering, surface instrumentation & vacuum technology". It identifies this issue as "volume 51/Number 4" published in "December 1998" and shows the journal's ISSN is "0042-207X." The cover also shows this is a special issue that contains "selected papers revised from the Proceedings of the Fourth International Symposium on Sputtering and Plasma Processes (ISSP '97)." The cover shows Pergamon (owned by Elsevier) as the

publisher and lists the journal as available at http://www.elsevier.nl/locate/vacuum. It also shows a Linda Hall Library date stamp but the date is not quite clear against the red background. To make the date discernable, a black and white copy of the cover is included as page 2, and the date looks to be "JAN 11 1999." A reverse contrast copy is also included as page 3 and the date seems to be "JAN 11 1999." While the exact date may not be clear, it is my opinion that these stamps show that vol. 51, no. 4 (1998) was received by the Linda Hall Library in January 1999. Page 4 is the copyright page that shows vol. 51, no. 4 (December 1998) of *Vacuum* has a "1998" copyright date with Elsevier Science Ltd., the publisher, as the copyright holder. It also shows the journal is "published monthly (3 volumes, 4 issues per volume)." Pages 5 to 7 are the table of contents and page 6 (internal page xvi) shows *Sproul* appears from page 641 to page 646. Page 8 to page 13 are the *Sproul* article.

B. Linda Hall Library Records

56. Appendix 1036-B is a true and correct copy of the bibliographic and MARC records for *Vacuum* that contains *Sproul*. I personally located, identified and obtained these records from the online catalog of the Linda Hall Library by searching for the ISSN "0042-207X" for records. This is the type of records experts in my field would reasonably rely upon when forming their opinions regarding the public availability of documents. I captured images of the bibliographic and MARC records

to produce **Appendix 1036-B**.

57. Page 1 of **Appendix 1036-B** identifies this *"Vacuum"* as a journal and shows that it is "Available at Linda Hall Library Closed Stacks – Serials (Vacuum.) and other locations." It also shows the library holds "v.37(1987)-v.85:no.12(2011:Jun.5), meaning it has volume 51, no. 4 (1998) that contains *Sproul*. Page 2 is the detailed bibliographic record that shows the journal title, subjects, identifiers, other title, publisher, creation date, frequency, general notes, citation/References note, and local notes.

58. Page 3 is the MARC record for *Vacuum* that shows the creation date and creator of this MARC record. The first six digits of Field 008 show the MARC record was created on "750722" (*i.e.*, July 22, 1975), and the "c19519999" code following this creation date indicates that the journal is a continuing resource that began publication in 1951 and is an ongoing publication. Subfield "a" of Field 040 shows that "DLC" created this record and Field 049 shows the holding library is "LHLA." According to the Directory of OCLC Members (https://www.oclc.org/en/contacts/libraries.html), "DLC" is the OCLC library symbol for the Library of Congress and "LHL" is the symbol for the Linda Hall Library. "LHL" is not in Field 040 subfield "d" because the library used the Library of Congress record for copy cataloging but did not modify the original record. This

is the practice documented in the MARC bibliographic standard. As discussed earlier, a customary library practice is to create a serial record for a serial, without creating records for individual issues of the serial. When individual issues are received, they go through the serial check-in process, which usually takes less than an hour. After that, the newly received issues are placed on the shelf or a periodical reading room for user access, usually on the same date of serial check-in or within a week after serial check-in. These procedures are what would have been followed in 1999 and are consistent with my experience with the Linda Hall library. I know this is the customary procedure from personal experience as a cataloging instructor and researcher that provided me with many opportunities to interact with catalogers, and many different libraries and their systems. The library date stamp of "JAN 11 1999" on page 1 of the Linda Hall Library copy (**Appendix 1036-A**) means that vol. 51, no. 4 (1998) of *Vacuum* (and *Sproul* contained therein) was received by the library on January 11, 1999. It is therefore my opinion that this issue would have been available for public access on January 11, 1999, or no later than January 18, 1999, at the Linda Hall Library. While the date stamp is not as clear as desired, it does show the issue was received at least in January 1999, so in my opinion the issue containing *Sproul* would have been available for public access at least by the end of January 1999, or by February 7, 1999 (a week after receipt and processing), and

certainly no later than the end of 1999.

59. Field 022 of the MARC record (**Appendix 1036-B**) shows the journal's ISSN is "0042-207X," Field 245 shows "Vacuum" as the journal title, and Field 260 shows Elsevier is the publisher. Field 362 shows the journal began publication with "v. 1" in "Jan. 1951." Field 321 shows "Frequency varies" between 1951 and 2004, and Fields 310 show the publication frequency has been "Fourteen no. a year" since 2005. The ISSN, journal title and publisher match the information presented in the Linda Hall Library copy (**Appendix 1036-A**).

60. The original MARC record by the Library of Congress uses a Library of Congress Classification (LCC) number "QC166" in Field 050 to represent the subject of this journal. Because Linda Hall Library does not assign classification numbers to their journals, and uses no subject headings to indicate the subjects of this journal. The Linda Hall Library record represents the journal's subject with a Library of Congress subject heading in Field 650, using "Vacuum" as the main heading, followed by "Periodicals" encoded in subfield "v" to show the topic is treated in a journal.

61. This MARC record (**Appendix 1036-B**) shows that *Vacuum* is a long-running journal, and this MARC record has made it searchable in the catalog of the Linda Hall Library. Users can also search for this journal by its title and ISSN, which

are access points in the MARC record. Because *Sproul* was received and processed in January 1999 by the Linda Hall Library, it is my opinion that the journal *Vacuum* would have been searchable in the online catalog of the Linda Hall Library by at least January 1999, if not earlier. Based on my experience and knowledge of the Linda Hall Library and libraries like it, it is my opinion that persons interested in locating *Sproul* in 1999 would have been able to use the access points provided in the MARC record to locate and access Sproul by the end of January 1999, and certainly no later than the end of 1999.

C. Actual Usage Record

62. Actual usage of a publication is reflected by the papers that make reference to it. The citation history on Google Scholar shows *Sproul* has been cited at least 107 times. The earliest citing papers appeared in 2000. **Appendix 1036-C** presents the full text of one citing paper by *Kelly* et al. that cites *Sproul*.

63. One citing paper appeared in November 2000: Kelly, P. J., Henderson, P. S., Arnell, R. D., Roche, G. A., & Carter, D. (2000), Reactive pulsed magnetron sputtering process for alumina films. *Journal of Vacuum Science & Technology A: Vacuum, Surfaces, and Films*, *18*(6), 2890-2896. This citing article is presented as **Appendix 1059** in this declaration and is further discussed below (regarding *Kelly*). The library copy obtained shows the article was received by the publisher on "17

March 2000; accepted 28 August 2000." This article history shows that *Kelly* and his coauthors had used *Sproul* by at least the date of **Appendix 1059** as I discuss below (November 27, 2000, or no later than December 4, 2000, and certainly by the end of 2000). (*See* **Appendix 1059** at 8 (citing reference no. 11 "W. D. Sproul, *Vacuum* 51, 641 (1998)").) That reference to "W. D. Sproul" is a reference to the same *Sproul* reference I discuss above (**Appendix 1036**) because it refers to the same author, volume, page, and date information as **Appendix 1036**. (**Appendix 1036** at 1 "***Vacuum***/Volume **51**/number 4/page **641** to 646/**1998**".)

64. Further, *Sproul* appeared in Kelly, P. J., Arnell, R. D, Magnetron sputtering: a review of recent developments and applications, *Vacuum 56 (2000) 159-172* (2000) (received September 20, 1999). (**Appendix 1036-C**) This article history shows that Kelly and his coauthor had access to *Sproul* by at least the date of submission (September 1999) and certainly by the end of 1999 and into 2000 (based on 2000 copyright date of **Appendix 1036-C**). (*See* **Appendix 1036-C** at 1, 13 (citing reference no. [21] "Sproul WD. Vacuum 1998;51(4):641-6").) That reference to "Sproul WD" is a reference to the same *Sproul* reference I discuss above (**Appendix 1036**) because it refers to the same author, volume, page, and date information as **Appendix 1036**. (**Appendix 1036** at 1 "***Vacuum***/Volume **51**/number **4**/page **641** to 64**6**/**1998**".)

65. This article history shows that Kelly and his coauthors had used *Sproul* at least by the date of these two articles. It is therefore my further opinion that *Sproul* was accessible to the public by those dates. Based on my experience in the field of library science, and as an expert in the field, it is my opinion that each of these two citing references by Kelly et al. would themselves have been available at the time of the publication dates identified on each of those respective documents.

D. Summary of My Opinion on *Sproul*

66. Based on the "JAN 11 1999" date stamp in the Linda Hall Library copy of *Sproul* (**Appendix 1036-A**), the Linda Hall Library records (**Appendix 1036-B**), my knowledge and experience with library cataloging and processing practices and procedures, and my experience with the Linda Hall Library, it is my opinion that the issue containing *Sproul* was received no later than January 31, 1999, by the Linda Hall Library, and users interested in *Sproul* in 1999 would have been able to search for it in the online catalog of the Linda Hall Library. It is my further opinion that the issue containing *Sproul* would have been publicly accessible by early February (e.g., February 7, 1999), at the latest, but certainly no later than the end of 1999. Citation history from Google Scholar shows other researchers had used *Sproul* in completed papers in September 1999 and March 2000, and those articles were published in 2000 and in November 2000. It is therefore my further opinion that *Sproul* would

have been accessible no later than the end of 2000. I reserve the right to expand on the basis for my opinion regarding *Sproul* if asked to do so.

V. AUTHENTICATION AND PUBLIC AVAILABILITY OF *SAFI* (APPENDIX 1039)

A. Authentication

67. **Appendix 1039** is a true and correct copy of "A novel reactive magnetron sputtering technique for producing insulating oxides of metal alloys and other compound thin films," ("*Safi*"), by I. Safi , in *Surface and Coatings Technology*, vol. 135, no. 1, pp. 48-59, that I obtained on from the publisher Elsevier. When I began preparing this declaration I searched Google Scholar by the title of *Safi* for records, and the search results informed me that *Safi* was available online at ScienceDirect at https://www.sciencedirect.com/science/article/abs/pii/S0257897200009853. ScienceDirect is a website that provides full text access to books and journals on science and medical research, and most items on this site are published by Elsevier. I then used the "Get Access" link to purchase *Safi*. This copy from the publisher is presented as **Appendix 1039** in this declaration.

68. **Appendix 1039** is a true and correct copy of *Safi* obtained from Elsevier. Page 1 is the first page of *Safi* that shows Safi published "A novel reactive magnetron sputtering technique for producing insulating oxides of metal alloys and other compound thin films" in vol. 135 (2000) of *Surface & Coatings Technology*. This page also shows the article history, indicating the manuscript was "received 20

March 2000; accepted in revised form 16 August 2000." This page includes an abstract that has a "2000" copyright date, with "Elsevier Science B.V." as the copyright holder, and nine keywords that represent the topics of *Safi*. The bottom of page 1 shows *Safi* carries a "2000" copyright date with "Elsevier Science B.V." as the copyright holder, and appears in "0257-8972," which is the ISSN of *Surface & Coatings Technology*. **Appendix 1039** shows that *Safi* runs from page 48 to page 59, including nine equations, 11 figures, one table, and 19 references.

69. To demonstrate public availability of *Safi* at libraries, I searched WorldCat by the title of *Safi* and the search results informed me that the Linda Hall Library was one of the holding libraries. I then requested a copy of *Safi* from the Linda Hall Library Document Delivery Service and received the copy on September 15, 2020 (**Appendix 1039-A**). I have closely compared the publisher's copy of *Safi* (**Appendix 1039**) with the Linda Hall Library copy (**Appendix 1039-A**) and concluded that the two copies contain the same *Safi* article. The difference between the two copies is that the Linda Hall Library copy includes front matter.

70. **Appendix 1039-A** is a true and correct copy of *Safi* that I obtained from the Linda Hall Library. It includes the front matter (cover, publisher information page, copyright page, and table of contents) and the Safi article. Page 1 is the cover that shows "Surface & Coatings Technology" as the journal title whose ISSN is

"0257-8972" and identifies the issue as "Volume 135/1" published in "December 2000" by Elsevier. The cover also shows a date stamp of "LINDA HALL LIBRARY JAN 10 2001." Page 2 the publisher page that shows that "For 2000 volumes 122-134 are scheduled for publication" and page 3 shows volume 135, issue 1 has a "2000" copyright date with "Elsevier Science S.A." as the copyright holder. Page 4 is the table of contents that shows *Safi* begins on page 48 and ends on page 59. Pages 5 to 16 of **Appendix 1039-A** are the Safi article.

B. Linda Hall Library Records

71. **Appendix 1039-B** is a true and correct copy of the bibliographic and MARC records for *Surface & Coatings Technology* that contains *Safi*. I personally located, identified and obtained these records from the online catalog of the Linda Hall Library by searching for the ISSN "0257-8972" for records. This is the type of records experts in my field would reasonably rely upon when forming their opinions regarding the public availability of documents. I captured images of the bibliographic and MARC records to produce **Appendix 1039-B**.

72. Page 1 of **Appendix 1039-B** identifies this *"Surface & coatings technology"* as a journal and shows that it is "Available at Linda Hall Library Closed Stacks – Serials (Surface and coatings technology.) and other locations." It also shows the library holds "v.27(1986)-v.234(2013:Nov.15)," meaning it has volume

135 that contains *Safi*. Page 2 is the detailed bibliographic record that shows the journal title, subjects, identifiers, other titles, publisher, journal creation date, publication frequency and citation/references notes.

73. Page 3 is the MARC record for *Surface & Coatings Technology* that shows the creation date and creator of this MARC record. The first six digits of Field 008 show the MARC record was created on "860219" (*i.e.*, February 19, 1986), and the "c19869999" code following this creation date indicates that the journal is a continuing resource that began publication in 1986 and is an ongoing publication. Subfield "a" of Field 040 shows that "LYU" created this record, and subfield "c" shows "DLC" modified the record later. Field 049 shows the holding library is "LHLA." According to the Directory of OCLC Members (https://www.oclc.org/en/contacts/libraries.html), "LYU" is the OCLC library symbol for Lehigh University, "DLC" is the symbol for the Library of Congress and "LHL" is the symbol for the Linda Hall Library. Data from Field 008 and Field 040 inform my opinion that the Linda Hall Library used the Lehigh University MARC record for copy cataloging by attaching holdings symbols to the record without modifying the original record, as is documented by the MARC bibliographic standard. As discussed earlier, a customary library practice is to create a serial record for a serial, without creating records for individual issues of the serial. When

individual issues are received, they go through the serial check-in process, which usually takes less than an hour. After that, the newly received issues are placed on the shelf or a periodical reading room for user access, usually on the same date of serial check-in or within a week after serial check-in. These procedures are what would have been followed in 2000-2001 and are consistent with my experience with the Linda Hall library. I know this is the customary library practice from personal experience as a cataloging instructor and researcher that provided me with many opportunities to interact with catalogers and many different libraries and their systems. The library date stamp of "JAN 10 2001" on the cover of the Linda Hall Library copy (**Appendix 1039-A**) means that vol. 135/1 (2000) of *Surface & Coatings Technology* (and *Safi* contained therein) was received by the library on January 10, 2001. It is therefore my opinion that this issue (and *Safi* contained therein) would have been available for public access on January 10, 2001, or no later than January 17, 2001, and certainly no later than least mid-2001 and even the end of 2001 at the Linda Hall Library.

74. Field 022 of the MARC record (**Appendix 1039-B**) shows the journal's ISSN is "0257-8972," Field 245 shows "Surface & coatings technology" as the journal title, and Field 246 shows "Surface and coatings technology" is included as a variant title for retrieval. Field 260 shows Elsevier Sequoia of Lausanne has

published this journal since 1986. Field 362 shows the journal began publication with "Vol. 27, no. 1 (Jan. 1986)" and Field 310 shows the publication frequency is "Twelve issues a year." Fields 510 show this journal is selectively indexed by at least four indexing and abstracting services, making some of the journal articles easier to discover. The ISSN, title, publisher information and publication frequency match the information presented in the Linda Hall Library copy of *Safi* (**Appendix 1039-A**).

75. The original MARC record from Lehigh University uses a Library of Congress Classification (LCC) number "TS670.A1" in Field 050 to represent the subject of this journal. Because Linda Hall Library does not assign classification numbers to their journals, Field 050 is retained in their MARC record but not used for retrieval purposes. Instead, the library uses five Library of Congress subject headings in the 650 fields to represent the subjects, using "Electroplating," "Metals $x Finishing" ("$x" indicates a topical subdivision), "Surface preparation," "Coating processes," and "Surfaces (Technology)" as the main headings, each followed by "Periodicals," a form subdivision encoded in subfield "v" to show the topics are treated in a journal.

76. This MARC record (**Appendix 1039-B**) shows that *Surface & Coatings Technology* is a long-running journal, and this MARC record has made it searchable

in the online catalog of the Linda Hall Library. Because the issue containing Safi was received and processed by the library on January 10, 2001, it is my opinion that the journal would have been searchable in the online catalog of the Linda Hall Library at least by January 2001, if not earlier. As a result, users in *Safi* in 2001 would have been able conduct subject searches and retrieve the journal by the Library of Congress subject heading assigned to it. They would also have been able to search for this journal by its title, variant title and ISSN, which are access points in the MARC record. Based on my experience and knowledge of the Linda Hall Library and libraries like it, it is my opinion that the issue containing Safi would have been publicly accessible by the end of January 2001, and certainly no later than the end of 2001 at the Linda Hall Library.

C. British Library Record

77. To further demonstrate public availability of *Safi*, I searched WorldCat for holding libraries and identified the British Library as another holding library. I searched their online catalog to obtain their MARC record and holdings information. **Appendix 1039-C** is a true and correct copy of the MARC record for *Surface and Coatings Technology*. I personally located, identified and obtained this record from the online catalog of the British Library. This is the type of record experts in my field would reasonably rely upon when forming their opinions.

78. The FMT field of the British Library MARC record (**Appendix 1039-C**) identifies this publication as "SE" (meaning serial). The first six digits of Field 008 shows this MARC record was created on "860219" (*i.e.*, February 19, 1986) and the "c19869999" code following this creation date indicates that the journal is a continuing resource that began publication in 1986 and is an ongoing publication. Subfield "a" of Field 040 shows that "Uk" created this record. According to the MARC codes for organizations in the UK and its dependencies (https://www.bl.uk/britishlibrary/~/media/bl/global/services/collection%20metadata/pdfs/marc-codes-directory.pdf?la=en&hash=95F3854F9268E590E81C13357506F393), "Uk" is the code for the British Library.

