

## Bruce W. Smith, Ph.D.

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### SUMMARY

Bruce Smith has over 30 years of research, academic, industry, and consulting engineering experience in integrated circuit processing, microelectronics, microlithography, and imaging systems. He is a professor of Microelectronic Engineering and the Director of the Ph.D. program in Microsystems Engineering at the Rochester Institute of Technology. His industry experience includes manufacturing and R&D and he has worked with companies in the US, Europe, and Asia. Professor Smith is a Fellow of the OSA, a Fellow of SPIE, a Senior Member of IEEE, and a member of AVS, ASEE, and SID. He is the recipient of RIT's Trustees Scholarship Award, a SPIE Research Mentoring Award, RIT's Creators Award, and the Rush Henrietta Outstanding Alumni Award, among others, and has been inducted into RIT's Innovator Hall of Fame. Professor Smith has over 150 publications including technical papers, articles, textbooks, and textbook chapters. He holds 25 patents and has licensed his technology both nationally and internationally.

### PROFESSIONAL EXPERIENCE

- Rochester Institute of Technology, Professor, Kate Gleason College of Engineering, 1988-present  
Director, Microsystems Engineering Ph.D. Program, 2008-present  
Intel Professor of Research and Technology, 2000-2007  
Associate Dean of Graduate Programs, Kate Gleason College of Engineering, 2001-2004  
Director, Center for Nanolithography Research, 2004-present  
Professor, Microelectronic Engineering Department, 1988-2008
- IMEC at University of Leuven, Belgium, Visiting Professor, 2008
- Lithographic Technology Corp / Amphibian Systems, President, 1998-present
- IMEC at University of Leuven, Belgium, Visiting Professor, 2001
- International SEMATECH, Austin Texas, Visiting Scholar, 1997
- Rutherford Appleton Laboratories, Oxford, U.K., Visiting Scientist, 1995
- Digital Equipment Corp., Hudson, Mass., Advanced Development Center, 1986-1988
- Gould AMI Semiconductor, Santa Clara, Calif., Process Development Group, 1983-1986

### EDUCATION

- B.S., M.S. Rochester Institute of Technology, Photographic and Imaging Science.
- Ph.D., Rochester Institute of Technology, Imaging Science.

### LITIGATION SUPPORT EXPERIENCE

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|----------|--------|---|
| Date:    | 2013-  | Ropes and Gray LLP  |
| Case:    |        | <u>Spansion LLC</u> v. Macronix America Co., Ltd. et al   |
| Project: |        | ITC patent infringement case – Testifying Expert  |
| Field:   |        | Flash memory chip method and processes  |
| Date:    | 2013 – | McKenna Long & Aldridge LLP   |
| Case:    |        | <u>Eidos Display, LLC</u> v. AU Optronics Corp. et al (AU, Chi Mei Innolux, Chunghwa, Hannstar, and Hannspree)  |
| Project: |        | Patent Infringement (USDC, E. Texas) – Testifying Expert  |
| Field:   |        | This film transistor (TFT) processing for LCDs  |
| Date:    | 2013-  | Mintz, Levin, Cohn, Ferris, Glovsky, and Pepeo PC   |
| Case:    |        | <u>Graphics Properties Holdings, Inc.</u> v. Panasonic Corp. of North America et al (Toshiba, Barnes and Noble, Google, Hewlett-Packard, Lenova, and ZTE) |
| Project: |        | Patent infringement (Delaware Federal District)   |
| Field:   |        | Wide angle LCD display devices  |

Date: 2012 – Bunsow, DeMory, Smith, & Allison LLP  
Case: NXP B.V. v. Research in Motion Ltd. et. al. (TriQuint, SanDisk, Hynix, and Qualcomm)  
Project: Patent Infringement (USDC, FLA Middle District), IPR (USPTO) – Testifying Expert  
Field: Dummy pattern fill for integrated circuit fabrication

Date: 2011 –2012 Mintz, Levin, Cohn, Ferris, Glovsky, and Pepeo PC  
Case: Graphics Properties Holdings v. Respondents (RIM, HTC, LG, Apple, Samsung, and Sony)  
Project: ITC Patent Infringement – Testifying Expert  
Field: LCD stack configuration for display devices

