UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

THE GILLETTE COMPANY, TAIWAN SEMICONDUCTOR MANUFACTURING COMPANY, LTD., TSMC NORTH AMERICA CORP., FUJITSU SEMICONDUCTOR LIMITED, and FUJITSU SEMICONDUCTOR AMERICA, INC.

Petitioners

v.

ZOND, LLC
Patent Owner

Case No. IPR2014-00578[1]

Patent 6,896,775 B2

DECLARATION OF LARRY D. HARTSOUGH, PH.D.

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[1] Case IPR 2014-01494 has been joined with the instant proceeding.

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I, Larry D. Hartsough, do hereby declare:

1. I am making this declaration at the request of patent owner Zond, LLC, in connection with the *Inter Partes* Reviews (IPRs) of U.S. Patent No. 6,896,775 (the "'775 patent"), set forth in the above caption.

2. I am being compensated for my work in this matter at the rate of $300 per hour. I have no interest in the '775 patent and my compensation in no way depends on the outcome of this proceeding.

3. In forming the opinions set forth in this declaration I reviewed a number of materials, including the '775 patent, the file history of the '775 patent, the Petitions for *Inter Partes* Review and the cited references discussed below, the Patent Trial and Appeal Board's (PTAB's) Institution Decisions in these IPR proceedings, the transcripts of the depositions of Mr. Richard DeVito concerning the '775 patent, and the additional materials discussed herein.

I. EDUCATION AND PROFESSIONAL BACKGROUND

4. My formal education is as follows. I received a Bachelors of Science degree in 1965, Master of Science degree in 1967, and Ph.D. in 1971, all in Materials Science/Engineering from the University of California, Berkeley.

5. I have worked in the semiconductor industry for approximately 30 years. My experience includes thin film deposition, vacuum system design, and plasma processing of materials. I made significant contributions to the development of magnetron sputtering hardware and processes for the metallization of silicon integrated circuits. Since the late 1980s, I have also been instrumental in the development of standards for semiconductor fabrication equipment published by the Semiconductor Equipment and Materials International ("SEMI") trade organization.

6. From 1971-1974, I was a research metallurgist in the thin film development lab of Optical Coating Laboratory, Inc. In 1975 and 1976, I developed and demonstrated thin film applications and hardware for an in-line system at Airco Temescal. During my tenure (1977-1981) at Perkin Elmer, Plasma Products Division, I served in a number of capacities from Senior Staff Scientist, to Manager of the Advanced Development activity, to Manager of the Applications Laboratory. In 1981, I co-founded a semiconductor equipment company, Gryphon Products, and was VP of Engineering during development of the product. From 1984-1988, I was the Advanced Development Manager for Gryphon, developing new hardware and process capabilities. During 1988-1990, I was Project Manager at General Signal Thinfilm on a project to develop and prototype an advanced cluster tool for making thin films. From 1991-2002, I was Manager of PVD

(physical vapor deposition) Source Engineering for Varian Associates, Thin Film Systems, and then for Novellus Systems, after they purchased TFS. Since then, I have been consulting full time doing business as UA Associates, where my consulting work includes product development projects, film failure analysis, project management, technical presentations and litigation support.

7. Throughout my career, I have developed and/or demonstrated processes and equipment for making thin films, including Al, Ti-W, Ta, and Cu metallization of silicon wafers, RF sputtering and etching, and both RF and DC magnetron reactive sputtering, for example SiO_2, Al_2O_3, ITO (Indium-Tin Oxide), TiN, and TaN. I have been in charge of the development of two sputter deposition systems from conception to prototype and release to manufacturing. I have also specialized in the development and improvement of magnetically enhanced sputter cathodes. I have experience with related technology areas, such as wafer heating, power supply evaluation, wafer cooling, ion beam sources, wafer handling by electrostatics, process pressure control, in-situ wafer/process monitoring, cryogenic pumping, getter pumping, sputter target development, and physical, electrical and optical properties of thin films.

8. I am a member of a number of professional organizations including the American Vacuum Society, Sigma Xi (the Scientific Research Society), and as a

referee for the Journal of Vacuum Science & Technology. I have been a leader in the development of SEMI Standards for cluster tools and 300mm equipment, including holding various co-chair positions on various standards task forces. I have previously served as a member of the US Department of Commerce's Semiconductor Technical Advisory Committee.

9. I have co-authored many papers, reports, and presentations relating to semiconductor processing, equipment, and materials, including the following:

a. P. S. McLeod and L. D. Hartsough, "High-Rate Sputtering of Aluminum for Metalization of Integrated Circuits", J. Vac. Sci. Technol., 14 263 (1977).

b. D. R. Denison and L. D. Hartsough, "Copper Distribution in Sputtered Al/Cu Films", J. Vac. Sci. Technol., 17 1326 (1980).

c. D. R. Denison and L. D. Hartsough, "Step Coverage in Multiple Pass Sputter Deposition" J. Vac. Sci. Technol., A3 686 (1985).

d. G. C. D'Couto, G. Tkach, K. A. Ashtiani, L. Hartsough, E. Kim, R. Mulpuri, D. B. Lee, K. Levy, and M. Fissel; S. Choi, S.-M. Choi, H.-D. Lee, and H. –K. Kang, "*In situ* physical vapor deposition of ionized Ti and TiN thin films using hollow cathode magnetron plasma source" J. Vac. Sci. Technol. B 19(1) 244 (2001).

10. My areas of expertise include sputter deposition hardware and processes,

thin film deposition system design and thin film properties. I am a named inventor on twelve United States patents covering apparatus, methods or processes in the fields of thin film deposition and etching. A copy of my CV is attached as Attachment A.

II. SUMMARY

11. My opinions in this proceeding are set forth in detail below. Briefly, it is my opinion that none of apparatus or methods recited claims 1-29 of the ‘775 patent would have been obvious to a person of ordinary skill in the art at the time of the invention in view of the combined teachings of *Wang*, *Mozgrin* and *Kudryavtsev*. It is further my opinion that none of the methods or apparatus recited in claims 30-37 of the ‘775 patent would have been obvious to a person of ordinary skill in the art at the time of the invention in view of the combined teachings of *Wang* and *Mozgrin* or *Wang*, *Mozgrin* and *Lantsman*.

12. *Wang* discusses a magnetron sputter reactor in which DC power pulses are applied to a plasma in order to sputter material from a target. While *Wang* describes controlling aspects of these power pulses, *Wang* does not teach controlling voltage amplitude or pulse width when generating a high-density plasma to perform the sputtering. Nor does Wang explain any of the

electrodynamics of the high-density plasma. As I explain below, control of a pulse's power level (as in *Wang*) is very different from controlling the voltage amplitude and rise time of a pulse and even *Wang* acknowledges this distinction.[1] Any voltage pulses disclosed by *Wang* are merely a consequence of the system attempting to deliver the desired power level, i.e., the voltage (and current) are driven by the power supply of *Wang* based upon the desired power level but are determined by the plasma impedance.

13. *Kudryavtsev* describes a flash tube, which is designed to apply a high voltage greater than the breakdown voltage across an inert gas resulting in a brilliant flash of light for a short duration. Flash tubes apply a voltage greater than the breakdown voltage, which may initiate the flash by an arc between the cathode and the anode. *Kudryavtsev* describes a voltage pulse that causes an "explosion" in electron density that appears to cause an arcing condition as shown in his measured voltage and current waveforms. A person of ordinary skill in the art would therefore not refer to *Kudryavtsev* at all when designing a plasma generator, where arcing is an undesirable characteristic.[2]

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[1] *Ex. 1008* at 5:52-54 ("Where chamber impedance is changing, the power pulse width is preferably specified rather than the current or voltage pulse widths.").

[2] *Ex. 1001* at 3:54-56.

14. In my opinion, it would not have been obvious to combine the teachings of *Wang* and *Kudryavtsev*. As I explain further below, there are significant differences between the experimental apparatus of *Kudryavtsev* and the magnetron sputter reactor described by *Wang.* Consequently, a person of ordinary skill in the art would not have expected that applying the teachings of *Kudryavtsev* in a *Wang*-type system would have yielded predictable results or would have performed in an expected way. Behaviors of charged particles (such as electrons and ions) in magnetic fields (as in systems such as those discussed by *Wang*) are vastly different from their behaviors in the absence of magnetic fields (as in systems reported by *Kudryavtsev)*. Petitioners and their expert, Mr. DeVito, fail to account for these differences in their analyses.

15. My conclusions regarding *Wang* and *Kudryavtsev* are not changed when one further considers the teachings of *Mozgrin*. While *Mozgrin* purports to have considered certain dependencies reported by *Kudryavtsev*, *Mozgrin* determined that for systems employing a magnetic field, a supply unit "providing square voltage and current pulses with rise times (leading edge) of 5 – 60 μs and durations as much as 1.5 ms" was needed.[3] *Wang*, on the other hand, was concerned with systems that used magnetic filed but considered it important that pulses have

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[3] *Ex. 1002* at p. 401, rt. col. ¶ 1.

"significant" rise times and pulse widths preferably less than 200 μs and no more than 1 ms.[4] Given these important distinctions in the nature of the supply unit, the teachings of *Mozgrin* would be of little value to a person of ordinary skill in the art when considering the system of *Wang*. Significant experimentation would still be required in order to adapt any teachings of *Mozgrin* to the new regime of *Wang*.

16. It is also my opinion it would not have been obvious to combine the teachings of *Wang* and *Lantsman*. *Lantsman* differs substantially from *Wang*. Whereas *Wang* describes the application of "narrow pulses of negative DC power supplied from a pulsed DC power supply,"[5] *Lantsman* employs two separate power supplies: "[a] secondary power supply [that] pre-ignites the plasma by driving the cathode to a process initiation voltage[, and] a primary power supply [that thereafter] electrically drives the cathode to generate plasma current and deposition on a wafer."[6] *Lantsman* does not disclose a pulsed power supply, any type of electrical pulse, or a strongly-ionized plasma. Consequently, a skilled artisan would not have been motivated to modify *Wang's* pulsed power magnetron

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[4] *Ex. 1008* at 5:26-27, 43-48; 8:41-42.

[5] *Id.* at 5:18-22.

[6] *Ex. 1025,* Abstract.

sputtering system with a system that employs separate, continuous DC power supplies, such as that discussed by *Lantsman*.

17. My opinions in this regard do not change when one considers the additional teachings of *Mozgrin*. Irrespective of any teachings *Lantsman* may or may not provide concerning the provision of a constant voltage, it remains the case that *Mozgrin* disclosed the use of a supply unit "providing square voltage and current pulses with rise times (leading edge) of 5 – 60 μs and durations as much as 1.5 ms . . . ."[7] A system that uses a pulsed discharge supply unit and a voltage pulse, like that of *Mozgrin*, would operate very differently if it were modified to use two DC power supplies and a continuous application of power during deposition, as taught by *Lantsman*. Accordingly, it would not have been obvious to combine the teachings of *Wang, Mozgrin,* and *Lantsman*.

III. LEGAL STANDARDS

18. In this section I describe my understanding of certain legal standards. I have been informed of these legal standards by Zond's attorneys. I am not an attorney and I am relying only on instructions from Zond's attorneys for these legal standards.

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[7] *Ex. 1002* at p. 401, rt. col. ¶ 1.

A. Level of Ordinary Skill in the Art.

19. I understand that a person of ordinary skill in the art provides a reference point from which the prior art and claimed invention should be viewed. This reference point prevents one from using his or her own insight or hindsight in deciding whether a claim is obvious.

20. In my opinion, given the disclosure of the ‘775 patent and the disclosure of the prior art references considered here, I consider a person of ordinary skill in the art at the time of filing of the ‘775 patent to be someone who holds at least a bachelor of science degree in physics, material science, or electrical/computer engineering with at least two years of work experience or equivalent in the field of development of plasma-based processing equipment. I met or exceeded the requirements for one of ordinary skill in the art at the time of the invention and continue to meet and/or exceed those requirements.

B. Claim Interpretation.

21. I understand that the Board has construed the term “strongly ionized plasma” as “a plasma with a relatively high peak density of ions” and has construed the

term “weakly ionized plasma” as “a plasma with a relatively low peak density of ions.” In rendering the opinions set forth herein I have applied these constructions.