79. I have compared the British Library MARC record for this journal with the MARC record from the Linda Hall Library and found them to contain many data and fields in common, including the ISSN in Field 022, title in Field 245, publisher in Field 260, beginning issue and date in Field 362, journal frequency in Field 321 and five Library of Congress subject headings in Fields 650. A difference is the British Library MARC record (**Appendix 1039-C**) has a Field 310 that shows the journal frequency since 2002 has been "Semimonthly." Another difference is the British Library assigns two classification numbers to this journal to represent the

subjects. Field 082 shows a Dewey Decimal Classification (DDC) number of "671.7," which represents the class number for "Finishing and surface treatment of metals; metal coating of nonmetals" and Field 084 shows a British Library Science reference information service subject classification (blsrissc) number of "TJ 40." The British Library holds two sets of this journal. Field 852 shows "DSC" (*i.e.*, the Document Supply Center) holds a set with "8547.720000" as the shelfmark for this journal and Field 866 shows it holds "Vol. 27, no. 1 (1986)-v.204, no.4 (2009)." Another Field 852 shows "STI" (*i.e.*, the Science, Technology & Business) has "(P) TJ 40 -E(7)" as the classification number for this journal and Field 866 shows STI holds "Vol.27 (1986)-v.135 (2001)."

80. This MARC record has made *Surface and Coatings Technology* searchable in the catalog of the British Library since February 19, 1986. Users interested in *Safi* in 2000 would have been able to search for this journal by conducting subject searches by the DDC number, the British Library's own classification number, and the five Library of Congress subject headings assigned to it. They would also have been able to find the journal through the ISSN and title. Based on my experience and usage of the British Library, it is my opinion that persons interested in locating *Safi* in 2000 would have been able to locate and access *Safi* soon after vol. 135 (2000) of *Surface and Coatings Technology* (and *Safi*

contained therein) was received, typically on the same day of serial check in or within a week after serial check in was completed. Based on my experience as an expert and my previous experience working with the collections of the British Library, it is my opinion that *Safi* would have been publicly available by the British Library no later than the end of 2001.

81. The British Library is closed due to the pandemic, so no physical copy from the British Library is included in the declaration. In case the copyright owner raises questions about library copies, I reserve the right to submit a library copy of *Safi* when the British Library reopens.

D. Actual Usage Record

82. Actual usage of a publication is reflected by the papers that make reference to it. The citation history on Google Scholar shows *Safi* has been cited at least 24 times. The earliest citing paper appeared in 2001: Blondeel, A., & De Bosscher, W. (2001), Arc handling in Reactive DC magnetron sputter deposition, n *Proceedings of the Annual Technical Conference*, Society of Vacuum Coaters, pp. 240-245 (presented as **Appendix 1039-D**). According to the Digital Library of the Society of Vacuum Coaters (https://www.svc.org/DigitalLibrary/document.cfm/1623/Arc-Handling-in-Reactive-DC-Magnetron-Sputter-Deposition), this conference took place in April

2001 and *Blondeel* was published on "November 15, 2001." Page 1 of *Blondeel* shows the article has a 2001 copyright. These data support my further opinion that a copy of *Safi* would have also been available for public access by at least "November 15, 2001" when *Blondeel* was published, and certainly no later than the end of 2001. *Blondeel* cites to *Safi* on page 6. (*See* **Appendix 1039-D** at 6 (citing reference no. 3 ("I. Safi, 'A novel reactive magnetron sputtering technique for producing insulating oxides of metal alloys and other compound thin films,' *Surf. Coat. Technol*., 135, 48, 2000").) That reference to "I. Safi" is a reference to the same *Safi* reference I discuss above (**Appendix 1039**) because they have the same author, title, date and journal identifications. (*See* **Appendix 1039-D** at 6 *and* **Appendix 1039** at 1.)

E. Summary of My Opinion on *Safi*

83. Based on the "JAN 10 2001" date stamp in the Linda Hall Library copy of *Safi* (**Appendix 1039-A**), the Linda Hall Library records (**Appendix 1039-B**), my knowledge and experience with library cataloging and processing practices and procedures, and my experience with the Linda Hall Library, it is my opinion that *Surface & Coatings Technology* (and *Safi* contained therein) was received by the Linda Hall Library on January 10, 2001, and this issue would have become available to the public on January 10, 2001, or no later than January 17, 2001, and certainly no later than the end of 2001. It is also my opinion that the British Library holds this

journal, and vol. 135 (2000) containing *Safi* would have been made available to the public soon after the serial check in process was completed. Based on my experience as an expert and my previous experience working with the collections of the British Library, it is my opinion that *Safi* would have been publicly available at the British Library no later than the end of 2001. Citation history from Google Scholar shows the earliest citing article, *Blondeel*, was provided as a part of the 44th *Annual Technical Conference Proceedings* dated April 21-26 2001, and published on November 15, 2001, supporting my additional opinion that *Safi* would have been available for public access by at least the end of 2001. I reserve the right to expand on the basis for my opinion regarding *Safi* if asked to do so.

VI. AUTHENTICATION AND PUBLIC AVAILABILITY OF *KELLY* (APPENDIX 1059)

A. Authentication

84. **Appendix 1059** is a true and correct copy of "Reactive pulsed magnetron sputtering process for alumina films," ("*Kelly*"), by Kelly et al. in *Journal of Vacuum Science & Technology A: Vacuum, Surfaces, and Films*, vol. 18, no. 6 (2000), pp. 2890-2896, that I obtained from the publisher American Institute of Physics. When I began preparing this declaration I searched Google Scholar by the title of *Kelly* for records, and the search results informed me that *Kelly* was available online at the publisher's website for *Kelly* at https://avs.scitation.org/doi/abs/10.1116/1.1319679. I then used the "PDF" link to purchase *Kelly*. This copy from the publisher is presented as **Appendix 1059** in this declaration.

85. **Appendix 1059** is a true and correct copy of *Kelly* obtained from the American Institute of Physics. Page 1 is the cover sheet of *Kelly* that shows Kelly et al. published "Reactive pulsed magnetron sputtering process for alumina films" in Journal of Vacuum Science & Technology A, vol. 18 (2000). It shows the article has a "2000" copyright date with the American Vacuum Society as the copyright holder. The cover sheet indicates the article should be cited as: Journal of Vacuum Science & Technology A18, 2890 (2000); https://doi.org/10.1116/1.1319679" and shows the

article was submitted "17 March 2000," accepted "28 August 2000" and published online on "10 November 2000." Page 2 is the first page of *Kelly* that shows the authors, title, and an abstract that has a "2000" copyright date with the American Vacuum Society as the copyright holder. The footer shows *Kelly* was published in a journal with "0734-2101" as its ISSN. *Kelly* is seven pages long, including three tables, 12 figures and 23 references.

86. To demonstrate public availability of *Kelly* at libraries, I searched WorldCat by the title of *Kelly* and the search results informed me that the Linda Hall Library was one of the holding libraries. I then requested a copy of *Kelly* from the Linda Hall Library Document Delivery Service and received the copy on September 15, 2020 (**Appendix 1059-A**). I have closely compared the publisher's copy of *Kelly* (**Appendix 1059**) with the Linda Hall Library copy (**Appendix 1059-A**) and concluded that the two copies contain the same *Kelly* article. The difference between the two copies is that the publisher's copy includes a cover sheet and Linda Hall Library copy includes front matter.

87. **Appendix 1059-A** is a true and correct copy of *Kelly* that I obtained from the Linda Hall Library. It includes the front matter (cover, copyright page, and table of contents) and the Kelly article. Page 1 is the cover that shows "Journal of Vacuum Science & Technology A: Vacuum, Surfaces, and Films" as the journal

title, identifies the issue as "Second Series Volume 18, Number 6, November/December 2000," and indicates the journal is an official journal of the American Vacuum Society "published by the Society through the American Institute of Physics." The cover carries a library date stamp of "LINDA HALL LIBRARY NOV … 2000." Page 2 shows a clearer date stamp that indicates the date of receipt was "NOV 27 2000." Page 3 is the publisher information page that shows the journal's acronym is "JVST A," its ISSN is "0734-2101" and its CODEN is "JVTAD6." It also shows the journal is published "six times annually" and vol. 18, no. 6 (November/December 2000) has a "2000" copyright date with the American Vacuum Society as the copyright holder. Pages 4 to 7 are the table of contents and page 6 shows *Kelly* appears from page 2890 to 2896. Pages 8 to 14 (internal pages 2890 to 2896) is the Kelly article. It has the same content as the publisher's copy (**Appendix 1059**).

B. Linda Hall Library Records

88. Appendix 1059-B is a true and correct copy of the bibliographic and MARC records for *Journal of Vacuum Science & Technology A: Vacuum, Surfaces, and Films* that contains *Kelly*. I personally located, identified and obtained these records from the online catalog of the Linda Hall Library by searching for the ISSN "0734-2101" for records. This is the type of records experts in my field would

reasonably rely upon when forming their opinions regarding the public availability of documents. I captured images of the bibliographic and MARC records to produce **Appendix 1059-B**.

89. Page 1 of **Appendix 1059-B** identifies the publication as the *"Journal of Vacuum Science & Technology A: Vacuum, Surfaces, and Films : an official journal of the American Vacuum Society"* and shows that it is "Available at Linda Hall Library Closed Stacks – Serials (A, Journal of vacuum science & technology. Vacuum, surfaces, and films :) and other locations." It also shows the library holds "ser.2:v.1(1983)-ser.2:v.31:no.6(2013:Nov./Dec.)", meaning it has volume 18, no. 6 (2000) that contains *Kelly*. Page 2 is the detailed bibliographic record that shows the journal title, creators, subjects, identifiers, other titles, related titles, publisher, creation date, frequency, general notes, and citation/References notes.

90. Page 3 is the MARC record for *Journal of Vacuum Science & Technology A: Vacuum, Surfaces, and Films* that shows the creation date and creator of this MARC record. The first six digits of Field 008 show the MARC record was created on "820818" (*i.e.*, August 18, 1982), and the "c19839999" code following this creation date indicates that the journal is a continuing resource that began publication in 1983 and is an ongoing publication. Subfield "a" of Field 040 shows that "NSD" created this record, and subfields "d" show that "DLC" and "LHL" both

modified the original record for their libraries. "NSD" is the National Serial Data Program of the Library of Congress. According to the Directory of OCLC Members (https://www.oclc.org/en/contacts/libraries.html), "DLC" is the OCLC library symbol for the Library of Congress and "LHL" is the symbol for the Linda Hall Library. As discussed earlier, a customary library practice is to create a serial record for a serial, without creating records for individual issues of the serial. When individual issues are received, they go through the serial check-in process, which usually takes less than an hour. After that, the newly received issues are placed on the shelf or a periodical reading room for user access, usually on the same date of serial check-in or within a week after serial check-in. These procedures are what would have been followed in 2000 and are consistent with my experience with the Linda Hall library. I know this is the customary library practice from personal experience as a cataloging instructor and researcher that provided me with many opportunities to interact with catalogers, and many different libraries and their systems. The library date stamp of "NOV 27 2000" on the cover and page 2 of the Linda Hall Library copy (**Appendix 1059-A**) means that vol. 18, no. 6 (2000) of *Journal of Vacuum Science & Technology A: Vacuum, Surfaces, and Films* (and *Kelly* contained therein) was received by the library on November 27, 2000. It is therefore my opinion that *Kelly* would have been available for public access on

November 27, 2000, or no later than December 4, 2000, and certainly no later than the end of 2000, at the Linda Hall Library.

91. Field 022 of the MARC record (**Appendix 1059-B**) shows the journal's ISSN is "0734-2101," Field 030 shows its CODEN is "JVTAD6," Field 245 shows "Journal of Vacuum Science & Technology A, Vacuum, Surfaces, and Films : an official journal of the American Vacuum Society" as the journal title, Fields 246 show two variant titles are included to help users discover this journal, and Field 260 shows the American Institute of Physics of New York has published this journal since 1983. Field 362 shows the journal began with "2nd ser., v. 1, no. 1 (Jan.-Mar. 1983)", Field 321 shows the publication frequency was "Quarterly" from 1983 on and Field 310 shows the frequency became "Bimonthly" since 1985. The front matter of the Linda Hall copy of *Kelly* shows that in 2000 the publication frequency became "six times a year" but that is not reflected in the library's MARC record for the journal. Nine 510 fields show this journal is completely indexed by four abstracting and indexing services and selectively indexed by five other services, making articles in this journal easier for users to discover. The ISSN, CODEN, journal title and publisher match the information presented in the Linda Hall Library copy (**Appendix 1059-A**).

92. The original MARC record by NDS of the Library of Congress uses a

Library of Congress Classification (LCC) number "TJ940" in Field 050 to represent the subject of this journal. Because Linda Hall Library does not assign classification numbers to their journals, this field is retained but not used by the Linda Hall Library for retrieval purposes. Instead, the Linda Hall Library record represents the journal's subject with a Library of Congress subject heading in Field 650, using "Vacuum technology" as the main heading, followed by "Periodicals" encoded in subfield "v" to show the topic is treated in a journal. Fields 710 show that the American Vacuum Society and the American Institute of Physics are included as additional access points to help users discover this journal.

93. This MARC record (**Appendix 1059-B**) shows that *Journal of Vacuum Science & Technology A: Vacuum, Surfaces, and Films* is a long-running journal, and the MARC record has made it searchable in the catalog of the Linda Hall Library. Because Kelly was received and processed by the Linda Hall Library on "NOV 27 2000," it is my opinion that *Journal of Vacuum Science & Technology A: Vacuum, Surfaces, and Films* would have been searchable in the online catalog of the Linda Hall Library no later than November 2000. Users interested in Kelly would have been able to search for this journal by its title, variant titles, ISSN, the Library of Congress subject heading, and the two organizations in Fields 710, which are provided as access points in the MARC record. Based on my experience and

knowledge of the Linda Hall Library and research libraries like it, it is my opinion that persons interested in locating *Kelly* in 2000 would have been able to search for and locate *Kelly* by the access points in the MARC record by the end of November 2000, and certainly no later than the end of 2000.

C. Actual Usage Record

94. Actual usage of a publication is reflected by the papers that make reference to it. The citation history on Google Scholar shows *Kelly* has been cited at least 119 times. The earliest citing article include a November 2001 publication: Blondeel, A., & De Bosscher, W. (2001), Arc handling in Reactive DC magnetron sputter deposition, in *Proceedings of the Annual Technical Conference*, Society of Vacuum Coaters, pp. 240-245. (which I included above as **Appendix 1039-D**.) *Blondeel* cites to *Kelly* on page 6. (*See* **Appendix 1039-D** at 6 (citing reference no. 6 ("P.J. Kelly, P.S. Henderson, R.D. Arnell, G.A. Roche, and D. Carter, 'Reactive pulsed magnetron sputtering process for alumina films,' *J. Vac. Sci. Technol*., A18(6), 2890, 2000").) That reference to "P.J. Kelly" is a reference to the same *Kelly* reference I discuss above (**Appendix 1059**) because they have the same author, title, date and journal identifications. (*See* **Appendix 1039-D** at 6 *and* **Appendix 1059** at 1.) The publication date of *Blondeel* informs my opinion that others had access to *Kelly* to use in their article published on November 15, 2001. This supports

my further opinion that a copy of *Kelly* would have also been available for public access by at least the publication date of *Blondeel* on November 15, 2001, and certainly by the end of 2001.

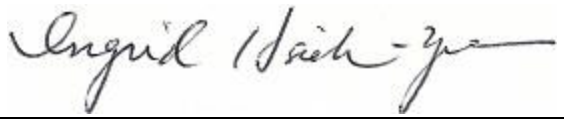
D. Summary of My Opinion on *Kelly*

95. Based on the "NOV 27 2000" date stamp in the Linda Hall Library copy of *Kelly* (**Appendix 1059-A**), the Linda Hall Library records (**Appendix 1059-B**), my knowledge and experience with library cataloging and processing practices and procedures, and my experience with the Linda Hall Library, it is my opinion that *Kelly* was available for public access on November 27, 2000, or no later than December 4, 2000, and certainly no later than the end of 2000, at the Linda Hall Library. Citation history from Google Scholar shows the earliest citing article was an article presented at an April 2001 conference and published on November 15, 2001. This citing article demonstrates usage of *Kelly* in late 2001, and thus further supports my opinion that *Kelly* was publicly available to interested persons by at least November 15, 2001, and certainly by the end of 2001. I reserve the right to expand on the basis for my opinion regarding *Kelly* if asked to do so.

VII. CONCLUSION

96. In signing this declaration, I recognize that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case. If cross-examination is required of me, I will appear at a reasonable time and place to be agreed upon.

97. I hereby declare that all statements made herein on my own knowledge are true and that all statements made on information and belief are believed to be true, and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Date: **10-20-2020** Executed: 

Ingrid Hsieh-Yee, Ph.D.

Appendix A

Ingrid Hsieh-Yee

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Education

Ph.D. Library and Information Studies, University of Wisconsin-Madison
Minors: Sociology and Psychology

M.A. Library and Information Studies, University of Wisconsin-Madison.

M.A. Comparative Literature, University of Wisconsin-Madison.

B.A. Foreign Languages and Literature, National Taiwan University.

Work Experience

Professor, School/Dept. of Library and Information Science, Catholic University of America, 2004- (Assistant Professor, 1990-1996; Associate Professor, 1997-2004)

Co-Chair, Dept. of Library and Information Science, Catholic University of America, June 2015-August 2016.

Acting Dean, School of Library and Information Science, Catholic University of America, January 2010-June 2012.

Cataloger, Dept. of Legislative Reference Library, Annapolis, Maryland, 1989-1990.

Lecturer, School of Library and Information Studies, University of Wisconsin-Madison, 1988.

Teaching Assistant, School of Library and Information Studies, University of Wisconsin-Madison, 1986-1988.

Cataloger, Health Sciences Library, University of Wisconsin-Madison, 1984-1986.

Areas of Teaching and Research Interests

Information Organization and Access; Metadata; Cataloging & Classification; Information Architecture; Information Retrieval; Digital Collections; Scholarly Communication; Information

Behavior; Health Informatics; Human Computer Interaction; Usability Studies

Grants & Honors

Cultural Heritage Information Management Project. IMLS grant. Amount: $498,741. Period: Aug. 2012 to July 2015. Co-PI with Dr. Youngok Choi.