Date: 2011 O’Melveny and Meyers  
Case: Samsung Electronics Co. Ltd. v. AU Optronics Corp. et al (Acer, BenQ, and SANYO)  
Project: ITC Patent infringement  
Field: Flat panel display device manufacturing processes

Date: 2010-2011 McDermott Will & Emery  
Case: Spansion Inc. v. Samsung Electronics Co  
Project: ITC patent infringement case – Testifying Expert  
Field: Contact hole processes for flash memory chips

Date: 2011- Keker and Van Nest LLP  
Case: STC UNM v. Intel Corp.  
Project: Patent infringement (USDC, New Mexico) – Testifying Expert  
Field: Lithography techniques and integrated circuit products

Date: 2010- Irell & Manella LLP  
Case: Patent re-examination  
Project: USPTO re-examination and hearing – Testifying Expert  
Field: Flat panel display illumination devices

Date: 2010 Keker and Van Nest LLP  
Case: STC UNM v. Taiwan Semiconductor Manufacturing Co.  
Project: ITC patent infringement  
Field: Lithography techniques and integrated circuit products

Date: 2010-2011 McDermott Will & Emery  
Case Spansion LLC v. Samsung Electronics Co. (and counter-claim)  
Project: Patent infringement case (USDC, E.D. Va. District) – Testifying Expert  
Field: Flash memory device processes

Date: 2010-2011 Irell & Manella LLP  
Case: Chi Mei Innolux v. Sony Corporation  
Project: ITC patent infringement case  
Field LCD flat panel patterned electrodes

Date: 2010-2011 Ropes and Gray LLP  
Case: Samsung Electronics Co. v. Spansion Japan Ltd.  
Project: ITC patent infringement case  
Field: Lithography and etch processing for flash memory products

Date: 2010 Sidley Austin LLP  
Case: Agere Systems Inc. and LSI v. Xilinx, Inc.  
Project: Patent infringement (S.D. N.Y.)  
Field: Metallization of integrated circuits

Date: 2010 McDermott Will & Emery  
Case: Samsung Electronics Co. v. Spansion LLC and Spansion Inc.

Project: ITC patent infringement case  
 Field: Lithography and etch processing for flash memory products

Date: 2010 Standley Law Group LLP  
 Case: American Panel v. Vertex  
 Project: Patent infringement arbitration  
 Field: Flat panel display technology

Date: 2009-2011 Irell & Manella LLP  
 Case: Apeldyn Corp. v. Chi Mei Optoelectronics Corp., et al (AU, Samsung, Sharp, and Sony)  
 Project: Patent infringement (USDC, Delaware) – Testifying Expert  
 Field: LCD flat panel response time

Date: 2009-10 Fish and Richardson P.C.  
 Case: Semiconductor Energy Laboratory Co. Ltd. v. Eastman Kodak  
 Project: Patent interference case (USPTO)  
 Field: Organic light emitting diode (OLED) display devices

Date: 2009 Steptoe and Johnson, LLP  
 Case: Qimonda AG v. Seagate Technology  
 Project: ITC patent infringement case - Testifying Expert  
 Field: Polysilicon and amorphous silicon technology; silicon-oxi-nitride anti-reflection coating deposition technology

Date: 2009 Fish and Richardson P.C.  
 Case: Sharp Corp. v. Samsung Electronics Co. Ltd.  
 Project: Patent infringement, (E.D. Tx.)  
 Field: Liquid crystal display polarizers and electro static discharge (ESD) technology

Date: 2008 Steptoe and Johnson, LLP  
 Case: Neumark-Rothschild v. Toshiba Corp.  
 Project: ITC patent infringement case  
 Field: Wide bandgap (II-VI and III-V) semiconductor materials processing for short-wavelength LEDs and laser diodes

Date: 2006 –2012 Wolf Block Schorr and Solis-Cohen, LLP  
 Bernstein Litowitz Berger & Grossmann LLP  
 Case: Anvik Corp. v. Nikon Corp., et al (Toshiba, Samsung, LG Electronics, Sharp, LG, Chi Mei, AU, AFPD, Panasonic, IPS, and Hitachi, )  
 Project: Patent infringement (USDC, S. NY District) – Testifying Expert  
 Field: Lithography method for LCD flat panel manufacturing