22. I also understand that a means plus function claim limitation must be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof. To that end, I understand the Board has adopted the following constructions of means plus function terms in the claims of the ‘775 patent.

Term	**Construction**
“means for ionizing a [volume of] feed gas”	a power supply electrically connected to a cathode, an anode, and/or an electrode
“means for generating a magnetic field”	a magnet assembly having either a permanent magnet or a current source coupled to one or more electro-magnets
“means for applying an electrical field [or pulse]”	a pulsed power supply electrically connected to a cathode, an anode, and/or an electrode
“means for exchanging”	a gas flow control system and structures for supplying the gas to the strongly-ionized plasma
“means for applying a bias voltage”	a bias voltage source electrically coupled to substrate

In rendering the opinions set forth herein I have applied the above constructions, with the exception of the Board's construction for "means for ionizing a [volume of] feed gas." In my opinion, the Board's construction of this term is flawed inasmuch as it fails to account for the important cathode-anode arrangement that is described by Dr. Chistyakov. According to the '775 patent, the anode 238 is positioned adjacent to the cathode assembly "so as to form a gap 244 between the anode 238 and the cathode 216 that is sufficient to allow current to flow through a region 245 between the anode 238 and the cathode 216."[8] "The dimensions of the gap 244 and the total volume of region 245 are parameters in the ionization process . . . ."[9] Because the gap (and the volume resulting therefrom) between the anode and cathode is specifically called out as being a parameter in the ionization process, in my opinion a person of ordinary skill in the art would consider the gap to be a part of the structure of the recited "means for ionization." Therefore, in rendering the opinions set forth herein I have construed the "means for ionizing a [volume of] feed gas" as "a power supply electrically connected to a cathode separated from an anode, and/or an electrode, by a gap there between."

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[8] *Ex. 1001* at 5:15-18.

[9] *Id.* at 5:21-24.

C. Legal Standards for Anticipation.

23. I understand that a claim is anticipated if (i) each and every element and limitation of the claim at issue is found either expressly or inherently in a single prior art reference, and (ii) the elements and limitations are arranged in the prior art reference in the same way as recited in the claims at issue.

D. Legal Standards for Obviousness.

24. I understand that even if a patent is not anticipated, it may still be invalid if the differences between the claimed subject matter and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person of ordinary skill in the pertinent art.

25. I understand that obviousness must be analyzed from the perspective of a person of ordinary skill in the relevant art at the time the invention was made. In analyzing obviousness, I understand that it is important to understand the scope of the claims, the level of skill in the relevant art, the scope and content of the prior art, the differences between the prior art and the claims, and any secondary considerations of non-obviousness. I have not been asked to study or analyze any secondary considerations of non-obviousness. As discussed further below, the prior art references describe systems that are so different from what is claimed that these

do not form a basis for an obviousness determination of the claimed subject matter.

26. I also understand that a party seeking to invalidate a patent as obvious must demonstrate that a person of ordinary skill in the art would have been motivated to combine the teachings of the prior art references to achieve the claimed invention, that the person of ordinary skill in the art would have had a reasonable expectation of success in doing so, and that such determinations are evaluated as of the time the invention was made. I understand that this temporal requirement prevents the forbidden use of hindsight. I also understand that rejections for obviousness cannot be sustained by mere conclusory statements and that Petitioners must show some *reason* why a person of ordinary skill in the art would have thought to combine *particular* available elements of knowledge, as evidenced by the prior art, to reach the claimed invention. I also understand that the motivation to combine inquiry focuses heavily on the scope and content of the prior art and the level of ordinary skill in the pertinent art.

27. In arriving at the opinions set forth herein, I have considered questions of obviousness from the perspective of a person of ordinary skill in the relevant art at the time the invention was made and have given consideration to (1) the scope and content of the prior art; (2) the differences between the prior art and the asserted claims; and (3) the level of ordinary skill in the pertinent art. I have been informed

and understand that the obviousness analysis requires a comparison of the properly construed claim language to the prior art on a limitation-by-limitation basis.

IV. BACKGROUND TOPICS

28. The ‘775 patent relates to “[m]agnetically enhanced plasma processing methods and apparatus.”[10] I understand that IPR2014-00578 was instituted to consider the obviousness of claims 1-7, 9-16, 18-26, 28, and 29 of the ‘775 patent in view of the combined teachings of Wang, et al., U.S. Patent 6,413,382 (Ex. 1008) (“*Wang*”), Mozgrin et al., *High-Current Low-Pressure Quasi- Stationary Discharge in a Magnetic Field: Experimental Research*, Plasma Physics Reports, Vol. 21, No. 5, 1995 (Ex. 1002) (“*Mozgrin*”), and Kudryavtsev, et al, *Ionization relaxation in a plasma produced by a pulsed inert-gas discharge*, Sov. Phys. Tech. Phys. 28(1), January 1983 (Ex. 1003) (“*Kudryavtsev*”); of claim 8 in view of the combined teachings of *Wang*, *Mozgrin*, *Kudryavtsev,* and Kouznetsov, U.S PGPUB 2005/0092596 (Ex. 1004) (“*Kouznetsov*”); of claim 17 in view of the combined teachings of *Wang*, *Mozgrin*, *Kudryavtsev,* and Lantsman, U.S. Patent 6,190,512 (Ex. 1025) (“*Lantsman*”); and of claim 27 in view of the combined teachings of *Wang*, *Mozgrin*, *Kudryavtsev,* and Li et al., *Enhancement of*

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[10] *Ex. 1001* at Abstract.

Aluminum Oxide Physical Vapor Deposition with a Secondary Plasma, 149 Surface and Coatings Tech. pp. 161–170 (2002) (Ex. 1010) ("*Li*"). I also understand that IPR2014-00604 was instituted to consider the obviousness of claims 30-34 and 37 of the '775 patent in view of the combined teachings of *Wang*, *Mozgrin,* and *Lantsman*, of claim 35 in view of the combined teachings of *Wang*, *Mozgrin*, *Lantsman,* and *Kudryavtsev*; and of claim 36 in view of the combined teachings of *Wang* and *Mozgrin*. In this section I provide some background information useful to understanding these cited references and the subject matter claimed in the '775 patent.

A. Voltage, current, impedance and power.

29. As is commonly known, when a voltage "V" is applied across an impedance "I," an electric field is generated that forces a current I to flow through the impedance. For purely resistive impedance, the relation between the voltage and the resultant current is given by: V = I * R.

30. A common analogy is that voltage is like a pressure that causes charged particles like electrons and ions to flow (i.e., current), and the amount of current depends on the magnitude of the pressure (voltage) and the amount of resistance or impedance that inhibits the flow. The '775 patent and the cited references

considered here involve the flow of current through an assembly having a pair of electrodes with a plasma in the region between them. The effective impedance of such an assembly varies greatly with the density of charged particles in the region between the electrodes. Although such an impedance is more complex than the simple resistive impendence of the above equation, the general relation is similar: a voltage between the electrode assembly forces a current to flow through the plasma, such that the amount of current is determined by the amplitude of the voltage and the impedance of the plasma. Thus, the current through the electrode assembly increases with the electrode voltage and, for a given electrode voltage, the current will increase with a drop in the impedance of the plasma.

31. The impedance varies with the charge density of the plasma: With a high density of charged particle the impedance is relatively small, and with a low density of charged particles the impedance is relatively large. Simply, the more ions and electrons to carry the charge, the less resistance. However, the charges and fields react with each other in a very complicated manner.

32. In response to the electric field in the region between the electrodes (i.e., the voltage across the electrodes), all charged particles in the region (the electrons and positive ions) feel a force that propels them to flow. This flow is an electric current "I." The amount of current depends upon the number of charged particles. When

there are no charged particles (i.e., no plasma), there is no current flow in response to the electric field. In this condition, the impendence of the assembly is extremely high, like that of an open circuit. But when there is a dense plasma between the electrodes (with many charged particles), a substantial current will flow in response to the electric field. In this condition, the impendence of the electrode assembly is very low. Thus, in general, the impedance of an electrode assembly varies greatly with the charge density of the plasma: The impedance is effectively infinite (an open circuit) when there is no plasma, and is very low when the charge density of the plasma is very high.

33. It is also well known that electric power (P) is the product of voltage (V) and current (I): P = V * I. Thus, for a given voltage across an electrode assembly, the amount of power will depend on the amount of corresponding current flowing through the electrode assembly. If there is no current flow (such as when there is no plasma between the electrodes), the power is zero, even if the voltage across the electrodes is very large. Similarly, at very low electrode voltages, the power can still be quite high if the current is large.

34. The claims of the ‘775 patent refer to a strongly-ionized plasma that is created by application of an electric field across a gap between a cathode and an anode. In some cases, the electric field is said to have rise times chosen to increase

ionization rates of the plasma. Also, the electric filed may be applied at a constant power or a constant voltage. I consider these and other aspects of the claims of the '775 patent below, but first, to provide context for understanding aspects of the '775 patent, I consider some basic principles of control systems (such as used in power supplies) for controlling various parameters.

B. Control systems.

35. The '775 patent describes a magnetically enhanced plasma processing apparatus that includes a power supply that controls the amplitude and pulse width of an electrical pulse.[11] The pulse produces an electric field in the plasma processing apparatus, and the rise time of the electric field is chosen to increase an ionization rate of excited atoms in a weakly-ionized plasma to generate a strongly-ionized plasma.[12] This power supply is an example of a control system. A simplified block diagram of a common feedback control system is shown the figure below from a text by Eronini.[13]

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[11] See, e.g., *Ex. 1001* at 17:17-24.

[12] *Id*. at 8:63 – 9:5; 17:42-48; and 22:5-7.

[13] *Ex. 2007* at p. 12, Fig. 1.6.

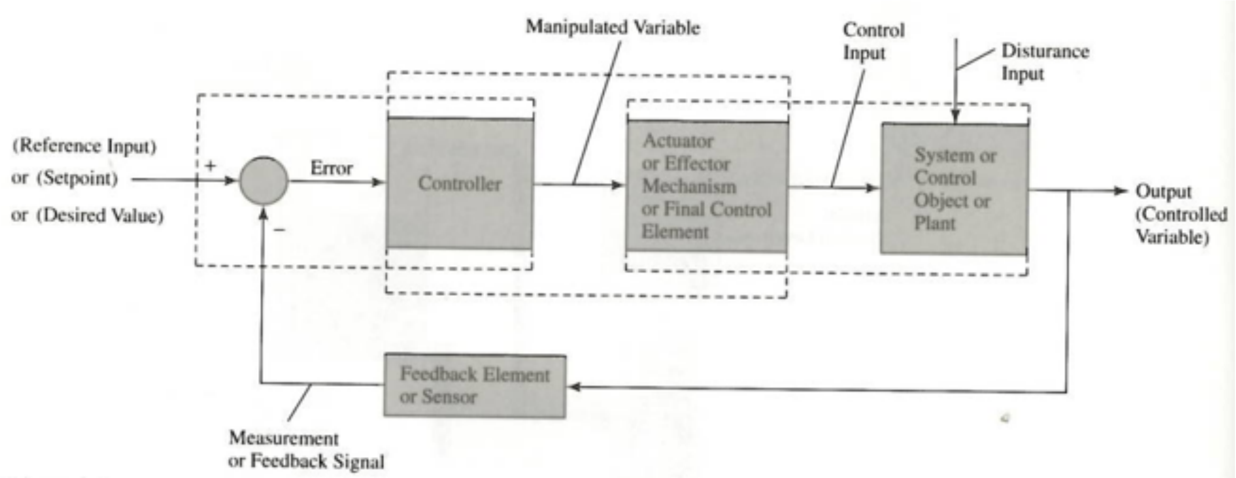

Figure 1: Control system simplified block diagram

36. The "reference input" signal represents a "desired value" or "set-point" of the controller. The control system directly controls the "controlled variable." In response to the difference between the set-point and a feedback signal (which represents the condition of the controlled variable), the control system directs the controlled variable in an attempt to reduce the difference to zero, thereby causing the controlled variable to equal the set point value.