D.C. Health Information Technology (HIT4): Building Capacity & Providing Access in Our Nation's Capital. Dept. of Labor H2B Training Grant. Grant amount: $4,175,500. Grant period: Nov. 2011 to Dec. 2015. Partner with the Metropolitan School of Professional Studies of the Catholic University of America, Children's National Medical Center, D.C. Department of Employment Services, Holy Cross Hospital, Howard University, Center for Urban Progress, Providence Hospital, and Sibley Memorial Hospital.

Capital Health Careers Project. Department of Labor Healthcare Sector and Other High Growth and Emerging Industries Grant. Grant amount: $4,953,999. Grant period: March 2010 – February 2013. Awarded to a group of healthcare organizations and educational institutions in Washington, D.C. Providence Health Foundation of Providence Hospital (Lead institution). Part of the grant supported the development of a Master's degree program in Information Technology with a concentration in Health Information Technology offered by the School of Library and Information Science.

The Washington D.C. School Librarians Project. IMLS grant. Grant amount: $412,660. Grant period: Aug. 2007 – June 2011. The School partnered with the District of Columbia Public Schools (DCPS) and the District of Columbia Library Association to educate and mentor school media specialists for the DCPS system. PI, Jan. 2010 to June 2011.

SIG Member of the Year, American Society for Information Science and Technology (2009).

Most Outstanding Paper of *OCLC Systems & Services* (2001).

ALISE Research Grant (2001).

Most Outstanding Paper of *OCLC Systems & Services* (2000).

Research Grant from ERIC (1999-2000).

Best Research Paper Award; Association for Library and Information Science Education (1998).

Research Grants, Catholic University of America. 1991, 1992, 1993, 1996, 1998, 1999, 2004, 2005, 2006, 2007, 2013-14.

Cooperative Faculty Research Grant, Consortium of Universities in the Washington Metropolitan Area (1993-1994).

Cooperative Research Grant, Council on Library Resources (1993-1994).

Journal of the American Society for Information Science Best Paper Award (1993).

ASIS/ISI Information Science Doctoral Dissertation Scholarship (1989).

HEA Title IIB Fellowship (Dept. of Education) (1989)

Chinese-American Librarians Association Scholarship (1987).

Beta Phi Mu (1985).

Vilas Fellowship, University of Wisconsin-Madison. 1984

Publications

Choi, Y., and Hsieh-Yee, I. (2010). Finding Images in an OPAC: Analysis of User Queries, Subject Headings, and Description Notes. *Canadian Journal of Information and Library Science,* 34(3): 271 – 295.

Hsieh-Yee, I. (2008). Educating Cataloging Professionals in a Changing Information Environment. *Journal of Education for Library and Information Science,* 46(2): 93-106.

Vellucci, S. L., Hsieh-Yee, I., and Moen, W.E. (2007). The Metadata Education and Research Information Commons (MERIC): A Collaborative Teaching and Research Initiative. *Education for Information,* 25(3&4): 169-178.

NISO Framework for Guidelines for Building Good Digital Collections. 3rd ed. Baltimore, MD: National Information Standards Organization, 2007. Also available online: http://www.niso.org/framework/framework3.pdf (NISO Working Group members: Priscilla Caplan (chair), Grace Agnew, Murtha Baca, Tony Gill, Carl Fleischhauer, Ingrid Hsieh-Yee, Jill Koelling, and Christie Stephenson.)

Choi, Y., Hsieh-Yee, I., and Kules, B. (2007). Retrieval Effectiveness of TOC and LCSH. *Proceedings of the Joint Conference on Digital Libraries*, pp. 233-234.

Vellucci, S., and Hsieh-Yee, I. (2007). They Didn't Teach Me That in Library School! Building a Digital Teaching Commons to Enhance Metadata Teaching, Learning and Research. *Proceedings of the National Conference of the Association of College and Research Libraries, Baltimore, MD*, pp. 26-31.

Mitchell, Vanessa, and Ingrid Hsieh-Yee. (2007). Converting Ulrich's Subject Headings to FAST Headings: A Feasibility Study. *Cataloging & Classification Quarterly,* 45(1): 59-85.

Hsieh-Yee, I., Tang, R., and Zhang, S. (2007). User Perceptions of a Federated Search System. *IEEE Technical Committee on Digital Libraries Bulletin,* Summer 3(2) (URL = http://www.ieee-tcdl.org).

Tang, R., Hsieh-Yee, I., and Zhang, S. (2007). User Perceptions of MetaLib Combined Search: An Investigation of How Users Make Sense of Federated Searching." *Internet Reference Services Quarterly,* 12(12): 211-236.

Hsieh-Yee, I., Tang, R., and Zhang, S. (2006). User Perceptions of a Federated Search System. *Proceedings of the Joint Conference on Digital Libraries*, *June 11-15, 2006, Chapel Hill*, p. 338.

Hsieh-Yee, I. (2006). *Organizing Audiovisual and Electronic Resources for Access: A Cataloging Guide*. 2nd ed. Westport, Conn.: Libraries Unlimited.

NISO A Framework of Guidance for Building Good Digital Collections. 2nd ed. Bethesda, MD: National Information Standards Organization, 2004. Framework Advisory Group: Grace Agnew, Liz Bishoff, Priscilla Caplan (Chair), Rebecca Gunther and Ingrid Hsieh-Yee.

Hsieh-Yee, I. (2004). Cataloging and Metadata Education in North American LIS Programs. *Library Resources & Technical Services,* 48(1): 59-68.

Hsieh-Yee, I. (2004). Cataloging and Metadata Education. In Gary E. Gorman (Ed.), *International Yearbook of Library and Information Management 2003: Metadata Applications and Management*, (pp.204-234). London: Facet Publishing.

Yee, P. L., Hsieh-Yee, I., Pierce, G.R., Grome, R., and Schantz, L. (2004). Self-Evaluative Intrusive Thoughts Impede Successful Searching on the Internet. *Computers in Human Behavior,* 20(1): 85-101.

Hsieh-Yee, I. (2003). Cataloging and Metadata Education: A Proposal for Preparing Cataloging Professionals of the 21st Century. A report submitted to the ALCTS-Education Task Force in response to Action Item 5.1 of the *Bibliographic control of Web Resources: A Library of Congress Action Plan*. Approved by the Association for Library Collections and Technical Services. Web version available since April 2003 at http://lcweb.loc.gov/catdir/bibcontrol/CatalogingandMetadataEducation.pdf.

Hsieh-Yee, I. (2002). Cataloging and Metadata Education: Asserting a Central Role in Information Organization. *Cataloging & Classification Quarterly* 34(½): 203-222.

Hsieh-Yee, I., and Smith, M. (2001). The CORC Experience: Survey of Founding Libraries, Part I. *OCLC Systems & Services,* 17: 133-140. (Received "The Most Outstanding Paper of OCLC Systems & Services in 2001" award.)

Hsieh-Yee, I., and Smith, M. (2001). The CORC Experience: Survey of Founding Libraries, Part II, Automated Tools and Usage. *OCLC Systems & Services,* 17: 166-177. (Received "The Most Outstanding Paper of OCLC Systems & Services in 2001" award.)

Hsieh-Yee, I. (2001). ERIC User Services: Changes and Evaluation for the Future. *Government Information Quarterly,* 18: 31-42.

Hsieh-Yee, Ingrid. (2001). Research on Web Search Behavior. *Library and Information Science Research,* 23: 167-185.

Logan, E., and Hsieh-Yee, I. (2001). Library and Information Science Education in the Nineties. *Annual Review of Information Science and Technology,* 35: 425-477.

Hsieh-Yee, I. (Ed.) (2001). *Library and Information Science Research*, 23 (2). A special issue in honor of the retirement of Douglas L. Zweizig.

Hsieh-Yee, I. (2000). *ERIC User Services: Evaluation in a Decentralized Environment*. Washington, D.C.: Dept. of Education.

Hsieh-Yee, Ingrid. (2000). *Organizing Audiovisual and Electronic Resources for Access: A Cataloging Guide*. Littleton, CO: Libraries Unlimited.

Hsieh-Yee, I. (2000). Organizing Internet Resources: Teaching Cataloging Standards and Beyond. *OCLC Systems & Services,* 16: 130-143. (Received "The Most Outstanding Paper of OCLC Systems & Services in 2000" award.)

Hsieh-Yee, I. (1998). The Retrieval Power of Selected Search Engines: How Well Do They Address General Reference Questions and Subject Questions? *Reference Librarian,* 60: 27-47.

Hsieh-Yee, I. (1998). Search Tactics of Web Users in Searching for Texts, Graphics, Known Items and Subjects: A Search Simulation Study. *Reference Librarian,* 60: 61-85. (Received the 1997 Best ALISE Research Paper Award.)

Hsieh-Yee, I. (1997). Access to OCLC and Internet Resources: LIS Educators' Views and Teaching Practices. *RQ,* 36: 569-86.

Hsieh-Yee, I. (1997). Teaching Online and CD-ROM Resources: LIS Educators' Views and Practices. *Journal of Education for Library and Information Science,* 38: 14-34.

Hsieh-Yee, I. (1996). The Cataloging Practices of Special Libraries and Their Relationship with OCLC. *Special Libraries,* 87: 10-20.

Hsieh-Yee, I. (1996). Modifying Cataloging Practice and OCLC Infrastructure for Effective Organization of Internet Resources. In *Proceedings of the OCLC Internet Cataloging Colloquium*. [Online]. Available: http://www.oclc.org/oclc/man/colloq/hsieh.htm

Hsieh-Yee, I. (1996). Student Use of Online Catalogs and Other Information Channels. *College & Research Libraries,* 57: 161-175.

Hsieh-Yee, I. (1995). Ten entries in James S. C. Hu (Ed.), *Encyclopedia of Library & Information Science*, 913, 1028-29, 1036, 1037, 1145-46, 1514, 1575, 1763-64, 2216-27, 2378-79. Taipei, Taiwan: Sino-American Publishing. (Topics include "Advanced Technology/Libraries," "Information Ethics," "Instruction on Cataloging and Classification," "Instruction on Reference Services.")

Hsieh-Yee, I. (1993). Effects of Search Experience and Subject Knowledge on Online Search Behavior: Measuring the Search Tactics of Novice and Experienced Searchers. *Journal of the American Society for Information Science,* 44: 161-174. (Received the 1993 Best JASIS Paper Award.)

Works in Progress

Bailey, T. & Hsieh-Yee, I. Combating the Sharing of False Information: History, Conceptual Framework, and Literacy Strategies (submitted for publication in August 2020)

Hsieh-Yee, I. Data Availability Policy of Top Scholarly Journals: A Cross-Discipline Analysis

Hsieh-Yee, I. Data Service and Management at Top 100 University Libraries WorldWide.

Hsieh-Yee, I. Information Organization and Retrieval in Practice.

Presentations

Bailey, T. & Hsieh-Yee, I. (February 2020). The Phenomena of Sharing Misinformation and the Need for Information Literacy, presented at the 2020 Bridging the Spectrum Symposium, Washington, D.C.

Hsieh-Yee, I. and Fragan-Fly, J. (May 2018) Trends, Design & Strategies for Digital Scholarship Services. Presented at the 2018 Maryland/Delaware Library Association Conference, Cambridge, MD.

Hsieh-Yee, I. (February, 2018) Research Data Management: What It Takes to Succeed. Presented at the 10th Bridging the Spectrum Symposium, Washington, D.C.

Hsieh-Yee, I. (February, 2017) *Research Data Management: New Competencies and Opportunities for Information Professionals*. Presented at the 9th Bridging the Spectrum Symposium, Washington, D.C.

Hsieh-Yee, I. and Lawton, P. (February, 2017) *Enhancing Catholic Portal Searches with User Terms and LCSH*. Presented at the 9th Bridging the Spectrum Symposium, Washington, D.C.

Hsieh-Yee, I. (2016, October) *Visualizing Data for Information*. Presented at the 2016 Virginia Library Association Conference, Hot Springs, VA.

Hsieh-Yee, I. (2016, August) *Religious Materials Toolbox for Archivists: Solutions to Problems Facing the Profession*. Presented at Archives * Records 2016, Atlanta, GA.

Hsieh-Yee, I. and Lawton, P. (2016, March) *Enhancing Retrieval of Catholic Materials with LCSH Knowledge Structure*. Presented at the 2016 Catholic Library Association Conference, San Diego, CA.

Fagan-Fry, J. and Hsieh-Yee, I. (2016, February) *Approaches to Digital Scholarship at Top Universities around the World: Scholarly Publishing in the Digital Age.* Presented at the 8th Bridging the Spectrum Symposium, Washington, D.C.

Hsieh-Yee and Fagan-Fry, J. (2016, January) *Innovative Services for Digital Scholarship at Top 100 Research Libraries of the World*. Poster presented at the 2016 Annual Conference of the Association for Library and Information Science Education, Boston, Mass.

Hsieh-Yee, I. and Lawton, P. (2015, June). *Crowdsourcing terms for CRRA portal themes.* Poster presented at the third CRRA symposium and annual meeting, Bringing the created toward the Creator: Liturgical art and design since Vatican II. Catholic Theological Union, Chicago, Illinois.

Hsieh-Yee, I. and Lawton, P. (2015, February). *Crowdsourcing terms for thematic exploration in the Catholic Portal.* Poster presented at the 7th Annual Bridging the Spectrum Symposium, Washington, D.C.

Hsieh-Yee, I., James, R., and Fagan-Fry, J. (2015, February). *Support for digital scholarship at top university libraries of the world*. Poster presented at the 7th Annual Bridging the Spectrum Symposium, Washington, D.C.

Hsieh-Yee, I., Zhang, S., Lin, K., and Cherry, S. (2015, February). *Thus said the end users: Summon experience and support for research workflows*. Poster presented at the 7th Annual Bridging the Spectrum Symposium, Washington, D.C.

Yontz, E., Hsieh-Yee, I., & Houston, S. (2015, February). *Healthy Heroes Summer Reading Club: Developing healthy youth at public libraries.* 11th Annual Jean Mills Health Symposium, Greenville, North Carolina.

Yontz, E., Hsieh-Yee, I., and Houston, S. (2015, January). *Healthy youth and libraries: A pilot study.* Association for Library & Information Science Education (ALISE) Annual Conference, Chicago, Illinois.

Hsieh-Yee, I. (2014, May). *Linking CRRA resources to portal themes via authority files*. Presented at the Catholic Research Resources Alliance 2014 Membership Meeting, Marquette, WI.

Hsieh-Yee, I. (2014, April). *Enhancing subject access to CRRA resources*. Presented at the 2014 Catholic Library Association Conference, Pittsburgh, PA.

Hsieh-Yee, I. (2014, January). *Health Information Technology Program: Educational entrepreneurship in action*. Presented at the 2014 annual Conference of the Association for Library and Information Science Education, Philadelphia, PA

Hsieh-Yee, I., Zhang, S., Lin, K., and Cherry, S. (2014, January). *Discovering information through Summon: An analysis of user search strategies and search success*. Paper presented at the 6th Bridging the Spectrum Symposium, Washington, D.C.

Hsieh-Yee, I. (2012, December). *National Digital Stewardship Alliance and SLIS at CUA: An Educational Partnership*. Paper presented at Best Practices Exchange: Acquiring, Preserving, and Providing Access to Government Information in the Digital Era, Annapolis, MD

Choi, Y. and Hsieh-Yee, I. (2010, January). *Finding Images in an OPAC: Analysis of User Queries, Subject Headings, and Description Notes*. Paper presented at 2nd Annual Bridging the Spectrum Symposium, Catholic University of America, Washington, D.C.

Hsieh-Yee, I. and Coogan, J. (2010, January). *Google Scholar vs. Academic Search Premier: What Libraries and Searchers Need to Know*. Paper presented at 2nd Annual Bridging the Spectrum Symposium, Catholic University of America, Washington, D.C.

Hsieh-Yee, I. (2009, November). *Information Science Education: An LIS School's Perspective*. Paper presented at Annual Meeting of the American Society for Information Science and Technology, Vancouver, British Columbia, Canada.

Hsieh-Yee, I., Menard, E., Ya-Ning Chen, A., Shu-Jiun Chen, S., Kalfatovic, M. R., Wisser. K. M. (2009, November). *Information Organization in Libraries, Archives and Museums: Converging Practices and Collaboration Opportunities*. Presented at Annual Meeting of the American Society for Information Science and Technology, Vancouver, British Columbia, Canada. (Organizer and moderator of this panel.)

Hsieh-Yee, I. and Coogan, J. (2009, July). *Catching up to Google Scholar: The Retrieval Power of Academic Search Premier and Google Scholar*. Poster presented at American Library Association Conference, Chicago, Illinois.

Hsieh-Yee, I., with the CUA Scholarly Communications Project Team. (2009, January). *Digital Scholarship@CUA: Developing an Institutional Repository for CUA*. Poster presented at 1st Annual Bridging the Spectrum Symposium, Catholic University of America, Washington, D.C.

Wise, M., Cylke, K., and Hsieh-Yee, I. **(**2009, January). *Digital Talking Books: Meeting the Needs of the Blind and the Handicapped*. Paper presented at the Bridging the Spectrum Symposium, Catholic University of America, Washington, D.C.

Hsieh-Yee, I. (2009, January). *User Expectations of MERIC*. Presented at the Information Organization Competencies for the 21st Century Discussion Session of the 2009 Conference of the Association for Library and Information Science Education, Denver, Colorado.

Choi, Y., and Hsieh-Yee, I. (2008,November). *Subject Access for Images in an OPAC.* Annual Meeting of the American Society for Information Science and Technology, Columbus, Ohio. (Also co-organized a panel on Retrieving and Using Visual Resources: Challenges and Opportunities for Research and Education.)

Hsieh-Yee, I. (2008, June). *Educating Cataloging Professionals in a Changing Information Environment*. National Taiwan University, Taipei, Taiwan.

Vellucci, S. L., Moen, W.E., Hsieh-Yee, I., Marson, B., and Wisser, K. (2008, January) *Building a Metadata Education and Research Community through MERIC (Metadata Education and Research Information Commons): Demo and Stakeholder Input*. A panel presented at the 2008 Conference of the Association for Library and Information Science Education, Philadelphia, Pennsylvania.

Hsieh-Yee, I., Choi,Y. and Kules, B. (2007, October). *Searching for Books and Images in OPAC: Effects of LCSH, TOC and Subject Domains.* A poster presented at the American Society for Information Science and Technology Annual Meeting, Milwaukee, Wisconsin.

