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APPLICANT:	Roman Chistyakov		
SERIAL NO.:	10/065,277	GROUP NO.:	1753
FILING DATE:	September 30, 2002	EXAMINER:	McDonald, Rodney G.
TITLE:	HIGH-POWER PULSED MAGNETRON SPUTTERING		

Commissioner for Patents
Alexandria, Virginia 22313-1450

AMENDMENT AND RESPONSE

Sir:

The following amendments and remarks are responsive to the Office Action mailed on January 15, 2004 in the above-identified patent application. Entry and consideration of the following amendments and remarks, and allowance of the claims, as presented, are respectfully requested. A Petition for a two–month extension of time, up to and including Tuesday, June 15, 2004 is submitted herewith. The Commissioner is hereby authorized to charge the extension fee, the additional claims fee, and any other proper fees to Attorney's Deposit Account No. 501211.

Please enter the following amendments and consider the remarks that follow.

Amendments to the Claims:

Please amend claims 1, 4, 5, 6, 8, 12, 16, 19, 21, 25, and 27-30, cancel claims 3 and 18 without prejudice, and add claims 31-39 as follows.

1. (currently amended) A sputtering source comprising:

a cathode assembly that is positioned adjacent to an anode, the cathode assembly including a sputtering target;

an ionization source that generates a weakly-ionized plasma proximate to the anode and the cathode assembly; and

a power supply that generates a voltage pulse ~~that produces an electric field~~ between the anode and the cathode assembly~~, the electric field~~ that creates~~ing~~ a strongly-ionized plasma from the weakly-ionized plasma, an amplitude and a rise time of the voltage pulse being chosen to increase ~~the strongly-ionized plasma comprising~~ a ~~volume~~ density of ions in the strongly-ionized plasma ~~that impact the sputtering target which~~ enough to generate sufficient thermal energy in the sputtering target to cause a sputtering yield of the sputtering target to be non-linearly related to a temperature of the sputtering target.

2. (original) The sputtering source of claim 1 wherein the electric field comprises a quasi-static electric field.

3. (cancelled).

4. (currently amended) The sputtering source of claim ~~3~~ 1 further comprising a gas flow controller ~~exchange means for exchanging~~ that controls a flow of feed gas to the strongly-ionized plasma, the additional feed gas allowing additional power to be absorbed by the ~~with a new volume of feed gas while applying the electrical pulse across the new volume of feed gas to generate additional~~ strongly-ionized plasma, ~~comprising a second plurality of ions, the second plurality of the additional power creating additional ions~~ that ~~impacting the surface of the sputtering target,~~ thereby generating additional thermal energy in the sputtering target.

Amendments to the Claims:

Please amend claims 1, 6, 7, 20, 34, and 40 and add claims 41-48 as follows.

1. (currently amended) A magnetically enhanced sputtering source comprising:

a) an anode;

b) a cathode assembly that is positioned adjacent to the anode ~~and forming a gap therebetween~~, the cathode assembly including a sputtering target;

c) an ionization source that generates a weakly-ionized plasma proximate to the anode and the cathode assembly;

d) a magnet that is positioned to generate a magnetic field proximate to the weakly-ionized plasma, the magnetic field substantially trapping electrons in the weakly-ionized plasma proximate to the sputtering target; and

e) a power supply generating a voltage pulse that produces an electric field between the cathode assembly and the anode, ~~across the gap, the electric field~~ an amplitude and a rise time of the voltage pulse being chosen to increase an excitation rate of ground state atoms that are present in the weakly-ionized plasma to create a multi-step ionization process that generates a strongly-ionized plasma from the weakly-ionized plasma, the multi-step ionization process comprising exciting the ground state atoms to generate ~~generating~~ excited atoms, and then ~~in the weakly ionized plasma and generating secondary electrons from the sputtering target, the secondary electrons~~ ionizing the excited atoms within the weakly-ionized plasma to~~-thereby creating a strongly-ionized plasma having~~ create ions that ~~impact a surface of the~~ sputter target material from the sputtering target.~~, to generate sputtering flux.~~

2. (original) The sputtering source of claim 1 wherein the power supply generates a constant power.