37. For example, the set-point for filling a water tank may be 1,000 gallons, or full. The desired value, set-point or desired level is the value "full" or "1000 gallons." An open loop control system (a control system without any feedback elements) might just fill the tank for a pre-calibrated time that result in the tank being full. The control system might be set to fill the tank once per day based on historical water usage. However, if water usage is not consistent, the tank may run

empty before it is filled, or may overflow because there was less water usage than normal. On the other hand, a closed loop system such as that shown above uses feedback control. For example, it measures the water level, and only adds the needed amount. It might have a switch or sensor that detects when the tank is full, and turns off the flow of water. The set point is the desired value. In such a system, all of the components could be left on in order to fill the tank if its level dropped to low. "Here the comparison of the tank level signal with the desired value of the tank level (entered into the system as a set-point setting) and the turning of the pump on or off are all performed by appropriate hardware in the controller."[14] Further, a closed loop system could be left on to fill the tank if the level dropped too low. "In feedback control, a measurement of the output of the system is used to modify its input in such a way that the output stays near the desired value."[15]

C. Set point (Controlled Parameter).

38. As shown in the above figure from *Eronini*, the parameter that is directed to a desired value is called the "controlled variable." The diagram also shows that while controlling the "controlled variable," the control system may "manipulate"

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[14] *Id.* at p. 12.

[15] *Id.* (internal citations omitted).

another parameter called the "manipulated variable."[16] In this parlance, "[t]he *controlled output* [ ] is the process quantity being controlled" and "[t]he *manipulated variable* [ ] is the control signal which the control elements process."[17] With this understanding, I now consider the difference between controlling the amplitude of a voltage and controlling the power.

D. Power Control vs. Voltage Control.

39. To demonstrate the difference between the control of voltage and the control of power, I will refer to the generic block diagram of a feedback control system from *Eronini*, labeled Figure 1 above. In a system for controlling voltage, the set point is a specified voltage and the controlled variable is voltage. Thus, in such a system, as shown in the above diagram, a feedback signal representative of the measured voltage is fed back and compared to the desired voltage level or set point. Based on the difference between the measured voltage and the desired voltage or set point, the control system drives or restrains the voltage in an attempt to move the actual voltage to match the desired voltage.

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[16] *Id*. at p. 12, Fig. 1.6; see also *Ex. 2008* at p. 13, Fig. 1-21.

[17] *Id.* (emphasis in original).

40. In a system for controlling power, the set point is a specified power value and the controlled variable is power. In such a system, the voltage and/or current can be driven by the control system to whatever levels are needed to achieve the target power level. Thus, in the example of a system for controlling the power of a plasma electrode assembly, if there is no plasma between the electrodes (and therefore little or no current) a controller attempting to achieve a target power level will drive the voltage extremely high in an attempt to achieve the target power P; i.e., P = V * I, and because I is very low (or zero) in this situation, V will be very high.

41. Thus, in a control system for controlling power to a desired set point, voltage will vary as the controller attempts to achieve the desired power level (i.e., a desired product of voltage and current). However, the amplitude of the voltage is not controlled and instead the voltage and/or the current vary as needed to achieve the desired power.

42. In addition to power, voltage and/or current levels, one may also need to consider the "rise time" of a controlled parameter. A "rise time" is the time required for the value of the controlled parameter to be driven from one level to another level.

43. The rise time of a voltage is a different parameter that the rise time of power.

For example, consider a scenario in which a voltage source outputs a constant voltage. If that source is connected across an impedance that gradually drops, the current will increase as the impedance drops. Since power is the product of voltage (here a constant) and current, the power will rise as the current increases. Thus, in this situation, power rises at rate determined by the rate at which the impedance decreases. But there is no rise in voltage because the source maintains a static, constant voltage at its output in this example. This demonstrates that a rise time in voltage is a different parameter than rise time in power.

44. This example can also be used to demonstrate the difference between a controlled change in the output of a voltage source, and a reaction to a change in impedance. If the impedance drops so fast that the voltage source cannot maintain the voltage at its target level, the voltage output by the source can drop due to limitations of the voltage source. This drop in voltage is not a controlled drop, caused by the power supply in response to a programmed change in the voltage set point: It is a transient drop caused by a change in the impedance load that exceeds the capacity of the voltage source.

E. Plasmas.

45. Plasma is a distinct state of matter characterized by a significant number of

electrically charged particles. In an ordinary gas, each atom or molecule contains an equal number of positive and negative charges, so that each is electrically "neutral." When those atoms or molecules are subjected to heat or other energy, they begin to lose electrons and are left with a positive charge. This process is called ionization. When enough gas atoms or molecules have been ionized such that the ions, together with the free electrons, significantly affect the electrical characteristics of the substance it is said to be plasma. Although made up of charged particles the plasma remains electrically neutral overall.

46. Common examples of the use of plasmas include applications in neon signs and fluorescent lights. Plasmas are also used in a number of industrial processes, including the manufacture of semiconductor devices. To that end, consider an object (hereinafter referred to as a "target") in or near a plasma. If the target (or an object in its vicinity) is made electrically negative compared to the plasma, positively charged ions in the plasma will be accelerated towards the target. At the surface of the target, a number of different interactions can occur (see Figure 2, below).

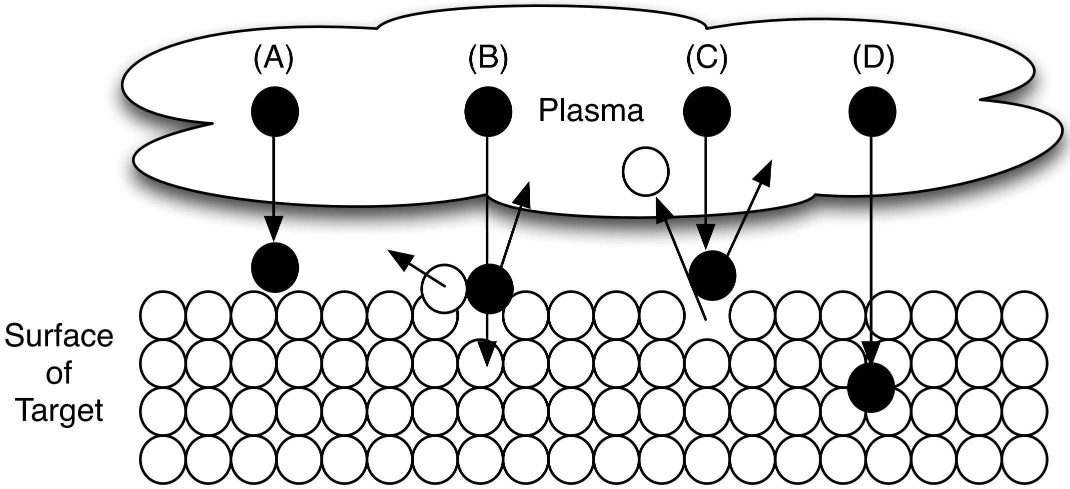

Figure 2: Interactions at a target's surface

47. In Figure 2, an arriving ion is "adsorbed" onto the surface of the target at (A). Adsorption is an adhesion of ions (or other particles) to a surface and is typically a low energy process, which is dominant around a few tens of eV, or less. At (B), the incoming ion transfers some of its momentum to one of the target's surface atoms and causes it to move. This is called displacement. If the energy of the incoming ion is sufficiently high, say on the order of 100 eV or more, surface atoms of the target may be removed in a process referred to as sputtering (shown in (C)). If the ion energy is even greater, say above 1 keV, then it may be implanted into the target (at (D)). These various processes form the bases of a number of plasma-assisted semiconductor manufacturing techniques.

F. Plasma ignition.

48. To ignite a plasma, a gas is introduced in a space between two electrodes, for example in a tube or other container, and an electric field is applied between the electrodes. A simplified example of such an arrangement is shown in Figure 3.

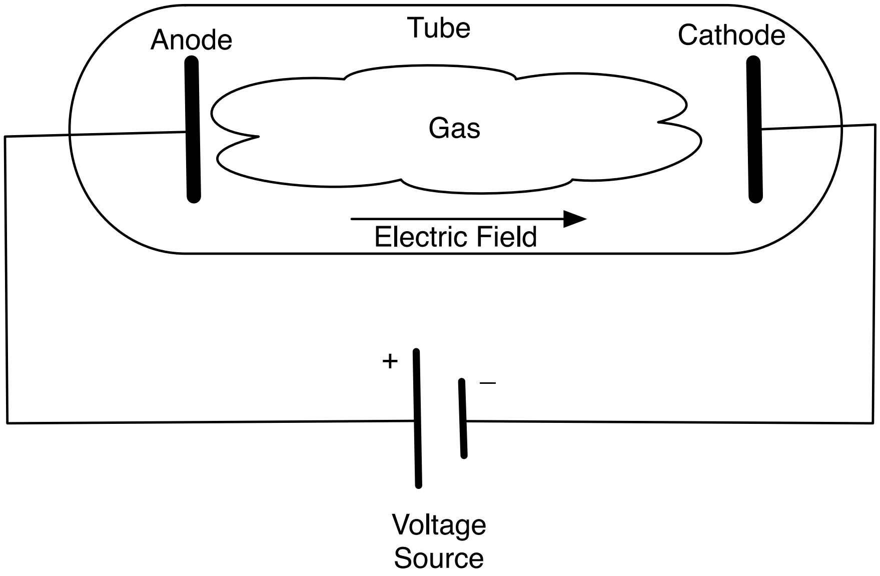

Figure 3: Simplified plasma system

Even at room temperature, the gas will contain a small number of ions and free electrons. These ions and electrons are accelerated towards the electrically negative electrode (the "cathode") and the electrically positive electrode (the "anode"), respectively. As electrons collide with gas atoms, they produce new ions.

49. When the ions are in close proximity to the cathode (e.g., on the order of a

few Angstroms), electrons can tunnel from the cathode, and the ions are neutralized. When an ion is neutralized, some amount of energy (corresponding to the ionization energy of the ion) is released. If this energy is transferred to a surface electron at the cathode (via an Auger process) and it is greater than the electron work function, new electrons (so-called "secondary electrons") are emitted into the gas from the cathode. These secondary electrons are accelerated towards the anode, and when they collide with gas atoms they generate new ions and free electrons. By the addition and acceleration of new electrons, the process of ionization proceeds; and, if the applied power is sufficiently high, a plasma is created.

G. High-Density Plasmas.

50. The '775 patent is particularly concerned with high-density plasmas, for example, plasmas having a density greater than 10^{12} cm^{-3}.[18] As explained by Dr. Chistyakov, denser plasmas, i.e., those with a relatively high concentration of ions per unit volume, provide more rapid etching of substrates in vicinities directly adjacent the higher concentration of ions.[19] Magnetron reactors develop high-

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[18] See, e.g., *Ex. 1001* at 23:31-33.

[19] *Id*. at 3:38-44.

density plasmas using a magnetic field configured parallel to a target surface. The magnetic field constrains the secondary electrons ejected by the bombarding ions to the vicinity of the target surface. The ions are also subject to the same forces and tend to concentrate in the same region, maintaining the quasi-electrical neutrality of the plasma.[20] The trapping of electrons and ions creates a dense plasma, which, in turn, leads to an increased ion bombardment of the target, leading to higher etching rates.

51. Conventional magnetron systems of the kind just described suffer from undesirable, non-uniform erosion or wear of the target that results in poor target utilization.[21] To address these problems, researchers tried increasing the applied power and later pulsing the applied power. However, increasing the applied power increased "the probability of establishing an electrical breakdown condition leading to an undesirable electrical discharge (an electrical arc) in the chamber."[22] Even the pulsed approach, in which the power is delivered over many pulses in an attempt to keep the average power relatively low, is accompanied by risks. For example, "very large power pulses can still result in an electrical breakdown

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[20] *Id.* at 3:34-40.

[21] *Id.* at 3:41-44.

[22] *Id.* at 3:51-56.

condition regardless of their duration [and] [a]n undesirable electrical discharge will corrupt the [ ] process . . . ."[23] An abrupt large increase in applied voltage can cause localized instabilities in electric fields to be large enough to initiate an arc on the cathode, even if a low-density discharge is already present.