Hsieh-Yee, I. and Coogan, J. (2007, August) *Google Scholar vs. Academic Search Premier: A Comparative Analysis.* Presented to the Faculty and Staff of the University of the District of Columbia.

Hsieh-Yee, I. and Coogan, J. (2007, June). *Google Scholar vs. Academic Search Premier: A Comparative Analysis*. Presented to the Washington Research Library Consortium Community, Catholic University of America, Washington, D.C.

Hsieh-Yee, I., Choi, Y., and Kules, B.. (2007, June). *What Users Need for Subject Access: Table of Contents or Subject Headings?* A poster presented at the 2007 American Library Association Annual Conference, Washington, D.C., June 2007.

Choi, Y., Hsieh-Yee, I., and Kules, B. (2007, June). *Retrieval Effectiveness of TOC and LCSH.* A paper presented at the Joint Conference on Digital Libraries 2007, Vancouver, Canada.

Vellucci, S. L., Hsieh-Yee, I., and Moen, W.E. (2007, May). *If We Build It, Will They Come? Building a Community of Practice for Metadata Stakeholders.* A poster presented at the Rutgers University Research Day, Bridgeton, New Jersey.

Hsieh-Yee, I. (2007, May). *Federated Searching: User Experience & Perceptions.* International Conference on Information Organization & Retrieval, National Taiwan University, Taipei, Taiwan.

Hsieh-Yee, I. (2007, May). *Search Performance of Google Scholar and Academic Search Premier.* International Conference on Information Organization & Retrieval, National Taiwan University, Taipei, Taiwan.

Hsieh-Yee, I. (2007, May) *MERIC: Building a Digital Commons for Metadata Education & Research.* International Conference on Information Organization & Retrieval, National Taiwan University, Taipei, Taiwan.

Hsieh-Yee, I., and Coogan, J. (2007, March/April). *A Comparative Analysis of Google Scholar and Academic Search Premier.* Poster presented at the Association of College & Research Libraries 13th National Conference, Baltimore, Maryland.

Vellucci, S. L. and Hsieh-Yee, I. (2007, March/April) *They Didn't Teach Me That in Library School! Building a Digital Teaching Commons to Enhance Metadata Teaching, Learning and Research*. On-site presentation and Webcast by Elluminate. A contributed paper presented at the Association of College & Research Libraries 13th National Conference, Baltimore, Maryland. The acceptance rate for contributed paper was 20%. This paper was one of 10 conference papers chosen for live webcast during the conference.

Moen, W., Hsieh-Yee, I. and Vellucci, S.L. (2007, January) *A DSpace Foundation for a Teaching & Research Commons: The Metadata Education and Research Information Commons.* A poster session presented at the Open Repositories Conference 2007, San Antonio, Texas.

Tang, R., Hsieh-Yee, I., and Zhang, S. (2006, November) *User Perception of MetaLib Combined Search*. Paper presented at the Annual Meeting of the American Society for Information Science and Technology, Austin, Texas, Nov. 2006.

Hsieh-Yee, I. (2006, November). *Federated Searching: User Perceptions, System Design, and*

Library Instructions. Paper presented at the Annual Meeting of the American Society for Information Science and Technology, Austin, Texas. (Panel organizer, moderator, presenter).

Hsieh-Yee, I. (2006, November). *Building a Digital Teaching Commons to Enhance Teaching and Learning: The MERIC Experience and Challenges.* Paper presented at the Annual Meeting of the American Society for Information Science and Technology, Austin, Texas. (Panel organizer, moderator, presenter)

Hsieh-Yee, I. (2006, September). *Search Performance of Google Scholar and Academic Search Premier.* Paper presented at the ERIC Publishers Meeting, Washington, D.C.

Hsieh-Yee, I., Zhang, S., and Rong Tang, R. (2006, June). *User Perceptions of a Federated Search System*. Poster presented at Joint Conference on Digital Libraries, Chapel Hill, North Carolina.

Hsieh-Yee, I. and Zhang, S. (2006, June). *Preparing Users for Federated Search: Implications of a MetaLib User Perceptions Study.* Paper presented at the 2006 Ex Libris User Groups of North America Conference, Knoxville, Tennessee.

Hsieh-Yee, I. (2006, January). *MERIC Organizations and Navigation*. Paper presented at the 2006 ALISE Annual Conference, San Antonio, Texas.

Hsieh-Yee, I. (2006, January). *Metadata and Cataloging Education: Recommended Competencies.* Paper presented at the 2006 ALISE Annual Conference, San Antonio, Texas.

Hsieh-Yee, I. (2005, November). *Digital Library Evaluation: Progress & Next Steps.* Presentation at the Annual Meeting of the American Society for Information Science & Technology, Charlotte, North Carolina.

Hsieh-Yee, I. (2005, August). *Providing Access to Digital Content: Issues for DL Managers.* Presentation at MDK12 Digital Library Steering Committee Meeting, Columbia, Maryland.

Hsieh-Yee, I. (2005, April). *Enhancing Teaching and Learning: The Role of School Library Media Specialists.* Presentation at Meeting of the Baltimore County Public School System School Media Specialists, Baltimore, Maryland.

Hsieh-Yee, I. (2005, January). *Subject Access and Users: Insights & Inspirations from Marcia J. Bates.* Paper presented at the Historical Perspectives SIG, 2005 Conference of the Association for Library and Information Science Education, Boston, Massachusetts.

Hsieh-Yee, I. (2005, January). *Electronic Resource Management: Practice, Employer Expectations, & CE Interests.* Paper presented at Technical Services Education SIG, 2005

Conference of the Association for Library and Information Science Education, Boston, Massachusetts.

Hsieh-Yee, I. (2004, October). *Library Professionals for the Digital Age: Competencies & Preparation.* Paper presented at Bibliographic Access Management Team meeting, Library of Congress, Washington, D.C.

Hsieh-Yee, I. (2004, January). *Cataloging and metadata expertise for the digital era.* Presented at Preparing 21st Century Cataloging and Metadata Professionals: A Workshop for Educators and Trainers, San Diego and sponsored by ALCTS, ALISE, LC, and OCLC.

Hsieh-Yee, I. (2004, January). *Educating catalogers for the digital era.* Paper presented at the Technical Services SIG, 2004 Conference of the Association for Library and Information Science Education, San Diego.

Hsieh-Yee, I. (2003, July). *Cataloging Education for the 21st Century.* A presentation at the Library of Congress, Washington, D.C.

Hsieh-Yee, I. (2002, January) *Metadata Education and Research Priorities: A Delphi Study of Metadata Experts.* Presentation at the 2002 Conference of the Association for Library and Information Science Education, New Orleans.

Hsieh-Yee, I. (2001, November). *A Delphi Study of Metadata: Preliminary Findings.* Poster session at the 2001 Annual Meeting of the American Society for Information Science & Technology, Washington, D.C.

Hsieh-Yee, I. (2001, June). *Resources on Asian American Children: Analysis of Retrieval by Search Engines and WorldCat.* Presentation at the National Conference on Asian Pacific American Librarians, San Francisco.

Hsieh-Yee, I. (2001, January). *Delphi Study on Metadata: Project Design.* Presentation at Research Awards Session, Association for Library & Information Science Education, Washington, D.C.

Hsieh-Yee, I. (2000, May). *Web Search Behavior Research: Progress and Implications.* Presentation at the Symposium on Evaluating Library and Information Science Research, University of Wisconsin-Madison, Madison, Wisconsin.

Hsieh-Yee, I. (2000, March). *ERIC User Services: Evaluation in a Decentralized Environment.* Presentation at the National ERIC Joint Directors/Technical Meeting, Arlington, Virginia.

Hsieh-Yee, I. (2000, January). *Enhancing Learning with Web Technology.* Presentation at Faculty Conversations, Catholic University of America, Washington, D.C.

Hsieh-Yee, I. (2000, January). *From Surrogates to Objects: CUA's Approaches to Organizing Electronic Resources.* Paper presentation at the Annual Conference of the Association for Library and Information Science Education, San Antonio, Texas.

Yee, P., and Hsieh-Yee, I. (1997, November). *Individual Differences in Search Behavior on the WWW.* A poster session presented at the 38th Annual Meeting of the Psychonomic Society, Philadelphia, Pennsylvania.

Hsieh-Yee, I. (1997, April). *Research + Marketing + Preparation = Job!* Presented at the "Workshop on Resume and Interview Techniques," Special Libraries Association, Student Chapter, Catholic University of America, Washington, D.C.

Hsieh-Yee, I. (1997, February). *Creating CyberCatalogers: Education and Training.* Presentation at ALA's Midwinter Meeting, Washington, D.C.

Hsieh-Yee, I. (1997, February). *Search Tactics of Web Users in Searching for Texts, Graphics, Known Items and Subjects: A Search Simulation Study.* Presented at the Conference of the Association for Library and Information Science Education, Washington, D.C.

Hsieh-Yee, Ingrid. "Beginning Your Special Library/Information Center Career." Presented at SLA's "Career Day," Jan. 11, 1997, Catholic University of America.

Hsieh-Yee, I. (1996, September). *The Roles of Library and Information Scientists in Managing Electronic Information.* Presentation at Hamilton College, Clinton, New York.

Hsieh-Yee, I. (1996, May). *The Future of Cataloging as a Profession.* Presented at "The Cataloging Forum, Library of Congress, Washington, D.C.

Hsieh-Yee, I. (1994, October). *The Impact of the Internet on OPACs.* Presented at the Third Workshop on User Interfaces for OPACs, Library of Congress, Washington, D.C.

Reports

Hsieh-Yee, I., with Knowledge Management Competencies and Performance Action Group of the Federal Knowledge Management Initiative. "From Knowledge Management Competencies to Improved Organizational Performance." April 9, 2009.

Hsieh-Yee, I., with Knowledge Practices Action Group of the Federal Knowledge Management Initiative. "KM Practice in Government Agencies: Findings and Recommendations." April 9, 2009.

Hsieh-Yee, I. "Delphi Study on Metadata." 2001. Three quarterly reports submitted to the Association for Library and Information Science Education.

Hsieh-Yee, I. "College Students' Information Channels: Patterns of Use and Possible Factors in Channel Selection." 1995. Submitted to the Catholic University of America.

Hsieh-Yee, I. "The Information-Seeking Patterns of Scholars and Their Use of an Online Information System." 1994. Submitted to the Council on Library Resources.

Book Reviews

Review of *The Measurement and Evaluation of Library Services*, by Sharon L. Baker and F. Wilfrid Lancaster. *Information Processing and Management* 30 (1994): 450-52.

Review of *Subject Access to Films and Videos, by Sheila S. Intner and William E. Studwell; and Cataloging Unpublished Nonprint Materials*, by Verna Urbanski with Bao Chu Chang and Bernard L. Karon. *Information Processing and Management* 30 (1994): 449-50.

Review of *Automated Information Retrieval in Libraries: A Management Handbook*, by Vicki Anders. *Journal of Library and Information Science* 19 (1993): 98-100.

Review of *Full Text Databases*, by Carol Tenopir and Jung Soon Ro. *Information Processing and Management* 28 (1992): 667-68.

Review of *Descriptive Cataloging for the AACR2R And USMARC: A How-to-Do It Workbook*, by Larry Millsap and Terry Ellen Ferl. *Information Processing and Management* 28 (1992): 809-11.

Review of *MARC Manual: Understanding and Using MARC Records*, by Deborah J. Byrne. *Information Processing and Management* 28 (1992): 537-38.

Service

Professional Associations and Societies

- Library of Congress. RDA Training Program for the Profession. Co-authored with Tim Carlton. 2013-2014.
- 2014 Digital Preservation Outreach & Education Survey. Contributed to the design of the survey, 2014.
- National Digital Stewardship Alliance. Outreach Committee. 2011-2014.
- National Digital Stewardship Residency Program. Advisory Group, 2012-2013.
- FEDLINK Health Information Technology Advisory Council, 2011-2015.
- 2012 Joint Conference on Digital Libraries. Program Planning Committee, Pre-Conference Proposals Review Committee, 2012
- Catholic Research Resources Alliance. Five-Year Strategic Plan Task Force, 2011-2012
- Institute of Museum and Library Services. Grant reviewer. 2004, 2005, 2010.

- Association for Library and Information Science Education.
  * ALISE Bodan Wynar Research Paper Award Committee, 2015, 2016, 2017
  * ALISE Eugene Garfield Dissertation Award Competition, Jury, 2013, 2014
  * ALISE Research Grant Competition Committee. Chair, 2012
  * Pratt-Severn Faculty Innovation Award. Chair, 2009, 2010
  * ALISE Doctoral Poster Jury, 2012
  * "Information Organization Competencies for the 21st Century" Discussion session leader. 2009 Conference of the Association for Library and Information Science Education.
  * Assisted Technical Services SIG Convener in organizing a program, ""Building a Metadata Education and Research Community through MERIC (Metadata Education and Research Information Commons): Demo and Stakeholder Input" for the 2008 ALISE conference.
  * Association for Library Collections and Technical Services/Association for Library and Information Science Education (ALCTS/ALISE) Metadata Education and Research Information Center (MERIC) Advisory Board, Co-Chair (with Sherry Vellucci), 2005-2007. Chair, 2008-2009 (leading the effort to build MERIC, a repository and collaborative space for metadata educators, practitioners, and researchers)
  * Technical Services SIG, Convener, 2004-2005. Organized a program on "Electronic Resources Management: Current Practices, Employer Expectations, and Teaching Strategies" for the 2005 conference in Boston, Massachusetts.
  * Technical Services SIG, Convener, 2003-2004. Organized a program on "Organizing Information with Metadata: Desired Competencies and Teaching Innovations" for the 2004 conference.
  * Technical Services SIG, Convener, 1999-2000. Organized a program on "Teaching the Organization of Electronic Resources" for the 2000 conference.
  * Curriculum SIG, Co-convener (with Sibyl Moses), 1996-97. Organized a program on "Government Information Policy" for the 1997 conference.

- American Society for Information Science & Technology.
  * Reviewer, Conference program panel submissions and poster submissions, 2005, 2006, 2007, 2009, 2011, 2012, 2013, 2014, 2015, 2016, 2017
  * Nomination Committee, 2009-2011
  * Information Science Education Special Interest Group. American Society for Information Science and Technology. Chair-Elect, 2007-2008. Chair 2008-2009.
  * Committee on Information Science Education. 1999-2006.
  * Committee on Information Science Education. Organizing Committee for an orientation program for students at ASIS annual meetings, 1999-2001
  * Committee on Information Science Education. Sub-committee on Student Welfare (focusing on issues related to master's education), 1998-2001
  * SIG ED. Organizing Committee for the "Seminar on Research and Career Development" for junior researchers. 1995-96 (chair), 1997-2001
  * ISI Doctoral Dissertation Proposal Scholarship Jury, 1997; 2001, 2002
  * Pratt-Severn Best Student Research Paper Award Jury. Chair. 1997
  * 1998 Midyear Meeting (referee of contributed papers), 1997

* Organizer and moderator of the ASIS Doctoral Forum and the Doctoral Research Seminar 1994-1995
* SIG Human Computer Interaction. Chair-Elect, Chair, 1993-1995
* Doctoral Forum Award Jury, 1995
* Best Student Paper Award Jury, 1995

- American Library Association.
  * Committee on Accreditation, External Review Panelist, 2009- (site visiting team 2013-2014; site visiting team 2016-2017)
  * Association for Library Collections and Technical Services Task Force on Competencies and Education for a Career in Cataloging, member, 2008-2009
  * Facilitator for "What They Don't Teach in Library School: Competencies, Education and Employer Expectations for a Career in Cataloging," an Association for Library Collections and Technical Services Preconference, June 22, 2007 in Washington, D.C. Also a local liaison for bringing this program to the Catholic University of America.
  * Facilitator for a discussion on "Effect of Electronic Resources on Technical Services" at ALA's Midwinter Meeting held in Feb. 1997 in Washington, D.C.
  * International Relations Committee, Subcommittee Task Force for IFLA and China, 1994-1997

- Virginia Association of School Librarians. Scholarships and Awards Committee. 2010-2012

- Federal Knowledge Management Initiative, Knowledge Management Practices Action Group. Member. 2009 (leading the effort to build a knowledge management repository)
- Federal Knowledge Management Initiative, Knowledge Management Competencies & Learning Action Group. Member. 2009 (developing an action plan for helping government knowledge workers and government agencies to develop knowledge management competencies)
- National Center for Education Statistics. Technical Review Panel. 2008.
- External evaluator for a case of promotion to full professorship. University of Tennessee. 2008.
- National Information Standards Organization (NISO). Advisory Board, Revision of "IMLS Framework of Guidance for Building Good Digital Collections," 2004, 2007.
- Library of Congress, Bibliographic Control of Web Resources: A Library of Congress Action Plan. Principal Investigator of Action Item 5.1, focusing on cataloging and metadata education for students and new librarians, 2002-2003. (worked with the Association for Library Collections and Technical Services, Education Task Force)

- Chinese American Librarians Association
  * Chinese American Librarians Association Outstanding Library Leadership Award in Memory of Dr. Margaret Chang Fung, Award Committee, 2016-2017
  * Achievement Award Jury, 2000-2001
  * CALA Goal 2000 Task Force, 1997
  * Scholarship Committee, 1995, 1996-1997 (chair)

* Board of Directors, 1994-1997
* Publication Committee, 1993-1995
* International Relations Committee, 1993-1996

- Sailor[SM] Assessment Advisory Group (An impact study of Sailor, Maryland's Public Information Network), 1995

- Editorial boards
  Journal of Library and Information Science. Editorial Board, 2012-
  Chinese American Librarians Association, *Occasional Papers Series*. Editorial Board, 2009-2016.
  Library Quarterly. Editorial Board, 2003-2008
  Bulletin of the Medical Library Association, 1994-97
  Newsletter editor for the Chinese American Librarians Association, 1989-92

- Referee for the following journals
  Information Processing and Management
  Journal of Digital Information
  Journal of Education for Library and Information Science
  Journal of Information Science
  Journal of Library & Information Science
  Journal of Library Metadata
  Journal of the American Society for Information Science & Technology
  Library and Information Science Research
  Library Quarterly

- Expert reviewer, "Digital Library" course, Evaluation module, University of North Carolina, Chapel Hill, 2007-2008.
- Expert reviewer, "Information Organization" course, University of Michigan, Ann Arbor. 2007.