3. (original) The sputtering source of claim 1 wherein the power supply generates a constant voltage.

4. (original) The sputtering source of claim 1 wherein the electric field comprises a quasi-static electric field.

5. (original) The sputtering source of claim 1 wherein the electric field comprises a pulsed electric field.

6. (currently amended) The sputtering source of claim 1 wherein a the rise time of the voltage pulse ~~electric field~~ is chosen to increase the ionization rate of the excited atoms in the weakly-ionized plasma.

7. (currently amended) The sputtering source of claim 1 wherein the weakly-ionized plasma ~~gas~~ reduces the probability of developing an electrical breakdown condition between the anode and the cathode assembly.

8. (original) The sputtering source of claim 1 wherein the ions in the strongly-ionized plasma impact the surface of the sputtering target in a manner that causes substantially uniform erosion of the sputtering target.

9. (original) The sputtering source of claim 1 wherein the strongly-ionized plasma is substantially uniform proximate to the sputtering target.

10. (original) The sputtering source of claim 1 further comprising a substrate support that is positioned in a path of the sputtering flux.

11. (original) The sputtering source of claim 10 further comprising a temperature controller that controls the temperature of the substrate support.

12. (original) The sputtering source of claim 10 further comprising a bias voltage power supply that applies a bias voltage to a substrate that is positioned on the substrate support.

13. (original) The sputtering source of claim 1 wherein a volume between the anode and the cathode assembly is chosen to increase the ionization rate of the excited atoms in the weakly-ionized plasma.

14. (original) The sputtering source of claim 1 wherein the ionization source comprises an electrode.

15. (original) The sputtering source of claim 1 wherein the ionization source comprises a DC power supply that generates an electric field proximate to the anode and the cathode assembly.

16. (original) The sputtering source of claim 1 wherein the ionization source comprises an AC power supply that generates an electric field proximate to the anode and the cathode assembly.

17. (original) The sputtering source of claim 1 wherein the ionization source is chosen from the group comprising a UV source, an X-ray source, an electron beam source, and an ion beam source.

18. (original) The sputtering source of claim 1 wherein the magnet comprises an electro-magnet.

19. (original) The sputtering source of claim 1 wherein the sputtering target is formed of a material chosen from the group comprising a metallic material, a polymer material, a superconductive material, a magnetic material, a non-magnetic material, a conductive material, a non-conductive material, a composite material, a reactive material, and a refractory material.

20. (currently amended) A method of generating sputtering flux, the method comprising:

a) ionizing a feed gas to generate a weakly-ionized plasma proximate to a sputtering target;

b) generating a magnetic field proximate to the weakly-ionized plasma, the magnetic field substantially trapping electrons in the weakly-ionized plasma proximate to the sputtering target; and

c) applying ~~an electric field~~ a voltage pulse to the weakly-ionized plasma, an amplitude and a rise time of the voltage pulse being chosen to increase an excitation rate of ground state atoms that are present in the weakly-ionized plasma to create a multi-step ionization process that generates a strongly-ionized plasma from the weakly-ionized plasma, the multi-step ionization process comprising exciting the ground state atoms to generate excited ~~that excites~~ atoms, and then ~~and that generates secondary electrons from the sputtering target, the secondary electrons~~ ionizing the excited atoms within the weakly-ionized plasma to ~~thereby creating a strongly-ionized plasma having~~ create ions that ~~impact a surface of the~~ sputter target material from the sputtering target, ~~to generate sputtering flux.~~

21. (original) The method of claim 20 wherein the applying the electric field comprises a applying a quasi-static electric field.

22. (original) The method of claim 20 wherein the applying the electric field comprises applying a substantially uniform electric field.

23. (original) The method of claim 20 wherein the applying the electric field comprises applying an electrical pulse across the weakly-ionized plasma.

24. (original) The method of claim 23 further comprising selecting at least one of a pulse amplitude and a pulse width of the electrical pulse that increases an ionization rate of the strongly-ionized plasma.

25. (original) The method of claim 23 further comprising selecting at least one of a pulse amplitude and a pulse width of the electrical pulse that reduces a probability of developing an electrical breakdown condition proximate to the sputtering target.