52. This latter point deserves further explanation. There are large changes in plasma impedance between the stages that occur during a pulsed DC magnetron discharge. The more charged particles within a plasma, the more electrically conducting it becomes. During ignition, the impedance may be in the hundreds of ohms, dropping to the tens of ohms in the low-density mode. In the transition from a low-density to a high-density plasma, the impedance drops to a few ohms, accompanied by up to two orders of magnitude increase in current. Depending on power supply design and control settings, the density of the plasma may increase quite unevenly, also leading to the possibility of plasma breakdown or arcs, if the transitions are uncontrolled. Thus, pulsed DC magnetron systems prior to the '775 patent were prone to arcing, for example upon igniting the plasma and when working with high-power pulses.[24] Such arcing can result in the release of undesirable particles in the chamber that can contaminate the sample, which is

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[23] *Id.* at 3:63-65.

[24] *Id.* at 3:62-66; *Ex. 1008* at 7:3-6, 46-48.

especially undesirable in semiconductor processing.[25]

53. To overcome some of the deficiencies of the prior art, Dr. Chistyakov invented a magnetically enhanced plasma processing apparatus and corresponding method in which:

> An ionization source generates a weakly-ionized plasma proximate to the cathode. A magnet is positioned to generate a magnetic field proximate to the weakly-ionized plasma. The magnetic field substantially traps electrons in the weakly-ionized plasma proximate to the cathode. A power supply produces an electric field in a gap between the anode and the cathode. The electric field generates excited atoms in the weakly-ionized plasma and generates secondary electrons from the cathode. The secondary electrons ionize the excited atoms, thereby creating a strongly-ionized plasma. A voltage supply applies a bias voltage to a substrate that is positioned proximate to the cathode that causes ions in the plurality of ions to impact a surface of the substrate in a manner that causes etching of the surface of the substrate.[26]

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[25] *Ex. 1001* at 3:64 – 4:1; *Ex. 1008* at 7:3-8.

[26] *Ex. 1001* at Abstract.

54. As illustrated in Fig. 2 of the ‘775 patent, Dr. Chistyakov’s magnetically enhanced plasma processing apparatus includes a chamber 202 in which is disposed a substrate 211, an anode 238 and a cathode 216.[27] The anode 238 is positioned adjacent to the cathode assembly “so as to form a gap 244 between the anode 238 and the cathode 216 that is sufficient to allow current to flow through a region 245 between the anode 238 and the cathode 216.”[28] “The dimensions of the gap 244 and the total volume of region 245 are parameters in the ionization process . . . .”[29] “[A] pulsed power supply 234 is a component of an

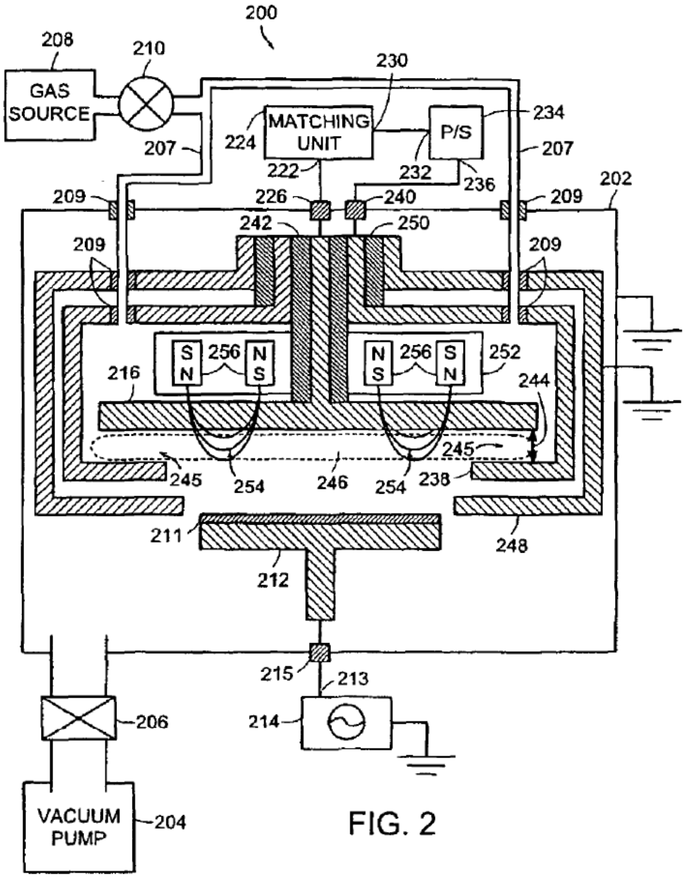

FIG. 2

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[27] *Id.* at 4:14-15, 31-32, 42-43, and 53-54.

[28] *Id.* at 5:15-18.

[29] *Id.* at 5:21-24.

ionization source that generates the weakly-ionized plasma,"[30] by "appl[ying] a voltage pulse between the cathode 216 and the anode 238."[31] "The amplitude and shape of the voltage pulse are such that a weakly-ionized plasma is generated in the region 246 between the anode 238 and the cathode 216."[32] "[T]he peak plasma density of the [weakly-ionized] plasma depends on the properties specific plasma processing system."[33]

55. "Once the weakly-ionized plasma is formed, high-power pulses are then generated between the cathode 216 and the anode 238."[34] "The desired power level of the high power pulse depends on several factors including the nature of the etch process, desired etch rate, density of the pre-ionized plasma, and the volume of the plasma."[35] "The high-power pulses generate a strong electric field . . . across the gap 244 between the cathode 216 and the anode 238. . . . [and] generate a highly-

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[30] *Id.* at 6:1-3.

[31] *Id.* at 6:3-4.

[32] *Id.* at 6:6-9.

[33] *Id.* at 6:14-16.

[34] *Id*. at 7:16-18.

[35] *Id*. at 7:19-22.

ionized or a strongly-ionized plasma from the weakly-ionized plasma."[36] Because "the substrate 211 is biased more negatively than the cathode 216[,] [t]he positively charged ions in the strongly-ionized plasma accelerate towards the substrate 211. The accelerated ions impact a surface of substrate 211, causing the surface of the substrate 211 to be etched."[37]

56. As explained by Dr. Chistyakov, "the ion flux density of the strongly-ionized plasma and the ion energy of the ions in the strongly-ionized plasma [can be] independently controlled. [For example], the ion flux density is controlled by adjusting the power level and the duration of the high-power pulses generated by the pulsed power supply 234[, while] the ion energy of the ions that strike the substrate 211 and cause the surface of the substrate 211 to be etched is controlled by adjusting the negative substrate bias voltage generated by the bias voltage source 214 (FIG. 2)."[38] Further, "the strongly-ionized plasma tends to diffuse homogenously in the region 246 and, therefore tends to create a more homogeneous plasma volume. The homogenous diffusion results in accelerated ions impacting the surface of the substrate 211 in a more uniform manner than with

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[36] *Id*. at 7:36-52.

[37] *Id*. at 7:59-63.

[38] *Id*. at 7:66 – 8:8.

a conventional plasma etching system. Consequently, the surface of the substrate is etched more uniformly."[39]

V. SCOPE AND CONTENT OF THE PRIOR ART.

A. Wang.

57. *Wang* discusses "[a] pulsed magnetron sputter reactor [with] a high plasma density."[40] In this reactor, "narrow pulses of negative DC power" are used to sputter material from a target.[41] In one example, *Wang* indicates that the pulses are applied to both ignite the plasma and maintain it,[42] while in another example *Wang* describes maintaining the plasma using a background power level with the pulses applying a much greater peak power to increase the density of the plasma.[43] In both

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[39] *Id*. at 8:9-15.

[40] *Ex. 1008* at 3:16-22.

[41] *Id*. at 5:19-20.

[42] *Id*. at 5:29-30.

[43] *Id*. at 7:13-30.

examples it is the power applied to a cathode target that is driven to a prescribed level, not voltage.[44]

58. As is known in the art, power (P) is the product of voltage (V) and current (I): P = V * I. Therefore, when *Wang* specifies a power supply output (e.g., as illustrated in Wang's Figs. 4 and 6), this is understood to be a combination (a product) of voltage and current. Stated differently, *Wang* does not teach controlling the amplitude of a voltage pulse (or a resulting electric field) when generating a high-density plasma, but rather teaches controlling the power applied to the cathode.

59. This is not merely a difference in semantics. *Wang* acknowledges there is a substantive difference between controlling power and controlling voltage, and chooses to control power parameters rather than those of current or voltage:

> Where chamber impedance is changing, the power pulse width is preferably specified rather than the current or voltage pulse widths.[45]

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[44] *Id*. at 5:18-20; 7:13-30; and see 5:52-54 ("Where chamber impedance is changing, the power pulse width is preferably specified rather than the current or voltage pulse widths.").

[45] *Ex. 1008* at 5:52-54.

Thus, unlike the ‘775 patent, in which the rise time of the electric field is chosen to increase an ionization rate of excited atoms in a weakly-ionized plasma to generate a strongly-ionized plasma,[46] *Wang* discloses a very different approach to achieving a high density plasma. In particular, *Wang* does not control voltage (or the resulting electric field) rise time for any purpose, and certainly not for the purpose of achieving an increase in ionization rate.

60. *Wang's* elections in this regard have consequences because when it comes to manipulating plasma density, control of electrode power can yield substantially different results than control of voltage amplitude and rise time: Constant power pulses have a voltage and current that can vary significantly as the system attempts to control the power to a desired level. Since such power supplies are designed to control the product of voltage and current to a target level, they can drive the voltage extremely high when the current is near zero (e.g., before plasma ignition or when the plasma density is low) as they attempt to maintain the target power level.[47] As a result, power pulses will tend to produce an arc during the ignition of the plasma, as observed by *Wang*:

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[46] *Id*. at 8:63 – 9:5; 17:42-48; and 22:5-7.

[47] *Ex. 1008* at 5:32-33.

> Plasma ignition, particularly in plasma sputter reactors, has a tendency to generate particles during the initial arcing, which may dislodge large particles from the target or chamber.[48]

61. *Wang* does not discuss any of the electrodynamics of the high-density plasma, but does describe some reactor characteristics, at least by reference. For example, although *Wang* does not specify what "low pressure" means in terms of operating conditions, *Wang* does refer to *Chiang*, which specifies pressures below 5 mTorr and preferably below 1 mTorr.[49] Likewise, although *Wang* does not specify actual dimensions for the subject magnetron sputter reactor, readers are again referred to *Chiang* for such details: "Most parts of this reactor have already been described by Chiang et al."[50] *Chiang* discloses a source to substrate spacing of 14-29 cm, and extension of a floating shield to 6-10 cm from the target (source).[51] Thus, readers could reasonably conclude that *Wang's* anode would preferably be at least 10-14 cm from the cathode.

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[48] *Ex. 2008* at 7:3-6.

[49] See, e.g., *Ex. 2009* at Abstract; 6:60-62.

[50] *Ex. 1008* at 3:60-61.

[51] *Ex. 2009* at 14:37-50; 6:66 – 7:2.

B. Kudryavtsev.

62. *Kudryavtsev* reports on “ionization relaxation” in a plasma when an external electric field is suddenly increased.[52] More particularly, *Kudryavtsev* is a study to determine how well or poorly a set of measured data fits into a simplified, analytically-solvable model for the initial stage of an inert gas pulsed discharge plasma in a flash tube. A flash tube is comprised of a sealed glass tube filled with an inert gas such as Argon with a cathode and an anode at either end to apply an electric field to the gas. Flash tubes are designed to apply a high voltage greater than the breakdown voltage across the inert gas, resulting in a simultaneous excitation and ionization of the gas and finally in a brilliant flash of light for a short duration. Flash tubes apply a voltage greater than the breakdown voltage, which may initiate the flash by an arc between the cathode and the anode.

63. *Kudryavtsev* predicts that electron density can “increase explosively” if an electric field is applied long enough to a pre-ionized gas in the tube.[53] Using the specified mathematical model (which presumes a tubular shaped assembly of radius R and, apparently, no magnetic field) *Kudryavtsev* shows that the electron

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[52] *Ex. 1003* at p. 30, left col, ¶ 1.