Catholic University of America

- Academic Senate Committee on Committees and Rules, 2019 - 2022
- Academic Senate representative (for School of Arts & Sciences), 2017-2020
- School of Arts & Sciences, Committee on Appointments and Promotions, 2015-2019
- School of Arts & Sciences, Academic Council, 2015-2016.
- School of Arts & Sciences, Ordinary Professor Group, 2013-
- Doctoral Dissertation Defense Committee, Chair, Dept. of Psychology, 2016, 2017, 2018, 2019, 2020
- Doctoral Dissertation Defense Committee, Chair, Dept. of Education, 2014, 2015, 2017, 2018, 2019
- Doctoral Dissertation Defense Committee, Chair, National Catholic School of Social Services, 2019
- President's Administrative Council, 2010-2012

- Deans' Council, 2010-2012
- Academic Leadership Group, 2010-2012
- Academic Senate, 2003-2012
- Academic Senate, Committee on Committees and Rules, 2009-2012
- Academic Senate, Committee on Appointments and Promotions, 2005-2008
- Graduate Board, 2010-2012
- CUA Scholarly Communication Project Team, Member (2007), Chair, 2008-2009
- Academic Senate Library Committee, Interim Chair (2007), Member, 2008-2012
- Doctoral Dissertation Defense Committee, Chair, School of Nursing, 2006, 2008
- Dean Search Committee, 1992-1994, 1998-1999, 2002-2003, 2006-2007
- Fulbright Review Panel, 2006
- Academic Senate Committee on Computing, 1995-2003
- CUA Service Learning Advisory Board, 2001-2002
- CUA Faculty Conversations on Enhancing Teaching and Learning through Technology, Planning Group, 1999-2001
- CUA Initiative on Technology and Teaching, 1998-2001

Dept. of Library and Information Science

- Admissions Committee, 2007-2009, Chair 2010-2012, Member 2013-2015, Member 2018-August 2021
- Curriculum Committee, 2020-21
- Scholarship & Awards Committee, 2020-21
- Comprehensive examination editor, 2020-21
- Symposium, Colloquium, Lecture Series Committee, May 2018-May 2020 (Chair)
- Symposium and Colloquium Committee, fall 2016-May 2018
- Organization of Information Core Course Outcomes Assessment, 2019, 2020
- The Information Professions in Society Core Course Outcomes Assessment, 2019, 2020
- Community Services Librarianship, Course of Study Review and Revision, 2020
- Organization of Information, Course of Study Review and Revision, 2019
- Organization of Information, Competency and Course Offerings Review, 2018-2019
- Accreditation presentation, Chair, June 2015-August 2016
- Interim Co-Chair, June 2015-August 2016.
- Appointments and Promotions Committee, 1991-
- Blended/OWL Learning Committee, spring 2016-2018
- Scholarship and Awards Committee, fall 2016-
- Technology Committee, fall 2016-2017
- Comprehensive examination editor, 2016-2017, reader (every year since 1990)
- LIS Advisory Board, 2015-2016 (chair); fall 2016- May 2018 (member)
- Committee on Planning and Assessment, 2015-2016 (chair)
- Senior Faculty Committee, 2014-2016.
- Accreditation Steering Committee, 2014-2016 (Chair, 2015-2016)

- Accreditation Students Standard Committee, co-chair, 2014-2016
- Accreditation Mission, Goals, and Objectives Standard Committee, co-chair, 2014-2016
- Accreditation Curriculum Standard, member 2014-2-16
- Accreditation Administration and Finance Standard, member 2014-2016
- Cultural Heritage Information Management Project (IMLS-funded), Co-PI, 2012-2015
- Cultural Heritage Information Management Forum (scheduled for June 2015), Co-Organizer, 2013-2015
- Health Information Technology Interim Review Committee, 2015 (chair)
- Health Sciences Librarianship Advisory Group, 2015- (chair)
- Comprehensive examination editors, 2013-2014, 2016-2017
- National Digital Stewardship Alliance liaison, 2011-2014
- Advisory Board, Chair 2010-2012
- Academic Honesty Committee, Chair, 2008-2012
- Blended Learning Committee, 2010-2012
- Colloquium Committee, 2010-2012
- Comprehensive Examination Administration, 2010-2012
- Cultural Heritage Information Management Advisory Committee, 2010-2012 (chair), 2013-
- Curriculum Committee, 1991-2003, 2007-2009, Chair 2010-2012, member 2013-
- Curriculum Subcommittee on Comprehensive Examination, Chair 2009-2012
- Health Information Technology Advisory Board, Chair 2010-2012. Member 2013-
- Health Sciences Advisory Committee, 2009, Chair 2010-2012. Member 2013-
- HIT Expert Forum, Chair 2012. Member 2013-
- Health Information Technology Student Group Advisor, 2011-2012
- State Council for Higher Education of Virginia, SLIS Representative, 2010-2012
- Symposium Planning Committee, 2010-2012
- Website Management Team, Chair, 2010-2012
- Urban School Librarianship Project (IMLS-Funded), PI, 2007-2011 (chair, 2010-11)
- Failing Grades Committee, 1995-1997 (chair), 2000-2001 (chair), 2004-2005 (chair), 2007 (chair)-2011
- Faculty Search Committee, 1994-1998, 2002-2004, 2006 (chair), Fall 2007-2009, Chair fall 2009-2012
- Recruitment Committee, Chair 2010-2012
- Strategic Planning Committee, Chair 2010-2012
- Technology Committee, 2010-2012
- Accreditation Advisory Committee, 2007-2009
- Accreditation Coordinating Committee, 2007-2009
- Accreditation Steering Committee, 2007-2009
- SLIS Advisory Group, 2007-2009
- Accreditation Curriculum Standard Committee, Co-chair, 2007-2009
- Accreditation Faculty Standard Committee, Co-chair, 2007-2009
- LSC 551 Information Organization Review Team, Co-chair, 2008-2009, 2015-2016.
- Curriculum Subcommittee on Portfolios, 2009

- LSC 555 Information Systems in Libraries and Information Centers Review Team, contributor, 2008-2009
- Redesign of LSC 730 Use and Users of Libraries and Information. 2009-
- Development of a metadata institute that was taught as LSC 715 Organization of Internet Resources in 2008. The institute is being revised and will be offered in 2010 under a new course title.
- Development of lesson plans, assignments, and evaluation rubrics for LSC 606, Cataloging and Classification, for the School's NCATE accreditation. 2008
- Howard and Mathilde Rovelstad Scholarship Committee, Chair, 2004-2007
- Assistant Dean Search Committee, Chair, Fall 2007
- Liaison to the Association for Library Collections and Technical Services to bring its preconference program, Cataloging Education and Employer Expectations, to CUA during the 2007 American Library Association Annual Meeting in Washington, D.C.
- Organizer of the colloquium presentation and reception for Tamar Sadeh of Ex Libris on PRIMO June 2007
- Practicum review and design (work with potential supervisors, such as the American Indian Museum internship description revision) 2006-
- Comprehensive examinations (edits, proctoring, and grading), 1990-
- SLIS Web site redesign: Comments and suggestions. Fall 2007
- Conducted surveys of current students and alumni in preparation for the 2005 re-accreditation, 2004-2005
- Student advisement, 1990-
- Technology Committee, 1992-1999 (chair, 1996-1998), 2002-2003 (member)
- Colloquia Committee 1997-1999, 2002-2003.
- Advisor of the CUA Student Chapter of the American Society for Information Science and Technology, 2002-2003
- Visiting Professor Search Committee, 1999, 2000, 2001
- Leader, Participation in the CORC experiment, 1999-2000
- Advisor of the Special Libraries Association Student Chapter, 1993-1999; the group was recognized for outstanding leadership by SLA in 1999.
- COA planning Committee, Task Force on Electronic Presentation of SLIS Reports (team leader) 1997-1998
- COA Planning Committee, Subcommittee on Technology 1996-1998
- NLM practicum coordinator, 1997-1998
- Computer Literacy Workshops: Assisted with the development and evaluation of the workshops, 1996-1998
- Leader, Participation in the InterCat project, 1995-1997

Appendix B

MARC 21 Reference Materials

Part VII:

A Summary of Commonly Used MARC 21 Fields

This is a summary of the MARC 21 tags used most frequently by libraries in entering their own bibliographic records. For full listings of all MARC 21 tags, indicators, and subfield codes, see *MARC 21 Format for Bibliographic Data*.

In the explanations on these pages:

Tags -- The tags (3-digit numbers) are followed by the names of the fields they represent. In this summary, and in the *MARC 21 Format for Bibliographic Data*, if a tag can appear more than once in one bibliographic record, it is labeled repeatable (R). If it can only be used once, it is labeled non-repeatable (NR). For example, a catalog record can have several subjects, so the tags for subject added entries (6XX) are labeled repeatable (R).

Indicators -- The use of indicators is explained in fields where they are used. Indicators are one-digit numbers. Beginning with the 010 field, in every field -- following the tag -- are two character positions, one for Indicator 1 and one for Indicator 2. The indicators are not actually defined in all fields, however. And it is possible that a 2nd indicator will be used, while the 1st indicator remains undefined (or vice versa). When an indicator is undefined, the character position will be represented by the character # (for blank space).

Subfield codes -- All the data in each field (beginning with the 010 field) is divided into subfields, each of which is preceded by a delimiter-subfield code combination. The most common subfield codes used with each tag are shown. Each subfield code is preceded by the character $, signifying a delimiter. The name of the subfield follows the code.

In general, every field MUST have a subfield 'a' (**$a**). One exception that is often seen is in Field 020 (ISBN), when the ISBN information (subfield **$a**) is unavailable but the price (subfield **$c**) is known. Some subfields are repeatable. In this summary, repeatability is noted for only the more common repeatable subfields.

Examples: Examples follow the explanation for each field. For clarity, one space has

been placed between the tag and the first indicator, one space has been placed between the second indicator and the first delimiter- subfield code, and one space has been inserted between the delimiter-subfield code and the subfield data.

010 Library of Congress Control Number -- (LCCN)
(NR, or Not Repeatable

Indicators undefined.
Subfield used most often:
$a -- Library of Congress control number

```
Example:    010 ##  $a ###86000988#
```

020 International Standard Book Number -- (ISBN)
(R, or Repeatable)

Indicators undefined.
Subfields used most often:
$a -- International Standard Book Number
$c -- Terms of availability (often a price)
$z -- Cancelled/invalid ISBN (R)

```
Example:    020 ##  $a 0877547637
```

040 Cataloging source -- (NR)

Indicators undefined.
Subfields used most often:
$a -- Original cataloging agency
$c -- Transcribing agency
$d -- Modifying agency (R)

```
Example:    040 ## $a DLC
                   $c DLC
                   $d gwhs
```

100 Main entry -- Personal name -- (primary author)
(NR; there can be only one main entry)

Indicator 1: Type of personal name entry element
0 -- Forename
1 -- Surname (this is the most common form)
3 -- Family name
Indicator 2 undefined.
Indicator 2 became obsolete in 1990. Older records may display 0 or 1
Subfields used most often:
$a -- Personal name
$b -- Numeration
$c -- Titles and other words associated with a name (R)
$q -- Fuller form of name
$d -- Dates associated with a name (generally, year of birth)

```
Example:    100 1# $a Gregory, Ruth W.
                   $q (Ruth Wilhelme),
                   $d 1910-
```

130 Main entry -- Uniform title -- (NR)

Indicator 1: Nonfiling characters
0-9 -- Number of nonfiling characters present (for initial articles, including spaces)
Indicator 2 undefined.
Indicator 2 became obsolete in 1990. (See 100 above.)
Subfields used most often:
$a -- Uniform title
$p -- Name of part/section of a work (R)
$l -- Language of a work
$s -- Version
$f -- Date of a work

```
Example:    130 0# $a Bible.
                   $p O.T.
                   $p Psalms.
```

240 Uniform title (NR)

Indicator 1: Uniform title printed or displayed
0 -- Not printed or displayed
1 -- Printed or displayed (most common)
Indicator 2: Nonfiling characters

0-9 -- Number of nonfiling characters present (for initial articles, including spaces)

Subfields used most often:

$a -- Uniform title
$l -- Language of a work
$f -- Date of a work

```
Example:    240 10 $a Ile mystérieuse.
                   $l English.
                   $f 1978
```

245 Title Statement (NR)

Indicator 1: Title added entry

(Should the title be indexed as a title added entry?)

0 -- No title added entry

(indicates a title main entry; i.e. no author is given)

1 -- Title added entry

(the proper indicator when an author given in 1XX; the most common situation)

Indicator 2: Nonfiling characters

0-9 -- Number of nonfiling characters present, including spaces; usually set at zero, except when the title begins with an article; e.g., for *The robe*, the second indicator would be set to 4. The letters *T*, *h*, *e*, and the space following them are then ignored in alphabetizing titles. The record will be automatically filed under "*r*" -- for *Robe*.

Subfields used most often:

$a -- Title proper
$h -- Medium (often used for non-book media)
$p -- Name of part/section of a work (R)
$b -- Reminder of title (subtitles, etc.)
$c -- Remainder of title page transcription/Statement of responsibility

```
Example:    245 14 $a The DNA story :
                   $b a documentary history of gene
                      cloning /
                   $c James D. Watson, John Tooze.
```

246 Varying form of title (R)

Indicator 1: Note/title added entry controller
1 -- Note, title added entry
3 -- No note, title added entry
Indicator 2: Type of title
-- No information provided
0 -- Portion of title
1 -- Parallel title
4 -- Cover title
8 -- Spine title
Subfield used most often:
$a -- Title proper

```
Example:    246 3# $a Four corners power review
```

250 Edition statement (NR)

Indicators undefined.
Subfield used most often:
$a -- Edition statement

```
Example:    250 ## $a 6th ed.
```

260 Publication, distribution, etc. (Imprint) (R)

Indicator 1: Sequence of publishing statements
-- No information provided
Indicator 2: Undefined
Subfields used most often:
$a -- Place of publication, distribution, etc. (R)
$b -- Name of publisher, distributor, etc. (R)
$c -- Date of publication, distribution, etc. (R)

```
Example:    260 ## $a New York :
                   $b Chelsea House,
                   $c 1986.
```

300 Physical description (R)

Indicators undefined.
Subfields used most often:
$a -- Extent (number of pages) (R)
$b -- Other physical details (usually illustration information)
$c -- Dimensions (cm.) (R)
$e -- Accompanying material (for example, "teacher's guide" or "manual")

```
Example:    300 ## $a 139 p. :
                   $b ill. ;
                   $c 24 cm.
```

440 Series statement / Added entry--Title
This field was made obsolete in 2008 to simplify the series statement. See 490 and 830.

490 Series statement (No added entry is traced from field) (R)

Indicator 1: Specifies whether series is traced (whether an 8XX tag is also present)
0 -- Series not traced
1 -- Series traced (8XX is in record)
Indicator 2 undefined.
Subfield used most often:
$a -- Series statement (R)
$v -- Volume number (R)

```
Example:    490 1# $a Colonial American craftsmen
```

500 General note (R)

Indicators undefined.
Subfield used most often:
$a -- General note (Used when no specialized note field has been defined for the information. Examples: Notes regarding the index; the source of the title; variations in title; descriptions of the nature, form, or scope of the item.)

```
Example:    500 ##  $a Includes index.
```

504 Bibliography, etc. note (R)

Indicators undefined.
Subfield used most often:
$a -- Bibliography, etc. note

```
Example:    504 ## $a Includes bibliographical
                      references.
```

505 Formatted contents note (R)

Indicator 1: Type of contents note
0 -- Complete contents
1 -- Incomplete contents (used with multivolume set when some volumes are not yet published)
2 -- Partial contents
Indicator 2: Level of content designation
-- Basic
Subfield used most often:
$a -- Formatted contents note

```
Example:    505 0# $a Pride and prejudice -- Emma
                      -- Northanger Abbey.
```

520 Summary, etc. note (R)

Indicator 1: Display constant controller
-- Summary
1 -- Review
2 -- Scope and content
3 -- Abstract
Indicator 2 undefined
Subfields used most often
$a -- Summary, abstract, or annotation
$b -- Expansion of summary note

```
Example:    520 ## $a This basic guide to parliamentary
                      procedure tells how to conduct
                      and participate in a meeting
                      properly.
```

600 Subject added entry -- Personal name (R)

Indicator 1: Type of personal name entry element
- 0 -- Forename
- 1 -- Surname (this is the most common form)
- 3 -- Family name

Indicator 2: Subject heading system/thesaurus (identifies the specific list or file which was used)
- 0 -- Library of Congress Subject Headings
- 1 -- LC subject headings for children's literature
- 2 -- Medical Subject Headings
- 3 -- National Agricultural Library subject authority file
- 4 -- Source not specified
- 5 -- Canadian Subject Headings
- 6 -- Répertoire de vedettes-matière
- 7 -- Source specified in subfield $2

(Note regarding Sears subject headings: The MARC 21 format does not provide an assigned indicator for Sears subject headings. Therefore, an indicator of 7 is used, and the MARC defined code "sears" is placed in subfield $2.)

Subfields used most often:
- **$a** -- Personal name (surname and forename)
- **$b** -- Numeration
- **$c** -- Titles and other words associated with a name (R)
- **$q** -- Fuller form of name
- **$d** -- Dates associated with a name (generally, year of birth)
- **$t** -- Title of a work
- **$v** -- Form subdivision (R)
- **$x** -- General subdivision (R)
- **$y** -- Chronological subdivision (R)
- **$z** -- Geographic subdivision (R)
- **$2** -- Source of heading or term (used with 2nd indicator of 7)

```
Example:    600 10 $a Shakespeare, William,
                   $d 1564-1616
                   $x Comedies
                   $x Stage history.
```

```
Example:    600 10 $a Shakespeare, William,
                   $d 1564-1616
                   $x Knowledge
```

```
                        $z Rome
                        $v Congresses.
```

Notice that subfields $v, $x, and $z in the 600 field are repeatable. Subfields $v, $x, $y, and $z do not have to be in alphabetical order. They will be in the order prescribed by the instructions given by the subject heading system.