Date: 2007-08 Ropes & Gray, LLP  
 Case: Aktron Inc., v. Solid State Equipment Corp.  
 Project: Patent infringement  
 Field: Silicon wafer cleaning and preparation

Date: 2007-08 Fish and Richardson P.C.  
 Case: Renesas Technology v. Samsung Electronics  
 Project: ITC patent infringement case – Testifying Expert  
 Field: Thin film and diffractive elements for photomask mask light blocking

Date: 2005-06 Vinson & Elkins, LLP  
 Case: Advanced Micro Devices v. Oki Electronics  
 Project: Patent infringement (USDC, N. CA District) – Testifying Expert  
 Field: Silicon wafer preparation and coating

Date: 2004-05 Irell & Manella, LLP  
 Case: Ultratech Stepper, Inc. v. ASM Lithography, Inc.

Project: Patent infringement (USDC, N. CA District) – Testifying Expert  
 Field: Optical microlithography scanning

Date: 1997-03 Ward Norris Heller & Reidy, LLP – Testifying Expert  
 Case: IBM Fishkill, NY and Essex, VT, including Union Carbide Corp., Eastman Kodak, J. T. Baker Chemical, KTI, Shipley, Ashland Oil, E. I. DuPont de Nemours and Industri-Chem, suppliers of solvents for the IBM cleanroom operations  
 Field: Multi-state litigation, allegations regarding various chemicals used in the manufacturing of semiconductor devices

Date: 1997-03 Ward Norris Heller & Reidy, LLP – Testifying Expert  
 Kasowitz Benson Torres & Friedman, LLP  
 Steptoe & Johnson, LLP  
 Cases: San Jose IBM Workers Litigation v. Shipley Company  
 San Jose IBM Workers Litigation v. American Hoechst Corporation  
 San Jose IBM Workers Litigation v. Ashland Chemical Company, Union Carbide Corporation, Fischer Scientific Company, and Eastman Kodak Company  
 Rubio v. IBM et al.  
 Field: Allegations regarding various chemicals used in an manufacturing of semiconductor devices

## SERVICE

### Professional Associations

Fellow, SPIE International Society for Optical Engineering  
 Fellow, The Optical Society of America  
 Senior Member, Institute of Electrical and Electronics Engineers  
 Member, American Vacuum Society  
 Member, American Society for Engineering Education  
 Member, Society for Information Display

### External Service

1997-2013 SPIE Optical Microlithography, Program Committee  
 2010-2013 EIPBN Program Committee  
 2003-2013 SPIE Zernike Award Committee  
 2009-2010 Councilor, Optical Society of America (OSA), Rochester Section  
 2008-2009 Program Chairman, International Symposium on Immersion Lithography Extensions  
 2004-2005 Conference Chairman, SPIE Optical Microlithography Conference  
 1997-2002 EIPBN Program Committee  
 1997-1998 SPIE/ISMA Singapore Program Committee  
 1995-1997 Chairman, OSA Lithography / Patterning Technical Working Group  
 1990-1996 Faculty Advisor, SPIE Student Chapter

### Honors and Awards

2011 SPIE Research Mentor Award  
 2008 Visiting Professor, IMEC Micro and Nanoelectronics Research Center  
 2007 Trustees Excellence in Scholarship and Teaching Award, Rochester Institute of Technology  
 2007 Fellow, SPIE International Society for Optical Engineering  
 2007 Rush Henrietta Outstanding Alumni Award  
 2005 Million Dollar Principle Investigator Award, Rochester Institute of Technology  
 2005 Patenting Productivity Award, Rochester Institute of Technology  
 2002 Intellectual Property Productivity Award, Rochester Institute of Technology  
 2001 Visiting Professor, IMEC Micro and Nanoelectronics Research Center  
 2000 Intel Professor of Research and Technology, Intel Corp.  
 1999 RIT Creators Award, Rochester Institute of Technology  
 1997 Visiting Scholar, International Sematech  
 1993 Texas Instruments, Douglas Harvey Award

**Editorial Review**

Editorial review of IEEE, JVAC, JM3, and SPIE, journals.