[53] *Id*. at p. 32, rt. col. ¶ 1.

density initially grows very slowly for a period of time designated "τ_s" but then enters a "fast stage:" "[O]nce steady conditions have been reached during the fast stage, ionization builds up explosively when the external field is constant."[54]

64. *Kudryavtsev's* work is targeted for "pulsed gas lasers, gas breakdown, laser sparks, etc."[55] The pressures or gas densities reported by *Kudryavtsev* are much higher than those used for sputtering.[56] Moreover, *Kudryavtsev's* experimental system involved a 2.5 cm diameter tube with two electrodes spaced 52 cm apart. This apparatus did not use magnets or magnetic fields.[57]

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[54] *Id*. at p. 32, left col. ¶ 1; and see p. 32, rt. col. ¶ 1 ("We see by inspecting the form of the above solutions that n_e builds up explosively with time.").

[55] *Id.* at p. 34, right col, ¶ 4.

[56] See, e.g., *Id.* at p. 32, FIG. 3 (reporting pressures of 11.4 Torr and 3.7 Torr); p. 33, FIG. 5 (11.4 Torr) and *cf. Ex. 2009* at Abstract, 6:60-62, which specifies pressures preferably below 1 mTorr.

[57] *Ex. 1003*, p. 32, right col, ¶ 4.

C. Mozgrin.

65. *Mozgrin* relates to "high-power quasi-stationary low-pressure discharge in a magnetic field."[58] "Two noncontracted discharge regimes in crossed E and H fields were studied."[59] The study used two "[d]ischarge device configurations: (a) planar magnetron; (b) shaped-electrode configuration."[60] The planar magnetron included "a plane cathode 120mm in diameter and a ring-shaped anode 160 mm in diameter."[61] "The system with shaped electrodes involved two hollow axisymmetrical electrodes 120 mm in diameter separated by about 10mm, and immersed in a cusp-shaped magnetic field produced by oppositely directed multilayer coils."[62]

D. Lantsman.

66. *Lantsman* relates to "a power supply circuit which reduces oscillations

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[58] *Ex. 1002* at p. 400, Abstract.

[59] *Id*.

[60] *Id*. at p. 401, Figs. 1a and 1b.

[61] *Id*. at p. 400, rt. col. ¶ 5.

[62] *Id*. at p. 401, left col. ¶ 2.

generated upon ignition of a plasma within a processing chamber."[63] In particular, *Lantsman's* circuit has two power supplies: "[a] secondary power supply pre-ignites the plasma by driving the cathode to a process initiation voltage. Thereafter, a primary power supply electrically drives the cathode to generate plasma current and deposition on a wafer."[64] Significantly, *Lantsman* does not disclose a pulsed power supply, any type of electrical pulse, or even a strongly-ionized plasma as recited in the claims of the '775 patent. *Lantsman* thus differs substantially from both *Wang* and *Mozgrin*. Whereas *Wang* is concerned with a "target 14 [ ] powered by narrow pulses of negative DC power supplied from a pulsed DC power supply,"[65] and *Mozgrin* discloses a "pulsed discharge supply unit,"[66] *Lantsman* relies on separate power supplies, one to ignite a plasma and the other to provide power for an entire deposition period.[67] Systems that use a pulsed discharge supply unit, like those of *Wang* and *Mozgrin*, would operate very differently if modified to use two DC power supplies as taught by *Lantsman*, requiring significant changes to

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[63] *Ex. 1025* at Abstract.

[64] *Id.*; see also 4:11 and 4:19 (describing two DC power supplies).

[65] *Ex. 1008* at 5:18-22.

[66] *Ex. 1002* at p. 401, left col, ¶ 5.

[67] *Ex. 1025* at Fig. 6; 2:49-51; 4:33-37; 5:42-52.

semiconductor processing methods employing such apparatus. Petitioners failed to provide any objective evidence that a skilled artisan would have been motivated to modify *Wang* and/or *Mozgrin* in such a fashion, and in my opinion there would be no such motivation. Indeed, inasmuch as *Lantsman* fails to even mention strongly-ionized plasma, there appears to be little, if any, reason for a person of ordinary skill in the art to have consulted *Lantsman* for any relevant teachings concerning systems in which an electrical pulse is applied across a weakly-ionized plasma to generate a strongly-ionized plasma, as recited in the ‘775 patent.

VI. CLAIM ANALYSIS VIS-À-VIS THE CITED REFERENCES

A. It Would Not Have Been Obvious To Combine the Teachings of *Wang*, *Mozgrin* and *Kudryavtsev* To Achieve the Invention Claimed in the ’775 Patent.

67. It is my opinion that it would not have been obvious to combine the teachings of *Wang*, *Mozgrin* and *Kudryavtsev* to achieve the invention recited the claims of the ’775 patent. In support of their obviousness contentions, Petitioners assert that, “it would have been obvious to combine Wang and Kudryavtsev . . . [b]ecause Wang applies pulses that ‘suddenly generate an electric field,’ [hence] one of ordinary skill in the art reading Wang would have been motivated to

consider Kudryavtsev to further appreciate the effects of applying Wang's pulse."[68] However, given the marked differences between the experimental apparatus of *Kudryavtsev* and the magnetron sputter reactor described by *Wang,* a person of ordinary skill in the art would not have expected that applying the teachings of *Kudryavtsev* in a *Wang*-type system would have yielded predictable results or would have performed in an expected way.

68. *Kudryavtsev's* theoretical work is targeted for "pulsed gas lasers, gas breakdown, laser sparks, etc."[69] Moreover, *Kudryavtsev's* experimental system involved a 2.5 cm diameter tube between two electrodes spaced 52 cm apart. This apparatus did not use magnets or magnetic fields.[70]

69. *Wang*, on the other hand, discusses "[a] pulsed magnetron sputter reactor [with] a high plasma density."[71] Magnetron sputter reactors achieve their high plasma densities specifically through the use of magnetic fields, which trap secondary electrons near the target increasing the probability that these electrons will collide with gas atoms and create additional ions and free electrons. One of

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[68] Corrected Pet. at p. 41 (citing *Ex. 1011* at ¶ 157).

[69] *Ex. 1003*, p. 34, right col, ¶ 4.

[70] *Ex. 1003*, p. 32, right col, ¶ 4.

[71] *Ex. 1008* at 3:16-22.

ordinary skill in the art would not be motivated to apply teachings related to the application of an electric field to a weakly ionized gas across a space of 52 cm unaffected by a magnetic field to a pulsed magnetron sputter reactor characterized by a "magnetic field near the face of the target [ ] which traps electrons from [a] plasma to increase the electron density."[72] There would be no predictable results to be achieved by such an experiment, for example because it was known at the time of the invention that "very large power pulses can still result in an electrical breakdown condition regardless of their duration[, and] undesirable electrical discharge will corrupt the etching process, caus[ing] contamination in the vacuum chamber . . . ."[73] Moreover, the behaviors of charged particles (such as electrons and ions) in magnetic fields are vastly different from their behaviors in the absence of magnetic fields. The examples of instances cited by *Kudryavtsev* (pulsed gas lasers, gas breakdown and laser sparks) are not indicative of conditions within a magnetron sputter reactor (such as that described by *Wang*). Hence, one could not expect that models derived for such applications (and experiments designed to confirm such models) would be directly applicable to magnetron sputter reactors.

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[72] *Ex. 1008* at 4:24-26.

[73] *Ex. 1001* at 3:63-66.

70. Much of Petitioners' argument seems to be based on the levels of operating parameters specified by *Wang* and similarities of those parameters to conditions disclosed in the '775 patent.[74] But such comparisons belie Petitioner's attempt to imply that the combination of *Wang* and *Kudryavtsev* would be one that would be made by a person of ordinary skill in the art. For example, Petitioners note, "Wang describes its [sic] process as 'low pressure.'"[75] Petitioners contend that this means a working pressure of 1-1000 mTorr.[76] I disagree with this. Although *Wang* does not specify what the authors mean by "low pressure," *Wang* does refer to *Chiang*, which specifies pressures below 5 mTorr and preferably below 1 mTorr.[77] Such working pressures are well below those reported by *Kudryavtsev*, for example in Figure 3 where results for pressures of 3.7 and 11.4 Torr are noted.[78] Thus, Petitioners' own arguments contradict the very rationales for the combination of teachings being advanced.

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[74] See, e.g., Corrected Pet. at pp. 41-44.

[75] *Id*. at p. 43 (citing *Ex. 1008* at 7:32-36).

[76] *Id*.

[77] See, e.g., *Ex. 2009* at Abstract, 6:60-62.

[78] *Ex. 1003* at p. 32, FIG. 3.

71. Petitioners also seem to ignore, or at least conveniently overlook, what the actual combination of the teachings of *Wang* and *Kudryavtsev* might suggest. *Wang* does not specify actual dimensions for the subject magnetron sputter reactor, but does refer readers to *Chiang* for such details: "Most parts of this reactor have already been described by Chiang et al."[79] *Chiang* discloses a throw (source to substrate) of 14-29 cm, and extension of a floating shield to 6-10 cm from the target (source).[80] Thus, Wang's anode would preferably be at least 10-14 cm from the cathode. *Kudryavtsev* reports, "the distance between the electrodes was L = 52 cm."[81] Thus, any combination of *Wang* and *Kudryavtsev,* to the extent such a combination would be made by a person of ordinary skill in the art, would suggest a system having a long throw. The '775 patent, in sharp contrast to both *Wang* and, especially, *Kudryavtsev* discloses a "gap 244 is between approximately 0.3 cm and 10 cm."[82] That is, the *Kudryavtsev* apparatus operates using a gap more than five times the length of the gap specified in the '775 patent[83] and, to the extent *Wang*

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[79] *Ex. 1008* at 3:60-61.

[80] *Ex. 2009* at 14:37-50; 6:66 – 7:2.

[81] *Ex. 1003*, p. 32, right col, ¶ 4.

[82] *Ex. 1001* at 5:19-20.

[83] *Ex. 1004 at* p. 32, right col, ¶ 6.

relies on *Chiang*, *Wang* teaches a preference for longer gaps and not the magnetically enhanced plasma processing apparatus having a gap between approximately 0.3 cm and 10 cm taught by Dr. Chistyakov. While the dimensions of the gap are not recited in the claims of the ‘775 patent (except that it is “adjacent” the anode, meaning next to with nothing in between) one must consider what the actual scope and content of the prior art is, and the conclusions the teachings of prior art references would lead to when considering the obviousness question as a whole. Here, it seems that any combination of the teachings of *Wang* and *Kudryavtsev*, to the extent such a combination could be made, would suggest to the person of ordinary skill in the art that any apparatus seeking to employ such teachings should, at a minimum, be characterized by an anode-cathode spacing significantly different from that advocated by Dr. Chistyakov and, therefore, that such teachings would not be applicable to an apparatus or method such as that described in the ‘775 patent. Indeed, Petitioners failed to explain *why* combining the teachings of a tubular gas discharge device designed to operate with a gap of 52 cm, as in *Kudryavtsev*, with a sputtering device with a substantially smaller gap and different geometry, as taught by *Wang*, would have led to an expected result, particularly in a system like that of the ‘775 patent having a gap that is between 1/5th and 1/170th the length of *Kudryavtsev’s* gap and no interposed floating shield.

72. My conclusions regarding *Wang* and *Kudryavtsev* are not changed when one further considers the teachings of *Mozgrin* cited by Petitioners. *Mozgrin* relates to "high-power quasi-stationary low-pressure discharge in a magnetic field."[84] Although it is true, as Mr. DeVito indicates, that "Mozgrin's Fig. 1 shows a cathode labeled '1', and an anode labeled '2,' forming a gap between them,"[85] there is no teaching in *Mozgrin* as to its importance. In Dr. Chistyakov's '775 patent the dimensions and volume of the gap are important parameters in the ionization process, as I pointed out above. The fact that *Mozgrin* shows a gap adds no teaching to aid in combining *Wang* and *Kudryavtsev*. Further, while it is true that *Mozgrin* took into account certain dependencies reported by *Kudryavtsev* in designing a pulsed supply unit,[86] this does not imply that one or ordinary skill in the art would have combined the teachings of *Wang* and *Kudryavtsev*. *Mozgrin* determined that for systems employing a magnetic field, a supply unit "providing square voltage and current pulses with rise times (leading edge) of 5 – 60 μs and durations as much as 1.5 ms" was needed.[87] *Wang*, on the other hand was

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[84] *Ex. 1002* at p. 400, Abstract.