610 Subject added entry -- Corporate name (R)

Indicator 1: Type of corporate name entry element
- 0 -- Inverted name (not used with AACR2)
- 1 -- Jurisdiction name
- 2 -- Name in direct order

Indicator 2: Subject heading system/thesaurus.
- See indicator 2 under 600

Subfields used most often:
- **$a** -- Corporate name or jurisdiction name as entry element
- **$b** -- Subordinate unit (R)
- **$v** -- Form subdivision (R)
- **$x** -- General subdivision (R)
- **$y** -- Chronological subdivision (R)
- **$z** -- Geographic subdivision (R)
- **$2** -- Source of heading or term (used with 2nd indicator of 7)

```
Example:    610 10 $a United States.
                   $b Army Air Forces
                   $v Biography.
```

650 Subject added entry -- Topical term (Most subject headings fit here.) (R)

Indicator 1: Level of subject
- # -- No information provided

Indicator 2: Subject heading system/thesaurus
(identifies the specific list or file which was used)
- 0 -- Library of Congress Subject Headings
- 1 -- LC subject headings for children's literature
- 2 -- Medical Subject Headings
- 3 -- National Agricultural Library subject authority file
- 4 -- Source not specified
- 5 -- Canadian Subject Headings
- 6 -- Répertoire de vedettes-matière
- 7 -- Source specified in subfield $2

Note regarding Sears subject headings: The MARC 21 format does not provide an assigned indicator for Sears subject headings. Therefore, an indicator of 7 is used, and the MARC defined code "sears" is placed in subfield $2.)

Subfields used most often:

$a -- Topical term
$v -- Form subdivision (R)
$x -- General subdivision (R)
$y -- Chronological subdivision (R)
$z -- Geographic subdivision (R)
$2 -- Source of heading or term used with 2nd indicator of 7)

```
Example:    650 #0 $a Theater
                   $z United States
                   $v Biography
                   $v Dictionaries.
```

Notice that subfields $v, $x, and $z in the 650 field are repeatable. Subfields $v, $x, $y, and $z do not have to be in alphabetical order. They will be in the order prescribed by the instructions given by the subject heading system.

651 Subject added entry -- Geographic name (R)

Indicator 1: undefined.
Indicator 2: Subject heading system/thesaurus.
See indicator 2 under 600
Subfields used most often:

$a -- Geographic name
$v -- Form subdivision (R)
$x -- General subdivision (R)
$y -- Chronological subdivision (R)
$z -- Geographic subdivision (R)
$2 -- Source of heading or term (used with 2nd indicator of 7)

```
Example:    651 #0 $a United States
                   $x History
                   $v Chronology.
```

Notice that subfields $v, $x, and $z in the 651 field are repeatable. Subfields $v, $x, $y, and $z do not have to be in alphabetical order. They will be in the order prescribed by the instructions given by the subject heading system.

700 Added entry -- Personal name (R)

Indicator 1: Type of personal name entry element
0 -- Forename
1 -- Surname (this is the most common form)
3 -- Family name
Indicator 2: Type of added entry
-- No information provided (most common; co-authors, editors, etc.)
2 -- Analytical entry (The values for Indicator 2 changed in 1994 with Format Integration, and older records may display additional values. An analytical entry involves an author/title of an item contained in a work.)
Subfields used most often:
$a -- Personal name
$b -- Numeration
$c -- Titles and other words associated with a name (R)
$q -- Fuller form of name
$d -- Dates associated with a name (generally, year of birth)
$e -- Relator term (such as ill.) (R)
$4 -- Relator code (R)

```
Example:    700 1# $a Baldridge, Letitia.
```

710 Added entry -- Corporate name (R)

Indicator 1: Type of corporate name entry element
0 -- Inverted name (not used with AACR2)
1 -- Jurisdiction name
2 -- Name in direct order
Indicator 2: Type of added entry.
See Indicator 2 under 700
-- No information provided
2 -- Analytical entry
Subfields used most often:
$a -- Corporate name or jurisdiction name as entry element
$b -- Subordinate unit (R)

```
Example:    710 2# $a Sunburst Communications (Firm)
```

740 Added entry -- Uncontrolled related/analytical title (R)

Indicator 1: Nonfiling characters

0-9 -- Number of nonfiling characters present (for initial articles, including spaces)

Indicator 2: Type of added entry. See Indicator 2 under 700

-- No information provided

2 -- Analytical entry

(This field was redefined in 1994 with Format Integration. Prior to 1994, the field was also used for variant titles, such as a different wording on a spine title. In records created since Format Integration, those variant tiles appear in a 246 field.)

Subfield used most often:

$a -- Title

```
Example:    740 02 $a Uncle Vanya.
```

800 Series added entry -- Personal name (R)

Indicator 1: Type of personal name entry element

0 -- Forename

1 -- Surname

3 -- Family name

Indicator 2 undefined.

Subfields used most often:

$a -- Personal name

$b -- Numeration

$c -- Titles and other words associated with a name (R)

$q -- Fuller form of name

$d -- Dates associated with a name (generally, year of birth)

$t -- Title of a work (the series)

$v -- Volume number

```
Example:    800 1# $a Fisher, Leonard Everett.
                   $t Colonial American craftsmen.
```

830 Series added entry -- Uniform title (R)

Indicator 1 undefined.

Indicator 2: Nonfiling characters

0-9 -- Number of nonfiling characters present (for initial articles, including spaces)

Subfield used most often:

$a -- Uniform title

$v -- Volume number

```
Example:    830 #0 $a Railroads of America (Macmillan)
```

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Part VIII:

A List of Other Fields Often Seen in MARC Records

001 Control number
003 Control number identifier
005 Date and time of latest transaction
006 Fixed-length data elements -- additional material characteristics
007 Physical description fixed field
008 Fixed length data elements (See Part X)
022 International Standard Serial Number (ISSN)
037 Source of acquisition
041 Language code
043 Geographic area code
050 Library of Congress call number
060 National Library of Medicine call number
082 Dewey Decimal classification number (the one recommended by the Library of Congress; locally-assigned call numbers may appear elsewhere)
110 Main entry -- Corporate name (less frequent under AACR2 rules)
256 Computer file characteristics
263 Projected publication date
(indicates a CIP -- Cataloging in Publication -- record)
306 Playing time
508 Creation/production credits note
510 Citation/references note (review sources)
511 Participant or performer note
521 Target audience note (first indicator: 0 = reading grade level, 1 = interest age level, 2 = interest grade level, 3 = special audience characteristics, 4 = motivation interest level)
530 Additional physical form available note
538 System details note
586 Awards note
656 Index term -- Occupation
730 Added entry -- Uniform title
852 Location

856 Electronic location and access
9XX Reserved for local use. (They are used by vendors, systems, or individual libraries to exchange additional data)

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Part IX:

The Leader

There are 24 positions in the Leader, numbered from 00 to 23. For fuller explanation, see the *MARC 21 Format for Bibliographic Data*.

00-04 Record length (calculated by the computer for each record)
05 Record status
- a = increase in encoding level
- c = corrected or revised
- d = deleted
- n = new
- p = increase in encoding from prepublication (previous CIP)

06 Type of record
- a = language material
- c = printed music
- d = manuscript music
- e = cartographic material
- f = manuscript cartographic material
- g = projected medium
- i = nonmusical sound recording
- j = musical sound recording
- k = 2-dimensional nonprojectable graphic
- m = computer file
- o = kit
- p = mixed materials
- r = 3-dimensional artifact or naturally occurring object
- t = manuscript language material

07 Bibliographic level
- a = monographic component part
- b = serial component part
- c = collection
- d = subunit
- i = integrating resource
- m = monograph/item
- s = serial

08 Type of control
- # = no specified type
- a = archival

09 Character coding scheme
# = MARC-8
a = UCS/Unicode
10 Indicator count (always "2")
11 Subfield code count (always "2")
12-16 Base address of data (calculated by the computer for each record)
17 Encoding level
# = full level
1 = full level, material not examined
2 = less-than-full level, material not examined
3 = abbreviated level
4 = core level
5 = partial (preliminary) level
7 = minimal level
8 = prepublication level (CIP)
u = unknown
z = not applicable
18 Descriptive cataloging form
# = non-ISBD
a = AACR2
i = ISBD
u = unknown
19 Multipart resource record level
# = Not specified or not applicable
a = Set
b = Part with independent title
c = Part with dependent title
20 Length of the length-of-field portion (always "4")
21 Length of the starting-character-position portion (always "5")
22 Length of the implementation-defined portion (always "0")
23 Undefined (always "0")

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Part X:

Field 008 for Books

Field 008 is used for Fixed Length Data Elements ("Fixed Field Codes"). There are 40 character positions in field 008, numbered from 00-39. Undefined positions must contain either a blank (#) or a fill character (|). Positions 00-17 and 35-39 are defined the same way for all media.

The information shown here for positions 18-34 applies only to books. For explanation of all the positions below and for positions 18-34 for other media, see the *MARC 21 Format*

for Bibliographic Data.

Note that field 008 has no indicators or subfield codes.

00-05 Date entered on file (YYMMDD),
where Y=year, M=month, and D=day

06 Type of date/publication status:
- b = no dates given; B.C. date involved
- e = detailed date
- s = single known date/probable date
- m = multiple dates
- r = reprint/reissue date (Date 1) and original date (Date 2)
- n = dates unknown
- q = questionable date
- t = publication date and copyright date
- | = no attempt to code

07-10 Date 1/beginning date of publication

11-14 Date 2/ending date of publication

Date fields contain the year(s) of publication. The type of date(s) in these elements are specified in fixed field element 06: Type of date/publication status. (For further details, see the field 008 description in the *MARC 21 Format for Bibliographic Data*.)

15-17 Place of publication, production, or execution
For example:
- pk# = Pakistan
- cau = California (US)

(For a full list of codes used in these positions, see the *MARC Code List for Countries*.)

18-21 Illustrations (up to 4 codes):
- # = no illustrations
- a = illustrations
- b = maps
- c = portraits
- d = charts
- e = plans
- f = plates
- g = music
- h = facsimiles
- i = coats of arms
- j = genealogical tables
- k = forms
- l = samples
- m = phonodisc, phonowire, etc.
- o = photographs
- p = illuminations
- | = no attempt to code

22 Target audience:
- # = unknown or not specified
- a = preschool
- b = primary
- c = pre-adolescent
- d = adolescent
- e = adult
- f = specialized
- g = general
- j = juvenile
- | = no attempt to code

23 Form of item:
- # = none of the following
- a = microfilm
- b = microfiche
- c = microopaque
- d = large print
- f = braille
- r = regular print reproduction
- s = electronic
- | = no attempt to code

24-27 Nature of contents (up to 4):
- # = no specified nature of contents
- a = abstracts/summaries
- b = bibliographies (is one or contains one)
- c = catalogs
- d = dictionaries
- e = encyclopedias
- f = handbooks
- g = legal articles
- i = indexes
- j = patent document
- k = discographies
- l = legislation
- m = theses
- n = surveys of literature
- o = reviews
- p = programmed texts
- q = filmographies
- r = directories
- s = statistics
- t = technical reports
- u = standards/specifications
- v = legal cases and notes
- w = law reports and digests
- z = treaties
- | = no attempt to code

28 Government publication:
- # = not a government publication
- i = international intergovernmental
- f = federal/national
- a = autonomous or semi-autonomous component
- s = state, provincial, territorial, dependent, etc.
- m = multistate
- c = multilocal
- l = local
- z = other type of government publication
- o = government publication -- level undetermined
- u = unknown if item is government publication
- | = no attempt to code

29 Conference publication:
- 0 = not a conference publication
- 1 = conference publication
- | = no attempt to code

30 Festschrift:
- 0 = not a festschrift
- 1 = festschrift
- | = no attempt to code

31 Index:
- 0 = no index
- 1 = index present
- | = no attempt to code

32 Undefined (since 1990) (Earlier records may contain the values 0 or 1)
- # = Undefined
- | = no attempt to code

33 Literary form:
- 0 = not fiction (not further specified)
- 1 = fiction (not further specified)
- c = comic strips
- d = dramas
- e = essays
- f = novels
- h = humor, satires, etc.
- i = letters
- j = short stories
- m = mixed forms
- p = poetry
- s = speeches
- u = unknown
- | = no attempt to code

34 Biography:
- # = no biographical material
- a = autobiography
- b = individual biography

c = collective biography
d = contains biographical information
| = no attempt to code

35-37 Language:
A three-letter code. For example: eng fre ger spa rus ita

(For a full list of codes used in these positions, see the *MARC Code List for Languages*.)

38 Modified record:
# = not modified
x = missing characters (because of characters unavailable in MARC character set)
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d = "dashed-on" information omitted
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o = completely romanized/printed cards romanized
| = no attempt to code

39 Cataloging source:
# = national bibliographic agency
c = cooperative cataloging program
d = other sources
u = unknown
| = no attempt to code

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Appendix 1008

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43rd Annual Technical Conference Proceedings

April 15–20, 2000
Denver, Colorado USA

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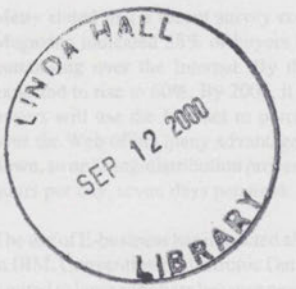

SOCIETY of VACUUM COATERS

Pulsed-DC Reactive Sputtering of Dielectrics: Pulsing Parameter Effects

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and D. Carter, L. Mahoney, G. McDonough, G. Roche, R. Scholl and H. Walde,
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Key Words: Pulsed deposition, Reactive sputtering, Pulsed plasma, Al_2O_3

ABSTRACT

Pulsed DC power is used for reactive sputtering of dielectrics. At certain pulsing frequencies and duty cycles, deposition can be done without arcing and high deposition rates can be achieved. In this work, the influence of frequency, on-time and off-time durations on the deposition process are investigated.

I. INTRODUCTION

DC reactive sputtering of dielectrics is often accompanied with strong arcing. Arcing appears mainly on the portion of the target surface that is not strongly bombarded by positive ions and may therefore be covered with a dielectric layer. Such a dielectric layer accumulates positive charges, which if dense enough, may cause arcing. To avoid this arcing, reactive sputter-deposition of dielectric films is done using either pulsed-DC [1-14] or mid-frequency ac power [15-17]. Pulsed-DC power is implemented mainly with a single magnetron system, while ac power is generally used with a dual magnetron arrangement. A waveform showing the effect of pulsed-DC power is shown in Figure 1. The pulsing parameters must satisfy certain conditions to avoid arcing. These conditions are usually satisfied when pulsing frequencies and duty cycle (defined as the ratio $\tau_{on}/(\tau_{on}+\tau_{off})$ are chosen properly from the range of about 20-350 kHz and 0.5-0.9, respectively. Pulsing parameters such as duty cycle and off-time influence also the forms of voltage and current peaks, deposition rate and the properties of the deposited thin films. In this paper, the proper choice of pulsing frequency and some details of pulsing parameter influences are described. Results are given for pulsed dc reactive sputtering of Al_2O_3 thin film.

2. EXPERIMENTAL TECHNIQUE

The experiments were done in a box coater with a planar rectangular unbalanced magnetron HRC-817 (BOC Coating Technology) previously described in [11,13,14]. The pulsed DC power was applied to the cathode using a DC power supply, model MDX-10 by Advanced Energy Industries (AEI), pulsed generator Sparcle®-V (AEI), and also by a PinaclePlus® unit (AEI). The DC power supply was run in the constant power and current modes. Another model of pulsed power supply, RPG (ENI), was used for comparison.

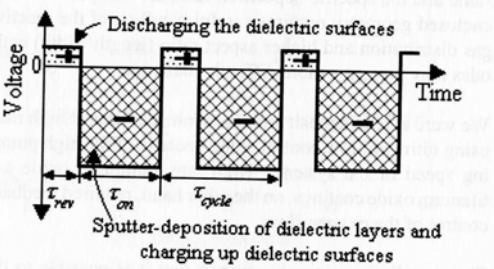

Figure 1. Pulsed voltage used to power a cathode

The current and voltage pulse forms were recorded using an oscilloscope model TDS 340, connected to a voltage probe model P5100, and a current probe, model A6303, (all from Tektronix). The pulsed power consumed by the plasma was obtained by dynamic multiplication (point-by-point) of the current and voltage waveforms. Plasma emission was recorded by two photomultipliers H5783 (Hamamatsu) with narrow filters attached to each of them to record Ar^+ (425 nm) and atomic oxygen (777 nm) emission. The time constant of optical responses was less than 10 ns.

3. PULSING PARAMETERS AND CATHODE MICROARCING

It is commonly accepted that positive charges accumulated on the surface of a dielectric layer deposited (or grown) on the target surface, are the main source of arcs. Accumulation of these charges takes place during each on-time pulse, τ_{on} (Figure 1) as ions bombard the target surface. During the following off-time, τ_{off}, electrons from the residual plasma discharge the layer. If the discharge is not complete, additional step-by-step charge accumulation during many sequential periods takes place, and layer breakdown may still occur. Let us consider first only charge accumulation in a single on-time.

If the electrical field in the dielectric layer created by the charge accumulated during an on-period exceeds the dielectric strength of the film, a breakthrough takes place in the film, and, as a result of a high level of electron emission from the

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breakthrough area, an arc appears. Estimations have been made [2,3,13,14,18] which show that, at the deposition conditions used in typical cases, a breakdown field of $E_{br} \approx 10^6$ V/cm appears in the Al_2O_3 films in about τ_{br} = 0.1-1 ms. To avoid such arcs, the on-time, τ_{on}, (Figure 1) should not larger than 0.1-1 ms and the pulsing frequency should be larger than the related critical frequency $f_{cr.1}$ = 1-10 kHz.

Another kind of microarc can appear when a high electrical field is created between positive charges accumulated on the dielectric layer and a nearby open metal surface of the race-track area. These might be called surface creepage breakdown. The traces of these microarcs are seen on the target surface as scratches. Very little is known about their electrical parameters. To avoid this kind of arcing, the on-time should not be larger than some duration dependent upon surface conditions; that is to say, the pulsing frequency should be larger than a critical frequency, $f_{cr.2}$. So, to avoid microarcing due to charge accumulation in a single on-time pulse, the on-time should less than a certain value, which is to say that the frequency should be larger than $f_{cr.1}$ or $f_{cr.2}$, whichever is higher. It is important to note that that $f_{cr.1}$ or $f_{cr.2}$ do not depend on the duty cycle, because they relate to an arc formed by charge buildup in a single on-time period.

Another limitation for pulsing frequency comes from possible step-by-step charge accumulation during many sequential periods. To avoid such accumulation, the dielectric surfaces must be discharged completely during each off-time, τ_{off} (also called the "reverse time", τ_{rev}). For this to occur, for each period τ_{on}, a minimal $\tau_{off.min}$ exists to avoid arcing. It is obtained as a first approximation that $\tau_{off.mi}$ is linearly related to τ_{on}, and the relationship coefficient is directly proportional to the current [13,14]. The linear relationship between these durations leads to a simple upper limitation on the duty cycle, d_{cr}, which decreases as the current increases.