**PATENTS**

1. 7,768,648 Method for aberration evaluation in a projection system
2. 7,345,735 Apparatus for aberration detection and measurement
3. 7,233,887 Method of photomask correction and its optimization using localized frequency analysis
4. 7,170,588 Reduction Smith-Talbot interferometer prism for micropatterning
5. 7,136,143 Method for aberration detection and measurement
6. 7,092,073 Method of illuminating a photomask using chevron illumination
7. 6,934,010 Optical proximity correction method utilizing gray bars as sub-resolution assist features
8. 6,881,523 Optical proximity correction method utilizing ruled ladder bars as sub-resolution assist features
9. 6,846,595 Method of improving photomask geometry
10. 6,835,505 Mask for projection photolithography at or below about 160 nm and a method thereof
11. 6,791,667 Illumination device for projection system and method for fabricating
12. 6,788,388 Illumination device for projection system and method for fabricating
13. 6,556,361 Projection imaging system with a non-circular aperture and a method thereof
14. 6,541,750 Modification of a projection imaging system with a non-circular aperture and a method thereof
15. 6,525,806 Apparatus and method of image enhancement through spatial filtering
16. 6,480,263 Apparatus and method for phase shift photomasking
17. 6,466,304 Illumination device for projection system and method for fabricating
18. 6,395,433 Photomask for projection lithography at or below about 160 nm and a method thereof
19. 6,388,736 Imaging method using phase boundary masking with modified illumination
20. 6,368,755 Masks for use in optical lithography below 180 nm
21. 6,309,780 Attenuated phase shift mask and a method for making the mask
22. 5,939,227 Multi-layered attenuated phase shift mask and a method for making the mask
23. JP2010079303 Method of improving photomask geometry
24. JP2006079117 Optical proximity correction method utilizing gray bar as sub-resolution assist feature
25. EP1240557 Imaging method using phase boundary masking with modified illumination

**SELECTED PUBLICATIONS**

1. "Extreme ultraviolet lithography resist-based aberration metrology," Germain L. Fenger; Lei Sun; Sudharshanan Raghunathan; Obert R. Wood; Bruce W. Smith, *J. Micro/Nanolith. MEMS MOEMS*. 12 (4), 2013.
2. "The Impact of Pupil Plane Filtering on Mask Roughness Transfer," Burak Baylav, Chris Maloney, Zac Levinson, Joost Bekaert, Alessandro Vaglio Pret, and Bruce W. Smith, *J. Vac. Sci. Technol. B* 31, 06F801, 2013.
3. "Modeling the effects of pupil-manipulated spherical aberration in optical nanolithography", M. K. Sears, B.W. Smith, *J. Micro/Nanolith. MEMS MOEMS*. 12(1), 2013.
4. "Scanning interference evanescent wave lithography for sub-22-nm generations," P. Xie, B. W. Smith, J. Micro/Nanolithography, MEMS, and MOEMS. 12(1), 2013.
5. "Lens wavefront compensation for 3D photomask effects in subwavelength optical lithography," M.K. Sears, J. Bekaert, B.W. Smith, *Applied Optics* 52 (3), 314-322, 2013.
6. "Line edge roughness (LER) mitigation studies specific to interference-like lithography,": B Baylav, A Estroff, P Xie, BW Smith, *Proc. SPIE 8683, Optical Microlithography XXVI*, 86831Y, 2013
7. "Pupil wavefront manipulation to compensate for mask topography effects in optical nanolithography," MK Sears, BW Smith, *Proc. SPIE 8683, Optical Microlithography XXVI*, 86830G, 2013.
8. "EUVL resist-based aberration metrology," Germain L. Fenger ; Sudharshanan Raghunathan ; Lei Sun ; Obert R. Wood ; Bruce W. Smith, *Proc. SPIE 8679, Extreme Ultraviolet (EUV) Lithography IV*, 86790P, 2013.
9. "Tuning Metamaterials for Applications at DUV Wavelengths," A. Estroff, B.W. Smith, *Intl. Journal of Optics*, 2012.

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