[85] *Ex. 1011* at ¶ 91.

[86] *Ex. 1002* at p. 401, rt. col.

[87] *Id*.

concerned with regimes in which pulses had "significant" rise times and pulse widths were preferably kept to less than 200 μs and no more than 1 ms.[88] Given these important distinctions in the nature of the supply unit, the teachings of *Mozgrin* would be of little value to a person of ordinary skill in the art when considering the system of *Wang*. Significant experimentation would still be required in order to adapt any teachings of *Mozgrin* to the regime of *Wang*.

B. It Would Not Have Been Obvious To Combine the Teachings of *Wang*, *Mozgrin* and *Lantsman* To Achieve the Invention Claimed in the '775 Patent.

73. My opinion does not change if one considers the teachings of *Lantsman* instead of (or even in addition to) those of *Kudryavtsev*. Irrespective of any teachings *Lantsman* may or may not provide concerning the provision of a constant voltage,[89] it remains the case that *Wang* and *Mozgrin* operated in very different regimes. For example, *Mozgrin* determined that for systems employing a magnetic field, a supply unit "providing square voltage and current pulses with rise

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[88] *Ex. 1008* at 5: 26-27, 43-48; 8:41-42.

[89] And here I note that insofar as there is any constant voltage applied, it appears to be for an entire deposition period. See, e.g., *Ex. 1025* at Fig. 6.

times (leading edge) of 5 – 60 μs and durations as much as 1.5 ms" was required.[90] *Wang*, on the other hand was concerned with regimes in which pulses had "significant" rise times and pulse widths were preferably kept to less than 200 μs and no more than 1 ms.[91] Given these important distinctions in the nature of the supply unit, the teachings of *Mozgrin* would be of little value to a person of ordinary skill in the art when considering the system of *Wang*. Significant experimentation would still be required in order to adapt any teachings of *Mozgrin* to the new regime of *Wang*.

74. Moreover, as I discussed above, *Lantsman* teaches the use of two power supplies: "[a] secondary power supply pre-ignites the plasma by driving the cathode to a process initiation voltage. Thereafter, a primary power supply electrically drives the cathode to generate plasma current and deposition on a wafer,"[92] and fails to discuss any pulsed power supply, electrical pulse, or strongly-ionized plasma. *Lantsman* thus differs substantially from both *Wang* and *Mozgrin* in these important regards. Systems that use a pulsed discharge supply unit, like those of *Wang* and *Mozgrin*, would operate very differently if modified to use two

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[90] *Ex. 1002* at p. 401, rt. col. ¶ 1.

[91] *Ex. 1008* at 5:26-27, 43-48; 8:41-42.

[92] See, e.g., *Ex. 1025* at 4:11 and 4:19 (describing two DC power supplies).

DC power supplies, one of which supplies power for an entire deposition period, as taught by *Lantsman*. Such modifications would be significant changes to semiconductor processing methods employing such apparatus and a person of ordinary skill in the art would need to undertake significant experimentation with such equipment to understand how the plasma was affected. Petitioners failed to provide any objective evidence that a skilled artisan would have been motivated to modify *Wang* and/or *Mozgrin* in such a fashion, and in my opinion there would be no such motivation. Indeed, inasmuch as *Lantsman* fails to even mention strongly-ionized plasma, there appears to be little, if any, reason for a person of ordinary skill in the art to have consulted *Lantsman* for any relevant teachings concerning systems in which an electrical pulse is applied across a weakly-ionized plasma to generate a strongly-ionized plasma.

C. The Combination of *Wang*, *Mozgrin* and *Kudryavtsev* Does Not Suggest "a cathode that is positioned adjacent to the anode and forming a gap there between," as Recited in Independent Claim 1.

75. It is my opinion that the combination of *Wang*, *Mozgrin* and *Kudryavtsev* does not suggest "a cathode that is positioned adjacent to the anode and forming a gap there between," as recited in independent claim 1.

76. Petitioners admit there are differences between the arrangement of the anode

and cathode taught by *Wang* and that required by the ‘775 patent.[93] In fact, I agree with Petitioners that “the gap shown in Wang is not identical to the gap shown in the ‘775 Patent between the cathode/target 14 and the anode 24.”[94] The ‘775 patent requires “a power supply that produces an electric field across the gap, the electric field generating excited atoms in the weakly-ionized plasma . . . .”[95] Because the electric field is applied across the gap and it generates excited atoms in the weakly-ionized plasma, the weakly-ionized plasma is positioned at least partially in the gap, as shown by FIG. 3, where a gap 244 is formed between cathode 216 and anode 238, the weakly-ionized plasma is partially within the gap, and electric field 260 is applied across the gap.[96]

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[93] Corrected Pet. at p. 36.

[94] *Id*.

[95] *Ex. 1001* at claim 1, 21:57-59.

[96] *Ex. 1001* at 8:21-51.

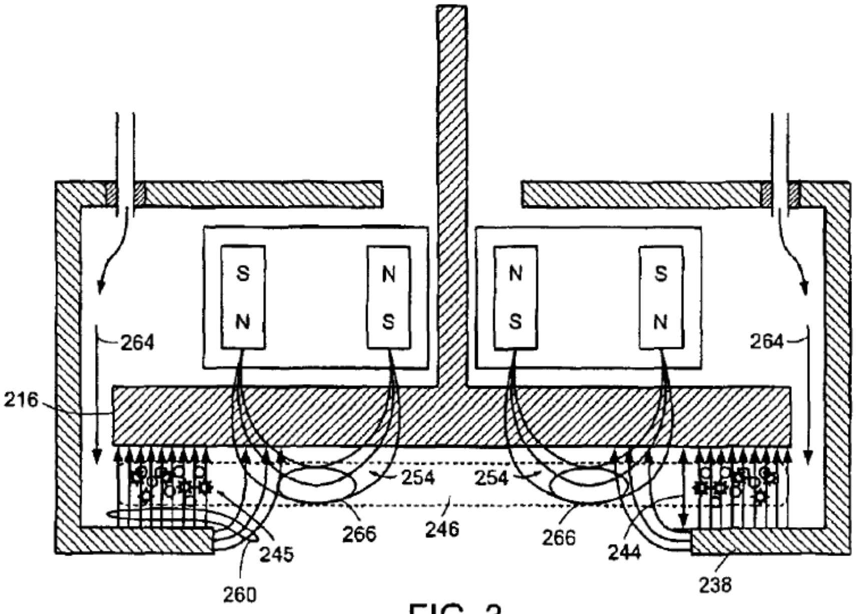

FIG. 3

Wang does not teach that any plasma is positioned between its cathode 14 and grounded shield anode 24. Thus, *Wang* cannot teach the claimed gap of the '775 patent. Further, although it is not discussed by Petitioners *Wang* teaches an important feature placed intermediate the two electrodes, namely a floating shield.[97] The floating shield performs the essential function of focusing the sputtered ions toward the wafer:

> A grounded shield 24 protects the chamber walls from sputter deposition and also acts as a grounded anode for the cathode of the negatively biased target 14. A floating shield 26 supported on a second dielectric isolator 28 becomes negatively charged

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[97] *Ex. 1008* at FIG. 1 (ref. 26); 4:1-5.

> in the presence of a high-density plasma and acts to focus sputtered metal ions towards the wafer 20.[98]

77. Petitioners argue that notwithstanding these differences, because *Wang* incorporates *Fu* by reference, *Wang* therefore teaches the gap required by claim 1 of the ‘775 patent.[99] I disagree with this conclusion. While I recognize that incorporation by reference is a permitted means of supplementing a patent disclosure, I understand that the burden is on the patentee to clearly articulate what subject matter is being so incorporated in the later disclosure. Here, there is no indication that *Wang's* incorporation by reference was intended to be specific to the gap region relied upon by Petitioners. Indeed, inasmuch as *Wang's* disclosed apparatus departs markedly from *Fu's* in this respect, one of ordinary skill in the art would conclude that *Wang* specifically did not intend to adopt this sort of gap.

78. The incorporation by reference statement relied upon by Petitioners is set forth at 1:42-51 of *Wang*:

> A recently developed technology of self-ionized plasma (SIP) sputtering allows plasma sputtering reactors to be only slightly modified but to nonetheless achieve efficient filling of metals

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[98] *Id*. at 4:1-5.

[99] Corrected Pet. at p. 37.

> into high aspect-ratio holes in a low-pressure, low-temperature process. This technology has been described by Fu et al. in U.S. patent application Ser. No. 09/546,798, filed Apr. 11, 2000, now issued as U.S. Pat. No. 6,306,265, and by Chiang et al. in U.S. patent application Ser. No. 09/414,614, filed Oct. 8, 1999, both incorporated herein by reference in their entireties.[100]

A person of ordinary skill in the art reading this passage would recognize that *Wang* was referring to (and incorporating by reference) *Fu's* teachings regarding the modifications that would be required in order to adapt a SIP sputtering reactor for use in high aspect ratio deposition processes. *Wang* goes on to explain that those modifications include the use of high amounts of DC power applied to a target, and the use of magnets with unbalanced poles.[101] This is consistent with the teachings of *Fu*.[102] Notably, neither *Wang* nor *Fu* discuss the gap between the anode and the cathode as part of this improvement of a SIP sputtering reactor, therefore, a person of ordinary skill in the art would not have recognized that *Wang* intended to make that portion of *Fu's* disclosure part of *Wang's* own. It is also

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[100] *Ex. 1008* at 1:42-51.

[101] *Id.* at 1:54 – 2:15.

[102] See, e.g., *Ex. 1014* at 4:31 – 5:17.

worth noting that in the same sentence referencing *Fu*, *Wang* incorporates by reference teachings of *Chiang*, which (as I discussed above) did disclose a SIP reactor and a gap of more than 10 cm with a grounded shield interposed between cathode and anode, yet Petitioners do not mention this fact. If anything, it is these teachings, rather than those of *Fu*, that a person of ordinary skill in the art may have looked to if interested in understanding anode-cathode geometry in a SIP reactor.

79. Petitioners also refer to Figure 1 of *Mozgrin* as disclosing the gap.[103] However, Petitioners fail to address why a person of ordinary skill in the art would abandon the use of a grounded shield, said by *Wang* to be needed to focus the sputtered ions toward the wafer. If anything then, Petitioners have merely pointed to a variety of prior art references in an attempt to show how various elements of the claims are disclosed in those teachings, but have not provided any persuasive, fact-based reasoning to explain why a person of ordinary skill in the art would arrange those elements in the manner required by claim 1 of the ‘775 patent. By failing to offer any rationale for eliminating a grounded shield, as taught by *Wang*, Petitioners invite (indeed demand) that the person of ordinary skill in the art engage in burdensome experimentation in order to determine the effect of such a

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[103] Corrected Pet. at p. 37.

modification, with no assurance that the resulting arrangement of components will achieve its desired outcome. Petitioners' argument is perhaps best characterized as hindsight inasmuch as it relies on the '775 patent as a blueprint for modifying *Wang* to have the gap corresponding to that taught by the '775 patent.

80. Insofar as claims 36 and 37 recite "means for ionizing a [volume] feed gas to generate a weakly ionized plasma proximate to a cathode," above I explained why this term should be understood to mean "a power supply electrically connected to a cathode separated from an anode, and/or an electrode, by a gap there between." Accordingly, the same analysis that applies to claim 1, applies to claims 36 and 37. That is, "the gap shown in Wang is not identical to the gap shown in the '775 Patent between the cathode/target 14 and the anode 24."[104] Wang does not teach that any plasma is positioned between its cathode 14 and grounded shield anode 24. Thus, *Wang* cannot teach the claimed gap of the '775 patent, even insofar as *Wang* incorporates teachings of *Fu*. Further, whether or not *Mozgrin* discloses any gap, Petitioners fail to address why a person of ordinary skill in the art would abandon the use of the grounded shield taught by *Wang*, and, if anything, Petitioners have merely pointed to a collection of elements in different references in an attempt to show how features of the claims are disclosed in those teachings,

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[104] *Id.*

but have not provided any persuasive, fact-based reasoning to explain why a person of ordinary skill in the art would arrange those elements in the manner required by the ‘775 patent.