Experimentally, the conditions for avoiding microarcs may be verified by counting microarcs at different pulsing frequencies. This may be done keeping on-time, off-time, or duty cycle, constant. The number of microarcs counted in a certain time is usually very low until the frequency is decreased to the critical frequency f_{cr}. Continuous arcing is observed at f_{cr} and lower [11,13,14]. In accordance with the discussed conditions, to avoid arcing and experimental data, the critical frequency depends on the duty as shown in Figure 2.

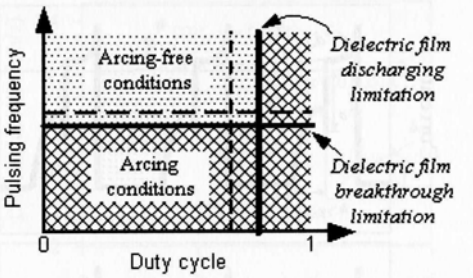

Figure 2. First-approximation view of arcing-free conditions in the 2-d space of pulsing frequency and duty cycle and two different currents, I_1 (solid lines) and I_2 (dotted lines): $I_1 < I_2$.

4. PULSING PARAMETERS AND DISCHARGE BEHAVIOUR

Current and voltage pulses during reactive sputtering of a dielectric are shown schematically in Figure 3. An example of actual shapes of current and voltage pulses as well as optical emission pulses, is shown Figure 4 [11,13,14]. Let us consider a moment when the cathode voltage is switched to a positive value (Point A on the time scale, Figure 3). Since at this moment the plasma support is turned off, the plasma begins to decay through bipolar charge carrier diffusion to the wall of the chamber, and the electrodes. As the plasma density diminishes, the electron current to the positive target decreases. As may be seen in Figure 3, the shape of the electron current waveform between times A and B may be described by two exponentials, with time constants of $\tau_{est.1}$ = 30÷40 μs and $\tau_{est.2}$ = 3÷5 ms for the balanced magnetron and of $\tau_{est.1} \approx$ 15 μs for the unbalanced magnetron [13,14]. The longest time constant is consistent with the overall plasma decay. These time constants are close to those observed in various high-density oxygen plasmas [19]. The larger time constant is consistent with Bohm bipolar plasma diffusion to the walls [20]. Note that the plasma emission in pulsed power reactive sputtering of Al_2O_3 recorded for the Al-line and O-line, also decay, but not at the same rate; to a first approximation, the emission lines decay exponentially with two time constants: 0.2-0.3 μs and 1 μs. This may be explained by noting that the excitation of optical emission in the plasma requires involvement of electrons with energies above about 10 eV. It is to be expected that when the plasma starts to decay, the fast electrons disappear much faster the slow ones [20]. Although the time constants obtained for optical emission are less that the ones obtained for electron current decay, they still confirm that there is a substantial plasma density at the end of a few microsecond-long off-time.

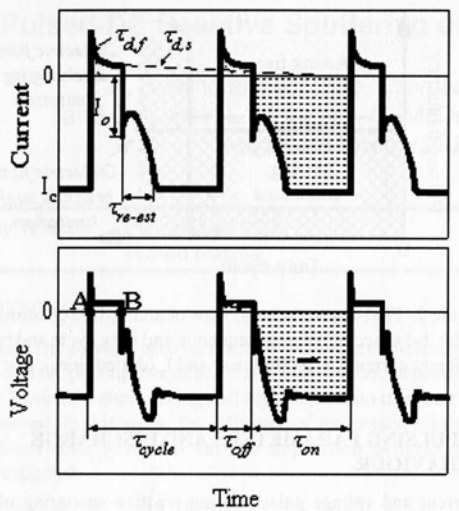

Figure 3. Typical current and voltage oscillograms

So, if the τ_{off} is of an order of a few microseconds or less, then at this moment a plasma still exists in the space between the cathode and anode, although its density has fallen off. The density of this residual plasma, $n_{e,res}$ depends on the off-time, τ_{off}; increasing τ_{off} decreases the density $n_{e,res}$.

The negative voltage is turned on again at the end of the off-, or reverse-, time (Point B on the time scale, Figure 3). At this moment, the density $n_{e,res}$ determines the initial current, I_o, and also the re-establishment time, $t_{re\text{-}est}$ (Figure 3). The higher the residual concentration of charge carriers $n_{e,res}$ (i.e., the smaller the off-time), the larger the current I_o and lower the duration $\tau_{re\text{-}est}$.

Plasma re-establishment time depends on the residual plasma density $n_{e,res}$, which increases with increasing cathode current and decreasing off-time. It takes, usually, a $\tau_{re\text{-}est}$ = 1-2 μs, sometimes even less, to recover to the original density. Such fast plasma re-establishment is promoted by a voltage overshoot created by the dc power supply, which will occur if the power supply has any substantial output inductance.

The unbalanced magnetron plasma decay time constants are higher than those of the balanced magnetron. This could be related to the fact that the dense part of the unbalanced magnetron plasma occupies much larger volume, and its decay thus requires a longer time.

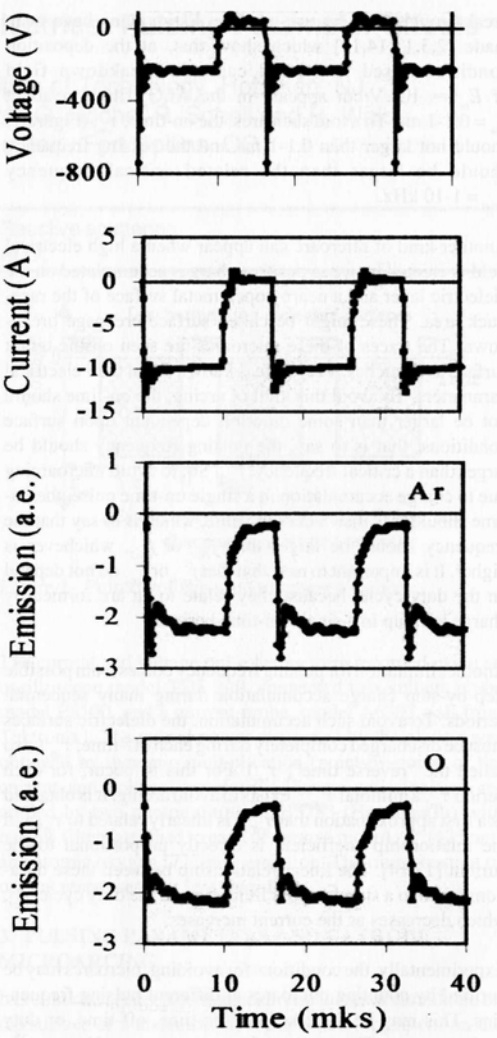

Figure 4. Voltage, current, and optical emission of Ar and O oscillograms.

5. PULSING PARAMETERS AND TAREGT STATE OF OXIDATION

The target surface in the racetrack area of a magnetron in reactive sputtering can be in either of two stable states or modes: metallic and reactive. If the target is largely or completely covered with oxide, it is said that the system is operating in the "oxide mode". In the "metallic mode", the racetrack area is practically clean from oxide, and sputtering of the metal is the dominant process. In addition to these stable

modes, the target racetrack area can be maintained also in an intermediate mode, which is not ordinarily stable, by employing a closed-loop control system. In all cases, the balance of sputtering and oxidation rates determines the racetrack area's surface conditions. Sputtering takes place only during the on-time, while oxidation takes place in both parts of the cycle, during the off-time as well as the on-time. During the on-time, oxidation takes place mainly by atomic oxygen generated in the plasma. During the off-time, oxidation is provided by the decaying concentration of atomic oxygen that at the end of an off-time is still high (emission of atomic oxygen line is still strong).

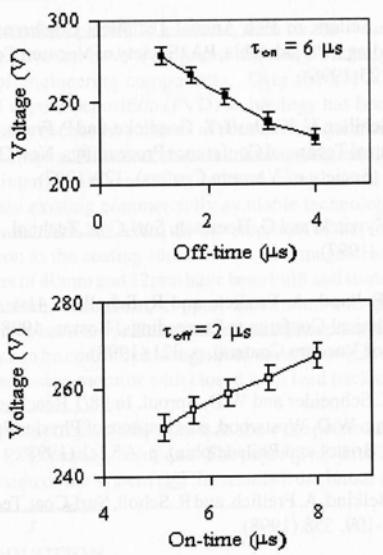

Figure 5. Voltage versus off-time at constant on time (upper) and versus on-time at constant on-time (lower).

Changing the duty cycle will change the equilibrium between oxidation and sputtering processes and result in a different average thickness of the oxide layer on the target surface. It is worthwhile to notice that the thickness of the oxide layer, even in the oxide mode, is very small; if this were not true, a substantial voltage drop would build up due to charging of the oxide layer, which would cut off the discharge. In spite of being very thin, however, slightly different thickness in the oxide layer leads to variation of the cathode voltage and deposition rate. An effect related to the target oxidation state is actually seen in the variation of the cathode voltage as shown in Figure 5. It is also seen in a variation of the linear relationship between the deposition rate and power consumed in the plasma at different constant duty cycles (Figure 6).

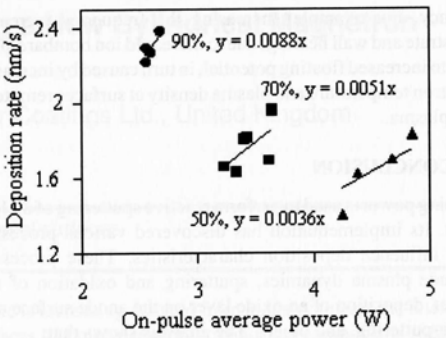

Figure 6. Deposition rate versus on-pulse average power at different constant duty cycles.

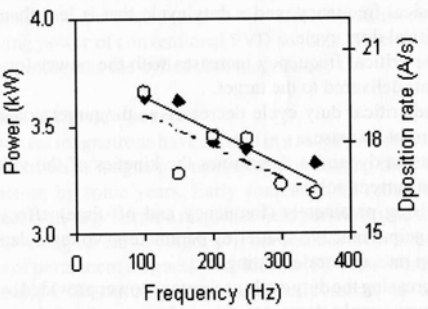

Figure 7. On-pulse average power (closed diamonds) and deposition rate (open circles) versus frequency at constant power of 2.5 kW and 0.7 duty cycle.

6. PULSING PARAMETERS AND POWER DISSIPATION

The pulsed power delivered to the plasma (i.e., the power delivered during the on-time) is slightly lower than the power generated by supply (Figure 7). The difference between the two increases with frequency; this is probably due to power loss in the pulsing device (the electronic switches dissipate a little energy for each switch operation, and thereby power loss increases with frequency). Deposition rate, measured in the power supply's constant power mode, also decreases with increasing frequency (Figure 7). It has been shown [13,14] that the deposition rate in pulsed systems is directly proportional to the power delivered to the plasma during the on-time.

The power delivered to magnetron to generate the plasma is released mainly in sputtering of the target material, but also can be lost through heating all surfaces: the target, chamber walls, and substrates. The power distribution between the sputtering and other processes depends on the pulsing fre-

quency. For example, increasing the frequency increases substrate and wall heating, due to increased ion bombardment due to increased floating potential, in turn caused by increased electron temperature and plasma density at surfaces remote to the plasma.

7. CONCLUSION

Pulsing power is used to perform reactive sputtering of dielectrics. Its implementation has discovered various processes that influence deposition characteristics. These processes include plasma dynamics, sputtering and oxidation of the target, deposition of an oxide layer on the anode surface and its resputtering, and others. The analysis shows that:

- Reactive sputtering of dielectrics can be performed without arcing using pulsing frequencies that exceed the critical frequency, and a duty cycle that is less than the critical duty cycle.
- The critical frequency increases with the power (or current) delivered to the target.
- The critical duty cycle decreases as the target power or current increases.
- Plasma dynamics determines the kinetics of the voltage and current pulses
- Pulsing parameters (frequency and off-time) affect the principal reactive sputtering parameters: voltage, deposition rate, substrate heating, etc.
- Increasing the duty cycle at constant power provided by the power supply decreases the oxidation state of the target surface and, therefore, increases the deposition rate
- Increasing the pulsing frequency increases power loss, both in the pulser switching devices and in substrate and wall heating. As the power measured by the power supply does not include these losses, there is an *apparent* decrease in specific deposition rate (deposition rate per watt) due to a decreasing fraction of the measured power being delivered to the target. This effect disappears when the actual power delivered to the plasma is measured and used as the power figure.

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Appendix 1029

Growth and optical characterization of aluminum nitride thin films deposited on silicon by radio-frequency sputtering

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Growth and optical characterization of aluminum nitride thin films deposited on silicon by radio-frequency sputtering

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Highly textured hexagonal aluminum nitride (AlN) thin films were deposited on silicon substrates by radio-frequency magnetron sputtering at a substrate temperature below 400 °C and annealed in the temperature range of 400–450 °C by rapid thermal annealing. The optical and the electro-optical properties have been investigated using the prism-coupling technique. Both ordinary and extraordinary refractive indices ($n_0=2.0058$ and $n_e=2.0374$ at 632.8 nm) were respectively determined from the transverse electric and the transverse magnetic mode excitations. Furthermore, refractive index profiles analysis by using an improved inverse Wentzel–Kramer–Brillouin method reveals a step-like behavior of AlN thin films. The optical losses have been evaluated to be around 7 dB cm^{-1}. The electro-optic coefficient r_{13} of 0.98 pm/V has been measured from the variation of the shift of guided-modes spectrum as a function of the applied electric field in the experiment. [S0003-6951(99)03709-2]

Aluminum nitride (AlN) thin films are of increasing interest for a large number of applications in microelectronic field. Because of its wide direct band gap, AlN is a promising material for integrated optics in the ultraviolet (UV) region, i.e., laser diode,[1] detectors,[2] and fabrication of high frequency surface acoustic wave (SAW) devices.[3] Moreover, the high insulating and conducting properties of AlN can be used in the fabrication of III–V based electronic structures. Various techniques have been developed for growing thin films of AlN.[4,5] Most recent works have been performed on epitaxial growth of aluminum nitride using sapphire as a substrate.[6] However, silicon substrates offer more advantages for nitride devices over sapphire: it is ideal in integrating electronic and optical devices at low costs using established silicon technology. In this letter we report the investigation of the optical and the electro-optical properties of AlN thin films by using the prism-coupling technique.[7,8] This work is both focused on the optimization of the growth process and the comprehensive study of the relationship between the structure and the optical characteristics.

For our study, AlN films were deposited by radio-frequency (rf) magnetron sputtering on Si/SiO_2 substrates from aluminum nitride targets, in a gas mixture of argon (Ar) and nitrogen (N_2) with a purity of 99.999%, respectively. In order to improve the structural properties of nitride compounds, a two-step process was used. First, the substrate temperature was maintained at a low temperature of 400 °C in the *in situ* growth. Second, a rapid thermal annealing (RTA) process was achieved for enhancement of the crystalline quality of the material. The optimization of the growth conditions leads to a single crystal AlN with a relatively smooth surface. We found that the growth rate was about 5 nm/min. The sputtering conditions are listed in Table I.

To investigate the structural properties of our AlN thin films, we used the x-ray diffractions (XRD) patterns in the θ–2θ configuration, as reported in Fig. 1. The growth direction for AlN films is (002), the best texture is obtained at a low temperature (400 °C) with a N_2 content of 30%. The orientation of the film is generally controlled by its interaction with the substrate and by kinetics of the growth process. As reported by Dovidenko *et al.*,[5] this effect is probably caused by the grain-boundary separating individual grains. These planar defects are mainly generated in the closed-packed plane of AlN during the growth process.

For the optical characterizations, we have used the prism-coupling technique. We report in Figs. 2 and 3, on transverse electric (TE) and transverse magnetic (TM) guided-modes spectra, respectively. Five guided modes have been excited for each case. We notice the sharpness of the reflectivity dips indicating a good confinement of the light into the wave guide. Therefore, moderate optical losses in the AlN film can be suggested. Indeed, those later have been evaluated by using the charge coupled device (CCD) camera

TABLE I Sputtering conditions for deposition of AlN thin films on silicon substrates

Parameter	Condition
Target	AlN 99 999%, 3 in ∅
Substrate	SiO_2/Si (100)
Target-substrate spacing	50 mm
Substrate temperature	400 °C
rf power	300 W
Gas pressure	1 2 mbar
Ar/N_2	70/30
Deposition rate	5 nm/min

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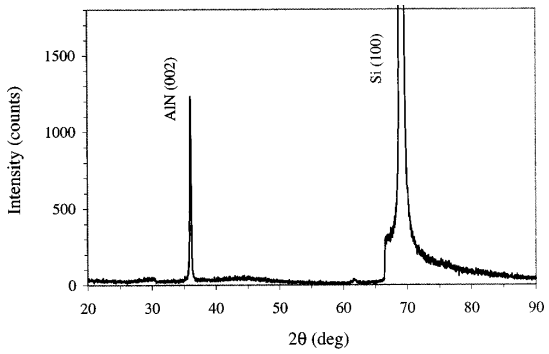

FIG 1 X-ray diffractions patterns of aluminum nitride thin films deposited on silicon substrate

technique[9] to be in the order of 7.3 dB cm^{-1}. Higher losses have been obtained for higher-order modes excited in the film. The wave guide losses are known to be strongly dependent on the surface roughness of the film. The surface morphology of AlN samples has been examined by atomic force microscopies (AFM) showing a good surface quality for our films (r_{ms} about of 40 Å). In order to minimize the optical losses, the epitaxial growth of AlN thin films is required.

From the angular position of the guided modes, we computed the corresponding effective indices and hence the refractive indices and the film thickness. For our samples, the ordinary (n_0) and the extraordinary (n_e) refractive indices are 2.0058 ± 0.0004 and 2.0374 ± 0.0006 ($\lambda = 632.8$ nm) respectively. These values are similar to those reported in the literature.[6,10] However, slight deviations of refractive indices are obtained in comparison with the corresponding AlN single crystal ordinary refractive index n_0 which is around 2.16.[11] This is mainly attributed to the nitrogen vacancy or oxygen impurities. The thickness was determined to be $1.28 \pm 0.04\,\mu$m which is in agreement with the scanning electron microscope (SEM) investigation.