D. The Combination of *Wang, Mozgrin* and *Kudryavtsev* Does Not Suggest the Electric Field Across the Gap is “a quasi-static electric field,” as Recited in Dependent Claims 2 and 18.

81. It is my opinion that the combination of *Wang, Mozgrin* and *Kudryavtsev* does not suggest that an electric field across the gap is “a quasi-static electric field,” as recited in dependent claims 2 and 18.

82. Petitioners argue that *Wang’s* electric field is quasi-static because the pulse width of the peak power P_P of 50 μs is greater than the collision time of 1.88 μs.[105]

83. But the ‘775 patent defines a quasi-static electric field as “an electric field that has characteristic time of electric field variation that is much greater than the collision time for electrons with neutral gas particles.[106] With this definition of “quasi-static electric field,” it is clear that claims 2 and 18 require the characteristic time of electric field variation to be much greater than the collision time.

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[105] Corrected Pet. at p. 47.

[106] *Ex. 1001* at 7:42-46.

Petitioners' analysis did not make any comparison between the ***characteristic time of electric field variation*** and collision time, let alone demonstrate that the former is much greater than the latter in *Wang's* system. Rather, Petitioners compared a different quantity (i.e., the pulse width of a power pulse) with a collision time.[107] There is no indication in *Wang* that the voltage is constant during any part of the power pulse as even *Wang* recognizes that the idealized pulses shown in Figures 4 and 6 are not what are actually applied.[108] Accordingly, Petitioners' computations do not establish the proposition for which they are being advanced.

E. The Combination of *Wang*, *Mozgrin* and *Kudryavtsev* Does Not Suggest "a rise time of the electric field is chosen to increase an ionization rate of the excited atoms in the weakly-ionized plasma," as Recited in Dependent Claim 4.

84. Petitioners argue, in essence, that because Wang's pulses have an associated rise time, these pulse rise times necessarily result in "an increased ionization rate of excited atoms and a resulting increase in etching rate."[109] This conclusory allegation is not only unsupported by any teaching of *Wang*, it is also unsupported

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[107] Corrected Pet. at p. 47.

[108] See, e.g., *Ex. 1008* at 5:24-27; 7:41-45.

[109] Corrected Pet. at p. 49.

by any analysis on the part of Mr. DeVito. Paragraph 176 of Mr. DeVito's declaration, the cited portion of the declaration relied upon by Petitioners for the above conclusion, repeats verbatim the allegations set forth in the Corrected Petition with no further explanation, analysis or citation of evidence. Simply restating an allegation, as Mr. DeVito has done, does not somehow transform it into a fact. Furthermore, simply because an applied voltage pulse has an associated rise time does not imply (and certainly does not demonstrate) that that rise time was somehow "*chosen* to increase an ionization rate of the excited atoms in the weakly-ionized plasma," as required by claim 4. In fact, insofar as Mr. DeVito's comments are directed to the rise time of *Wang's* voltage pulse, which is actually a power pulse, and not the rise time of an electric field, as required by the claim, it seems these comments are of little assistance in determining whether *Wang* suggests such limitations at all.

85. The pulse referenced by Mr. Devito and repeated in the petition is a *power pulse* having an unspecified rise time. Indeed, "Its [the pulse's] exact shape depends on the design of the pulsed DC power supply 80, and significant rise times and fall times are expected."[110] Claim 4, on the other hand, recites choosing the rise time of an *electric field*. While *Wang* suggests that the rise time of the power pulse

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[110] *Ex. 1008* at 5:25-27.

varies with the design of the power supply, Petitioners and Mr. DeVito fail to explain how such a disclosure suggests choosing the rise time of the electric field. Indeed, such considerations seem completely absent from *Wang* inasmuch as readers are advised that “The choice of pulse widths τ_w is dictated by considerations of both power supply design, radio interference, and sputtering process conditions. . . . Where chamber impedance is changing, the power pulse width is preferably specified rather than the current or voltage pulse widths.”[111] If Wang had intended that the rise time of an electric field was an important factor to be selected one would have expected greater emphasis on the selection of the voltage pulse characteristics rather than the power pulse characteristics, as it is the voltage pulse that leads to the electric field. Accordingly, I do not agree that the combination of *Wang*, *Mozgrin* and *Kudryavtsev* suggests “a rise time of the electric field is chosen to increase an ionization rate of the excited atoms in the weakly-ionized plasma,” as recited in claim 4.

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[111] *Id.* at 5:43-54.

F. The Combination of *Wang*, *Mozgrin* and *Kudryavtsev* Does Not Suggest "a rise time of the electric field is chosen to increase an etch rate of the surface of the substrate," as Recited in Dependent Claim 5.

86. Petitioners argue, in essence, that because Wang's pulses have an associated rise time, these pulse rise times necessarily result in "an increased ionization rate of excited atoms and a resulting increase in etching rate."[112] This conclusory allegation is not only unsupported by any teaching of *Wang*, it is also unsupported by any analysis on the part of Mr. DeVito. Paragraph 176 of Mr. DeVito's declaration, the cited portion of the declaration relied upon by Petitioners for the above conclusion, repeats verbatim the allegations set forth in the Corrected Petition with no further explanation, analysis or citation of evidence. Simply restating an allegation, as Mr. DeVito has done, does not somehow transform it into a fact. Furthermore, simply because an applied voltage pulse has an associated rise time does not imply (and certainly does not demonstrate) that that rise time was somehow "*chosen* to increase an etch rate," as required by claim 5. In fact, insofar as Mr. DeVito's comments are directed to the rise time of *Wang's* voltage pulse and not the rise time of an electric field, as required by the claim, it seems these comments are of little assistance in determining whether *Wang* suggests such limitations at all.

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[112] Corrected Pet. at p. 49.

87. The pulse referenced by Mr. Devito and repeated in the petition is a *power pulse* having an unspecified rise time. Indeed, "Its [the pulse's] exact shape depends on the design of the pulsed DC power supply 80, and significant rise times and fall times are expected."[113] Claim 5, on the other hand, recites choosing the rise time of an *electric field*. While *Wang* suggests that the rise time of the power pulse varies with the design of the power supply, Petitioners and Mr. DeVito fail to explain how such a disclosure suggests choosing the rise time of the electric field. Indeed, such considerations seem completely absent from *Wang* inasmuch as readers are advised that "The choice of pulse widths τ_w is dictated by considerations of both power supply design, radio interference, and sputtering process conditions. . . . Where chamber impedance is changing, the power pulse width is preferably specified rather than the current or voltage pulse widths."[114] If Wang had intended that the rise time of an electric field was an important factor to be selected one would have expected greater emphasis on the selection of the voltage pulse characteristics rather than the power pulse characteristics, as it is the voltage pulse that leads to the electric field. Accordingly, I do not agree that the combination of *Wang*, *Mozgrin* and *Kudryavtsev* suggests "a rise time of the

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[113] *Ex. 1008* at 5:25-27.

[114] *Id.* at 5:43-54.

electric field is chosen to increase an etch rate of the surface of the substrate," as recited in claim 5.

G. The Combination of *Wang*, *Mozgrin* and *Kudryavtsev* Does Not Suggest "selecting at least one of a pulse amplitude and a pulse width of the electrical pulse in order to cause the strongly-ionized plasma to be substantially uniform in an area adjacent to the surface of the substrate," as required by dependent claim 21 or "the strongly ionized plasma is substantially uniform proximate to a surface of the substrate," as recited in claim 24.

88. With respect to claim 21, Petitioners assert that *Wang's* power pulses P_P result in "a uniform, strongly ionized plasma adjacent to the surface of the sputtering target," and that "[t]his uniformity also extends to the surface of the substrate located opposite to the target, as shown in Fig. 1 of Wang."[115] I disagree. In my opinion, *Wang* teaches conditions that would not result in a strongly ionized plasma that is substantially uniform proximate to the surface of the substrate or in an area adjacent to the surface of a substrate.

89. *Wang* specifically teaches a strongly ionized plasma confined to the HDP region adjacent to the sputtering target 14, as shown in the annotated version of Wang's Fig. 1, below.

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[115] Corrected Petition at p. 56.

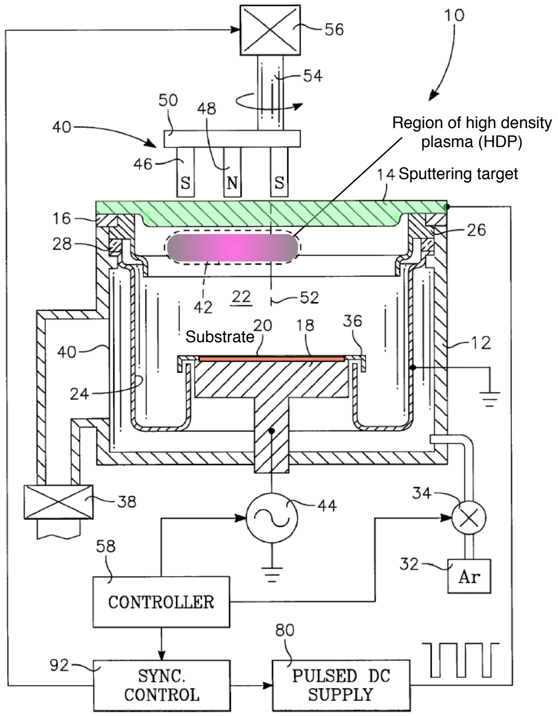

FIG. 1

As is readily apparent from this illustration, the high density plasma (HDP) is maintained in a region 42 close to the sputtering target 14, but at a considerable distance from the substrate 20. While it is correct that for SIP sputtering the use of an unbalanced magnetic field will cause the HDP region to extend into the processing space 22,[116] there is no suggestion in *Wang* that the HDP region will remain uniform throughout. Indeed, because one would expect the magnetic field to be highly non-uniform in such a circumstance,[117] one would expect that the

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[116] *Ex. 1008* at 4:35-45.

[117] See, e.g., *id.* at Fig. 6A – 6D.

plasma in the extended HDP region would similarly be non-uniform. Therefore, I do not agree that the combination of *Wang*, *Mozgrin* and *Kudryavtsev* suggest "selecting at least one of a pulse amplitude and a pulse width of the electrical pulse in order to cause the strongly-ionized plasma to be substantially uniform in an area adjacent to the surface of the substrate," as required by dependent claim 21 or "the strongly ionized plasma is substantially uniform proximate to a surface of the substrate," as recited in claim 24.

H. The Combination of *Wang*, *Mozgrin* and *Lantsman* Does Not Suggest "selecting at least one of a pulse amplitude and a pulse width of the electrical pulse that causes the strongly-ionized plasma to be substantially uniform in an area adjacent to the surface of the substrate," as required by dependent claim 33.

90. As explained above in connection with claims 21 and 24, it is my opinion that *Wang* teaches conditions that would not result in a strongly ionized plasma that is substantially uniform proximate to the surface of the substrate or in an area adjacent to the surface of a substrate. *Wang* specifically teaches a strongly ionized plasma confined to the HDP region adjacent to the sputtering target 14. While it is correct that for SIP sputtering the use of an unbalanced magnetic field will cause the HDP region to extend into the processing space 22,[118] there is no suggestion in

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[118] *Id.* at 4:35-45.

Wang that the HDP region will remain uniform throughout. Indeed, because one would expect the magnetic field to be highly non-uniform in such a circumstance,[119] one would expect that the plasma in the extended HDP region would similarly be non-uniform. Therefore, in my opinion the combination of *Wang*, *Mozgrin* and *Lantsman* do <u>not</u> suggest "selecting at least one of a pulse amplitude and a pulse width of the electrical pulse that causes the strongly-ionized plasma to be substantially uniform in an area adjacent to the surface of the substrate," as required by dependent claim 33.

I. The Combination of *Wang*, *Mozgrin* and *Kudryavtsev* Does Not Suggest "a volume between the anode and the cathode is chosen to increase an ionization rate of the excited atoms and molecules in the weakly-ionized plasma," as Required by Dependent Claim 9

91. Petitioners assert, "both Wang and Mozgrin carried out their ionization within a volume in which the ionization rate of excited atoms was increased, and Kudryavtsev explains that ionization occurs with an initial 'slow stage' (Fig. 1a) followed by a 'fast stage' (Fig. 1b). Therefore the combination of Wang, Mozgrin, and Kudryavtsev teach the limitations of claim 9."[120] I disagree with this

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[119] See, e.g., *Ex. 1001* at Fig. 6A – 6D.

[120] Corrected Pet. at p. 51 (citations omitted).

conclusion.

92. Claim 9 requires that the volume between the anode and cathode be *chosen* to increase the ionization rate of excited atoms and molecules. None of the cited references discusses the impact of the choosing of the volume between the anode and cathode on such an ionization rate. At best, *Kudryavtsev* provides a model that describes ionization relaxation in terms of atomic densities in different states, electron densities, rate constants for collisional transitions, rate coefficients for ionization contributions through different processes, diffusion fluxes of electrons and excited atoms for a particular geometry, and other factors, but none of these parameters are specified in terms of the volume between the anode and cathode.[121] Moreover, the equations defining the model do not permit a solution for volume between the anode and cathode (or any related parameter), hence, one could not "choose" such a volume based on this model.

93. It is of no import that *Wang* and *Mozgrin* (or *Kudryavtsev* for that matter) "carried out their ionization within a volume," for such teachings say nothing about how one would go about *choosing* a volume that would lead to an increase in the ionization rate of excited atoms and molecules. Notably, Petitioners cite nothing in any of the references that suggests *choosing* this dimension. Moreover, as I

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[121] *Ex. 1003* at pp. 30-31.

explained above, to the extent any combination of *Wang* and *Kudryavtsev,* with or without *Mozgrin*, would be made by a person of ordinary skill in the art, such a combination would suggest a system having a long cathode to anode gap. While the '775 patent discloses the "gap 244 is between approximately 0.3 cm and 10 cm,"[122] *Kudryavtsev*, teaches using a gap more than five times that length,[123] and *Wang* (insofar as it relies on *Chiang*), teaches a preference for longer gaps and not the 0.3 cm and 10 cm taught by Dr. Chistyakov.

94. If anything then, the combination of references relied upon by Petitioners suggests an apparatus having a long anode-cathode gap, but does not teach or suggest choosing that gap (hence volume) so as to increase the ionization rate of excited atoms and molecules. The model taught by *Kudryavtsev* would not suggest choosing such a parameter nor would it provide guidance for making such a choice. Therefore, it is my opinion that the combination of *Wang*, *Mozgrin* and *Kudryavtsev* does not suggest "a volume between the anode and the cathode is chosen to increase an ionization rate of the excited atoms and molecules in the weakly-ionized plasma," as required by dependent claim 9.

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[122] *Ex. 1001* at 5:19-20.

[123] *Ex. 1004*, p. 32, right col, ¶ 6,

J. The Combination of *Wang*, *Mozgrin* and *Kudryavtsev* Does Not Teach "applying the electric field at a constant power," as recited in dependent claim 16

95. Petitioners argue that *Wang* teaches applying the electric field at a constant power because "Wang's pulsed DC power supply 80 (shown in Wang's Figs. 1 and 7) generates a peak level power, P_P, which is constant for the duration of the pulse τ_w, as shown in Fig. 6."[124] Whether Petitioners are correct or not in their characterization of what is shown in *Wang's* figures, claim 16 requires more than a pulsed DC power supply. Specifically, claim 16 requires "applying the electric field at a constant power."[125] Nowhere do Petitioners explain how a pulsed DC power supply applies an electric field at a constant power. Moreover, as explained above, the portion of *Wang* cited by Petitioners describes an idealized power pulse and *Wang* cautions the reader that the actual shape of power pulse differs from what is shown in the illustration.[126] In fact, because the pulse width τ_w "should be measured as the full width [of the pulse] at half maximum,"[127] and because

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[124] Corrected Pet. at p. 55.

[125] *Ex. 1001* at 22:66-67.

[126] *Ex. 1005* at 7:40-41.

[127] *Id*. at 5:51-52.

"significant rise and fall times are expected,[128] one can expect that the power is not constant over this period. Accordingly, it is my opinion that the combination of *Wang*, *Mozgrin*, and *Kudryavtsev* does not suggest applying an electric field at a constant power, as required by claim 16.

K. The Combination of *Wang*, *Mozgrin*, *Kudryavtsev* and *Lantsman* Does Not Teach "applying the electric field at a constant voltage," as recited in Dependent Claim 17

96. Petitioners argue that, "Wang, Mozgrin, and Kudryavtsev teach the limitations of claim 15,"[129] but do not discuss the latter two in relationship to dependent claim 17. Petitioners also state that *Wang* teaches claim 17's requirement of "applying the electric field at a constant voltage" because "[o]ne of ordinary skill would have understood that a constant voltage would produce pulse P_P of constant power for the duration of the pulse τ_w."[130] I disagree. As I explained above, power is the product of voltage and current. If, as Petitioners contend, power is constant during the pulse τ_w taught by *Wang*, then the product of voltage and current must be constant for that period. With *Wang's* admitted drop in plasma

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[128] *Id*. at 5:26-27, and see 7:41-44.

[129] Corrected Pet. at p. 58.

[130] *Id*. at p. 59.

impedance during the pulse, current will rise and voltage will drop.

97. My analysis does not change when considering the additional teachings of *Lantsman* that "[a] typical DC power supply 10 includes a relatively sophisticated control system, designed to permit operation in constant power, constant voltage, or constant current modes."[131] Indeed, this recognition serves to confirm my options above inasmuch as *Lantsman* recognizes that one must pick which parameter (power, current or voltage) to hold constant while the others will vary in accordance with the above-described relationship. Petitioners contend that *Wang* teaches the use of constant power, thus precluding the use of constant voltage given the dynamic nature of the plasma ionization that is taking place.[132] They give no motivation for deciding that one can arbitrarily choose *Lantsman's* constant voltage over *Wang's* constant power in combining the cited references.

VII. DECLARATION

98. I declare that all statements made herein on my own knowledge are true and

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[131] *Ex. 1025* at 1:22-24.

[132] *Ex. 1002* at p. 402, rt. col.; and see *Ex. 1008* at 5:30-35 (recognizing that current varies as the impedance of the plasma changes).

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: January 5, 2015

Larry D. Hartsough

Larry D. Hartsough, Ph.D.

Appendix A

Larry D. Hartsough, Ph.D.
dba U A Associates
3007 Benvenue Ave.
Berkeley, CA 94705

Ph: 510-548-5027 Cell: 510-847-7033 email: ldhphd1971@yahoo.com

Updated: December 2014

Technical Expertise

- Semiconductor Manufacturing Equipment
- Physical metallurgy
- Thin film metallurgy
- Planar and hollow-cathode magnetron sputter source design
- SEMI Standards Development and Compliance
- Vacuum system design & practice
- Cluster tool design and interfaces
- PVD Thin film process and process control
- Electrostatic chuck technology
- Magnetic modeling

Education

B.S., M.S., and Ph.D. in Materials Science/Engineering from the University of California, Berkeley

Professional Summary

Thirty years of R&D and Engineering in the semiconductor capital equipment industry in the areas of thin film deposition, vacuum system design and plasma processing of materials. Pioneer in the development of magnetron sputtering hardware and processes for the metallization of silicon integrated circuits. Instrumental in the development of cluster tool and 300mm interface standards for semiconductor fabrication equipment.

Professional Experience

1990- Present	*Consultant in private practice.* dba **UA Associates** Product development projects; litigation support; film failure analysis; project management; technical presentations.
1997- 2002	*Manager, PVD Source Engineering* **Novellus Systems, Inc.** Sputter hardware, target and process development. Thin film and component failure analysis.
1991- 1997	*Manager, PVD Source Technology* **Varian Associates, Thin Film Systems Division** Development and improvement of advanced deposition sources and hardware.

1988-1990 *Project Manager*

General Signal Thinfilm Co.

Design, engineer and build an advanced cluster tool.

1984-1988 *Manager, Advanced Development*

Gryphon Products, Inc.

Develop enhancements for semiconductor fabrication equipment to enable advanced processes.

1981-1984 *VP Engineering & Founding Partner*

Gryphon Products/Exeltek, Inc.

Cofounder and partner in startup company. Led engineering, prototyping and initial testing of magnetron sputtering system with automated wafer handling.

1977-1981 *Manager, Advanced Development; Manager, Applications Lab; Senior Staff Scientist*

Perkin-Elmer Corp., Plasma Products Division

Development, characterization, demonstration and maintenance of

Sputter deposition equipment.

1975-1977 *Research Engineer*

Airco Temescal

Characterization, process development and demonstration of a high

throughput in-line magnetron sputter deposition system.

1971-1975 *Research Metallurgist*

Optical Coating Laboratory, Inc.

Deposition processes and optical properties of thin films

Litigation Support Experience

- Confidential technical consultant
- Trade secrets analysis, discovery, declarations, deposition
- Analyze patent portfolio for relative value of lapsed patent
- Prepare expert reports and declarations
- Testify as expert witness before arbitration panel
- Literature searches
- Deposition testimony before opponents counsel

Professional Associations and Activities

- Member, American Vacuum Society since 1977
- Member, Sigma Xi, The Scientific Research Society, since 1971
- Referee for Journal of Vacuum Science & Technology
- Leader in development of SEMI Standards for cluster tools and 300mm equipment:
    - Co-Chair, first MESA task force on Utilities (electrical interconnect and EPO)(1989)
    - Co-Chair, SEMI Standards E6 task force to revise Facilities Interface Specifications Format
    - Co-Chair, SEMI Standards E15 task force to rewrite Load Port Interface Standard
    - Technical Architect, SEMI Standards North America Physical Interfaces Committee
    - North America Co-Chair, SEMI Standards Global Physical Interfaces and Carriers (PIC) Committee
    - Recipient, 1997 North America Regional Standards Merit Award
    - Co-Chair, SEMI Standards North America Factory Integration Division (2003-2005)
    - Member-at-Large, SEMI Standards North America Regional Standards Committee (2005-2009)

  - Member, SEMI International Standards Committee Audit & Review Sub-Committee (2008-); Chair (2011-)
  - Technical Editor, SEMI Standards North America Physical Interfaces Committee (2005-)
  - Member, SEMI International Standards Committee Regulations Sub-Committee (2011-)
  - Leader, PIC Standards Maintenance TF (2011-)
  - Recipient, 2012 North America Regional Standards Honor Award
  - Recipient, 2013 Karel Urbanek Memorial Award
- Member of ASTM subcommittee F01.17 on Sputter Metallization (1997-2002)
- Local Arrangements Chair – 1978 International Conference on Metallurgical Coatings
- Member of US Department of Commerce Semiconductor Technical Advisory Committee, 1980-84 (in re: Export Administration Act of 1979).

U. S. Patents (as inventor or co-inventor)

Patent Number	Date Issued	Title
6,500,321	Dec 31, 2002	Control of erosion profile and process characteristics in magnetron sputtering by geometrical shaping of the sputtering target..
6,497,796	Dec 24, 2002	Apparatus and method for controlling plasma uniformity across a substrate
6,444,105	Sept 3, 2002	Physical Vapor Deposition Reactor Including Magnet to Control Flow of Ions
6,193,854	Feb 27, 2001	Apparatus and Method for Controlling Erosion Profile in Hollow Cathode Magnetron Sputter Source
6,179,973	Jan 30, 2001	Apparatus and Method for Controlling Plasma Uniformity Across a Substrate
5,985,115	Nov 16, 1999	Internally Cooled Target Assembly for Magnetron Sputtering
5,503,676	Apr 2, 1996	Apparatus and Method for Magnetron In-Situ Cleaning of Plasma Reaction Chamber
5,417,833	May 23, 1995	Sputtering Apparatus Having a Rotating Magnet Array and Fixed Electromagnets
4,420,385	Dec. 13, 1983	Apparatus and Process for Sputter Deposition of Reacted Thin Films
4,260,649	Apr. 7, 1981	Laser Induced Dissociative Chemical Gas Phase Processing of Workpieces
4,204,936	May 27,	Method and Apparatus for Attaching A Target to

	1980	the Cathode of a Sputtering System
4,125,446	Nov. 14, 1978	Controlled Reflectance of Sputtered Aluminum Layers

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