Note that in this study, we focused our attention to the simple case of light propagation in anisotropic uniaxial thin film deposited onto an isotropic substrate. In this configuration, TE and TM modes can exist separately. Therefore, the problem was treated using the well-known guided-modes dispersion equation. However, the deposition technique may

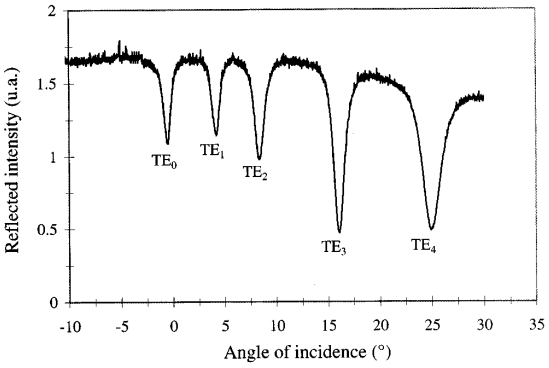

FIG 2 TE guided mode spectra obtained by measuring the reflected intensity vs the angle of incidence (n_0 excitation)

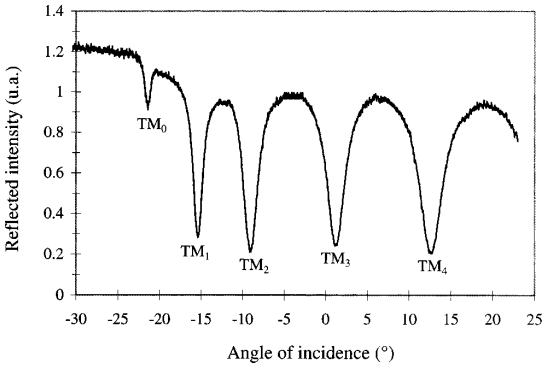

FIG 3 TM guided mode spectra obtained by measuring the reflected intensity vs the angle of incidence (n_e excitations)

yield thin films with the optical axis tilted from normal to the substrate surface. In this situation, TM modes are affected by the tilt angle (φ) of the optical axis which determines the refractive index seen by the optical wave propagating within the guiding structure. The calculation procedure[12] provides a weak tilt angle (φ) of nearly 6° with respect to the normal to the substrate surface, confirming the uniaxial nature of our AlN thin films deposited by rf sputtering, with the optical axis very likely oriented perpendicular to the substrate surface.

To complete this analysis, we have reconstructed the refractive index profiles directly from the measured effective indices by using an improved version of the inverse Wentzel–Kramer–Brillouin (*i*WKB) method. This method only depends on the refractive index distributions within the guiding layer. More details of calculation are given by Chiang.[13] Using a polynomial interpolation of the measured effective indices, we computed the refractive index profiles as a smooth function of the thickness. As shown in Fig. 4, the refractive index profiles indicate a step-index variation which is synonymous of a good optical homogeneity along the film thickness. Indeed, the refractive index remains constant within the guiding region and decreases rapidly near the film–substrate interface. Therefore, this result did not show any clear influence of the substrate on the growth process.

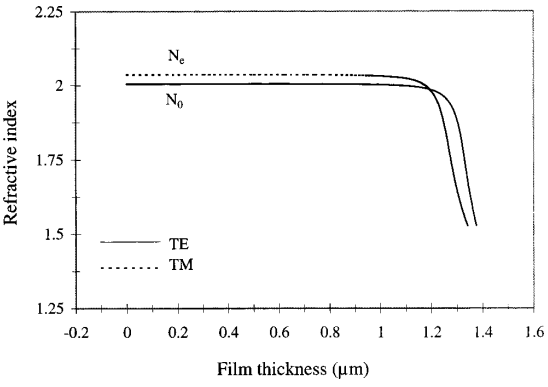

FIG 4 Ordinary (n_0) and extraordinary (n_e) refractive index profiles obtained by an improved inverse WKB method for AlN thin films deposited on silicon substrates

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Using TE guided modes, we have investigated the electrooptic (EO) coefficient using the angular shift technique as described by Boudrioua *et al.*[14] The top electrode consists of a semitransparent gold film with a thickness of 10 nm. By applying a transverse electric field through the AlN layer, a change of the resonant coupling angle ($\Delta\theta$) in the guided-modes spectrum has been observed. This effect is directly correlated to the variation of the refractive index (Δn) due to the EO effect. Finally, the linear EO coefficient r_{13} obtained is evaluated to be 0.98 pm/V.

In summary, AlN thin films have been grown on Si/SiO_2 substrates by radio-frequency magnetron sputtering from an aluminum nitride target. The deposition parameters and annealing process were optimized for the elaboration of highly textured AlN thin films. We have investigated the optical performances of the films using the prism-coupling technique. Refractive indices were therefore determined to be $n_0 = 2.0058$ and $n_e = 2.0374$ at 632.8 nm. From the effective guided-mode indices, the analysis of the optical anisotropy confirmed the uniaxial nature of the AlN thin film with the optical axis likely oriented normal to the surface of the substrate. The optical losses were evaluated to be around 7 $dB\,cm^{-}$. The EO measurements using the angular shift method showed a linear electro-optic coefficient r_{13} of about 0.98 pm/V. These results demonstrate the interest of AlN thin films to be used in integrated optics applications.

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Growth and optical characterization of aluminum nitride thin films deposited on silicon by radio-frequency sputtering

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 [S0003-6951(99)03709-2]

Aluminum nitride (AlN) thin films are of increasing interest for a large number of applications in microelectronic field. Because of its wide direct band gap, AlN is a promising material for integrated optics in the ultraviolet (UV) region, i.e., laser diode,[1] detectors,[2] and fabrication of high frequency surface acoustic wave (SAW) devices.[3] Moreover, the high insulating and conducting properties of AlN can be used in the fabrication of III–V based electronic structures. Various techniques have been developed for growing thin films of AlN.[4,5] Most recent works have been performed on epitaxial growth of aluminum nitride using sapphire as a substrate.[6] However, silicon substrates offer more advantages for nitride devices over sapphire: it is ideal in integrating electronic and optical devices at low costs using established silicon technology. In this letter we report the investigation of the optical and the electro-optical properties of AlN thin films by using the prism-coupling technique.[7,8] This work is both focused on the optimization of the growth process and the comprehensive study of the relationship between the structure and the optical characteristics.

For our study, AlN films were deposited by radio-frequency (rf) magnetron sputtering on Si/SiO_2 substrates from aluminum nitride targets, in a gas mixture of argon (Ar) and nitrogen (N_2) with a purity of 99.999%, respectively. In order to improve the structural properties of nitride compounds, a two-step process was used. First, the substrate temperature was maintained at a low temperature of 400 °C in the *in situ* growth. Second, a rapid thermal annealing (RTA) process was achieved for enhancement of the crystalline quality of the material. The optimization of the growth conditions leads to a single crystal AlN with a relatively smooth surface. We found that the growth rate was about 5 nm/min. The sputtering conditions are listed in Table I.

To investigate the structural properties of our AlN thin films, we used the x-ray diffractions (XRD) patterns in the θ–2θ configuration, as reported in Fig. 1. The growth direction for AlN films is (002), the best texture is obtained at a low temperature (400 °C) with a N_2 content of 30%. The orientation of the film is generally controlled by its interaction with the substrate and by kinetics of the growth process. As reported by Dovidenko *et al.*,[5] this effect is probably caused by the grain-boundary separating individual grains. These planar defects are mainly generated in the closed-packed plane of AlN during the growth process.

For the optical characterizations, we have used the prism-coupling technique. We report in Figs. 2 and 3, on transverse electric (TE) and transverse magnetic (TM) guided-modes spectra, respectively. Five guided modes have been excited for each case. We notice the sharpness of the reflectivity dips indicating a good confinement of the light into the wave guide. Therefore, moderate optical losses in the AlN film can be suggested. Indeed, those later have been evaluated by using the charge coupled device (CCD) camera

TABLE I. Sputtering conditions for deposition of AlN thin films on silicon substrates.

Parameter	Condition
Target	AlN 99.999%, 3 in. ∅
Substrate	SiO_2/Si (100)
Target-substrate spacing	50 mm
Substrate temperature	400 °C
rf power	300 W
Gas pressure	1.2 mbar
Ar/N_2	70/30
Deposition rate	5 nm/min

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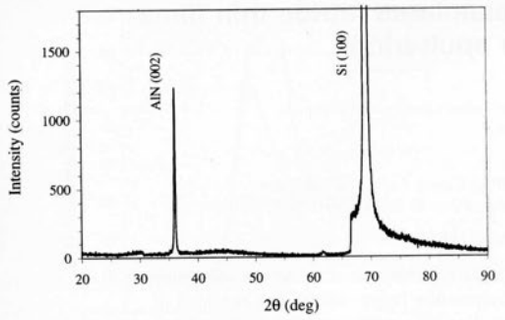

FIG. 1. X-ray diffractions patterns of aluminum nitride thin films deposited on silicon substrate.

technique[9] to be in the order of 7.3 dB cm^{-1}. Higher losses have been obtained for higher-order modes excited in the film. The wave guide losses are known to be strongly dependent on the surface roughness of the film. The surface morphology of AlN samples has been examined by atomic force microscopies (AFM) showing a good surface quality for our films (r_{ms} about of 40 Å). In order to minimize the optical losses, the epitaxial growth of AlN thin films is required.

From the angular position of the guided modes, we computed the corresponding effective indices and hence the refractive indices and the film thickness. For our samples, the ordinary (n_0) and the extraordinary (n_e) refractive indices are 2.0058 ± 0.0004 and 2.0374 ± 0.0006 ($\lambda = 632.8$ nm) respectively. These values are similar to those reported in the literature.[6,10] However, slight deviations of refractive indices are obtained in comparison with the corresponding AlN single crystal ordinary refractive index n_0 which is around 2.16.[11] This is mainly attributed to the nitrogen vacancy or oxygen impurities. The thickness was determined to be $1.28 \pm 0.04\,\mu$m which is in agreement with the scanning electron microscope (SEM) investigation.

Note that in this study, we focused our attention to the simple case of light propagation in anisotropic uniaxial thin film deposited onto an isotropic substrate. In this configuration, TE and TM modes can exist separately. Therefore, the problem was treated using the well-known guided-modes dispersion equation. However, the deposition technique may

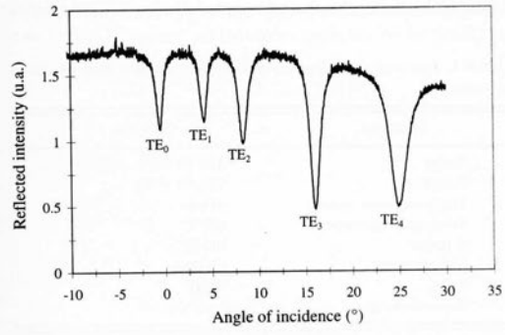

FIG. 2. TE guided mode spectra obtained by measuring the reflected intensity vs the angle of incidence (n_0 excitation).

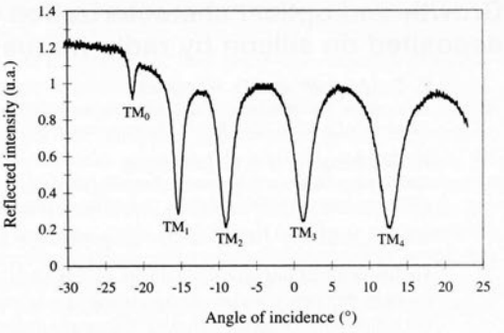

FIG. 3. TM guided mode spectra obtained by measuring the reflected intensity vs the angle of incidence (n_e excitations).

yield thin films with the optical axis tilted from normal to the substrate surface. In this situation, TM modes are affected by the tilt angle (φ) of the optical axis which determines the refractive index seen by the optical wave propagating within the guiding structure. The calculation procedure[12] provides a weak tilt angle (φ) of nearly 6° with respect to the normal to the substrate surface, confirming the uniaxial nature of our AlN thin films deposited by rf sputtering, with the optical axis very likely oriented perpendicular to the substrate surface.

To complete this analysis, we have reconstructed the refractive index profiles directly from the measured effective indices by using an improved version of the inverse Wentzel–Kramer–Brillouin (*i*WKB) method. This method only depends on the refractive index distributions within the guiding layer. More details of calculation are given by Chiang.[13] Using a polynomial interpolation of the measured effective indices, we computed the refractive index profiles as a smooth function of the thickness. As shown in Fig. 4, the refractive index profiles indicate a step-index variation which is synonymous of a good optical homogeneity along the film thickness. Indeed, the refractive index remains constant within the guiding region and decreases rapidly near the film–substrate interface. Therefore, this result did not show any clear influence of the substrate on the growth process.

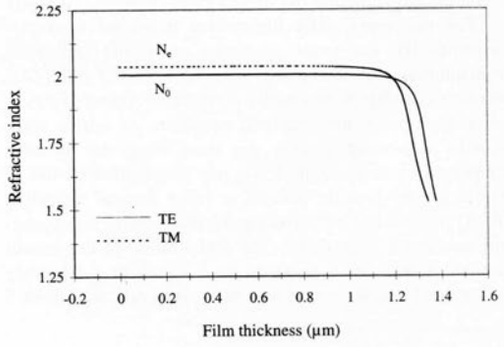

FIG. 4. Ordinary (n_0) and extraordinary (n_e) refractive index profiles obtained by an improved inverse WKB method for AlN thin films deposited on silicon substrates.

Using TE guided modes, we have investigated the electrooptic (EO) coefficient using the angular shift technique as described by Boudrioua *et al.*[14] The top electrode consists of a semitransparent gold film with a thickness of 10 nm. By applying a transverse electric field through the AlN layer, a change of the resonant coupling angle ($\Delta\theta$) in the guided-modes spectrum has been observed. This effect is directly correlated to the variation of the refractive index (Δn) due to the EO effect. Finally, the linear EO coefficient r_{13} obtained is evaluated to be 0.98 pm/V.

In summary, AlN thin films have been grown on Si/SiO_2 substrates by radio-frequency magnetron sputtering from an aluminum nitride target. The deposition parameters and annealing process were optimized for the elaboration of highly textured AlN thin films. We have investigated the optical performances of the films using the prism-coupling technique. Refractive indices were therefore determined to be $n_0 = 2.0058$ and $n_e = 2.0374$ at 632.8 nm. From the effective guided-mode indices, the analysis of the optical anisotropy confirmed the uniaxial nature of the AlN thin film with the optical axis likely oriented normal to the surface of the substrate. The optical losses were evaluated to be around 7 $dB\,cm^{-1}$. The EO measurements using the angular shift method showed a linear electro-optic coefficient r_{13} of about 0.98 pm/V. These results demonstrate the interest of AlN thin films to be used in integrated optics applications.

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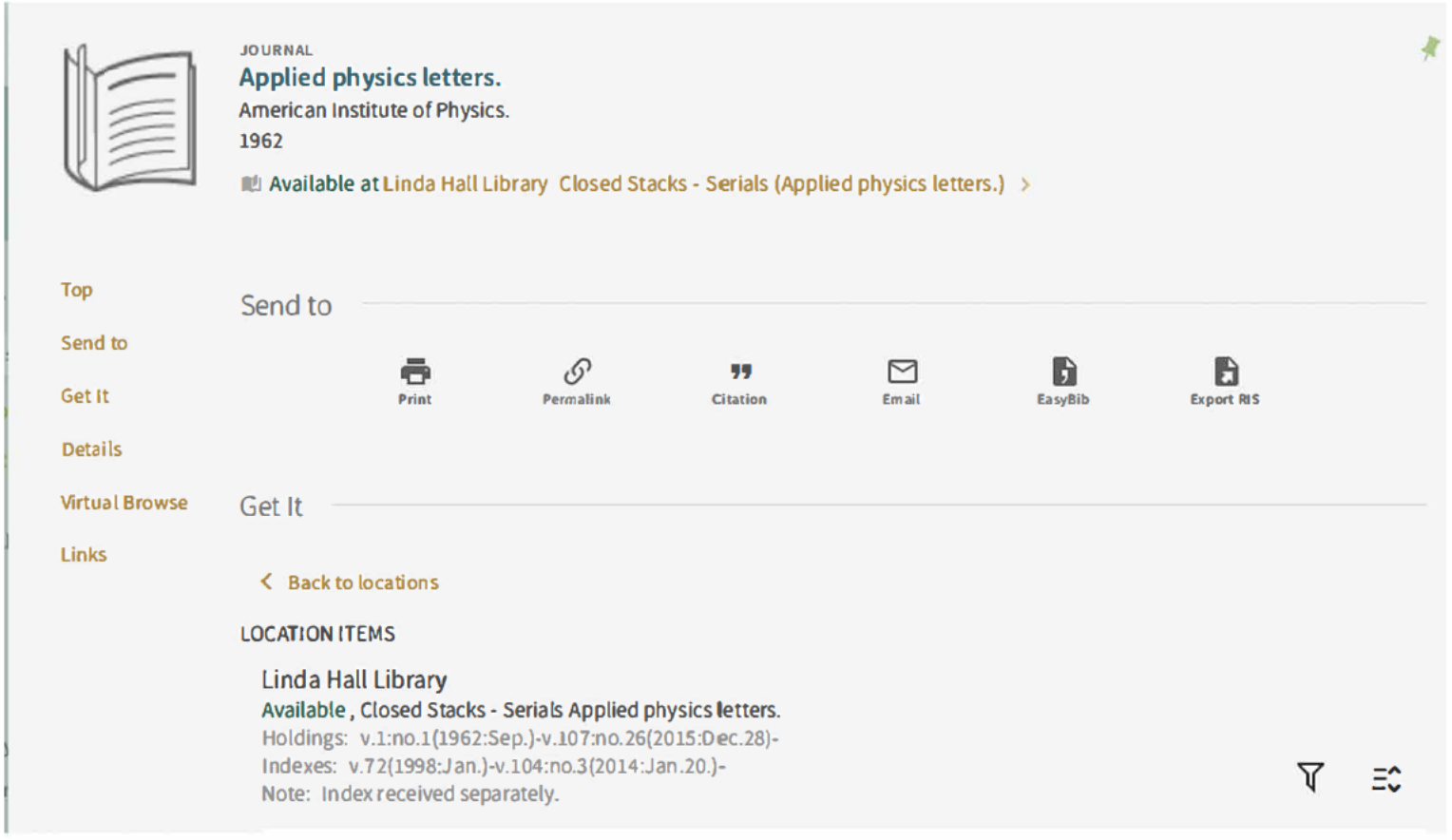
Appendix 1029-B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