26. (original) The method of claim 23 further comprising 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 a surface of the sputtering target.

27. (original) The method of claim 23 wherein the electrical pulse comprises a pulse having a current density that is greater than $1 A/cm^2$.

28. (original) The method of claim 23 wherein the electrical pulse comprises a pulse having a pulse width that is greater than 1.0 microseconds.

29. (original) The method of claim 23 wherein the electrical pulse comprises a pulse train having a repetition rate that is substantially between 0.1Hz and 1kHz.

30. (original) The method of claim 20 wherein the ions in the strongly-ionized plasma impact the surface of the sputtering target in a substantially uniform manner.

31. (original) The method of claim 20 wherein the strongly-ionized plasma is substantially uniform proximate to the sputtering target.

32. (original) The method of claim 20 wherein the peak plasma density of the weakly-ionized plasma is less than about 10^{12} cm^{-3}.

33. (original) The method of claim 20 wherein the peak plasma density of the strongly-ionized plasma is greater than about 10^{12} cm^{-3}.

34. (currently amended) The method of claim 20 further comprising forming a film ~~from the sputtering flux~~ on a surface of a substrate <u>from the material sputtered from the sputtering target</u>.

35. (original) The method of claim 34 further comprising controlling a temperature of the film.

36. (original) The method of claim 34 further comprising applying a bias voltage to the film.

37. (original) The method of claim 20 wherein the ionizing the feed gas comprises exposing the feed gas to an electric field.

38. (original) The method of claim 20 wherein the ionizing the feed gas comprises exposing the feed gas to an electrode that is adapted to emit electrons.

39. (original) The method of claim 20 wherein the ionizing the feed gas comprises exposing the feed gas to at least one of a UV source, an X-ray source, an electron beam source, and an ion beam source.

40. (currently amended) A magnetically enhanced sputtering source comprising:

a) means for ionizing a feed gas to generate a weakly-ionized plasma proximate to a sputtering target;

b) means for generating a magnetic field proximate to the weakly-ionized plasma, the magnetic field substantially trapping electrons in the weakly-ionized plasma proximate to the sputtering target; and

c) means for applying ~~an electric field~~ a voltage pulse to the weakly-ionized plasma, an amplitude and a rise time of the voltage pulse being chosen to increase an excitation rate of ground state atoms that are present in the weakly-ionized plasma to create a multi-step ionization process that generates a strongly-ionized plasma from the weakly-ionized plasma, the multi-step ionization process comprising exciting the ground state atoms to generate excited ~~that excites~~ atoms, and then ~~and that generates secondary electrons from the sputtering target, the secondary electrons~~ ionizing the excited atoms within the weakly-ionized plasma to ~~thereby creating a strongly-ionized plasma having~~ create ions that ~~impact a surface of the~~ sputter target material from the sputtering target. ~~to generate sputtering flux.~~

41. (new) The sputtering source of claim 1 wherein the cathode assembly and the anode are positioned so as to form a gap therebetween.

42. (new) The sputtering source of claim 1 wherein the weakly-ionized plasma is generated from a feed gas that comprises the ground state atoms.

43. (new) The sputtering source of claim 1 wherein the excited atoms within the weakly-ionized plasma are ionized by electrons to create the ions that sputter material from the sputtering target.

44. (new) The sputtering source of claim 1 wherein the rise time of the voltage pulse is approximately between 0.01 and 100V/μsec.

45. (new) The sputtering source of claim 1 wherein the amplitude of the voltage pulse is approximately between 100V and 30kV.

46. (new) The method of claim 20 wherein the weakly-ionized plasma is generated from a feed gas that comprises the ground state atoms.

47. (new) The method of claim 20 wherein a duration of the weakly-ionized plasma is approximately between one microsecond and one hundred seconds.

48. (new) The method of claim 20 wherein the ionizing the excited atoms within the weakly-ionized plasma to create ions that sputter material from the sputtering target comprises ionizing the excited atoms with electrons.

49. (new) The method of claim 20 wherein the rise time of the voltage pulse is approximately between 0.01 and 100V/μsec.

50. (new) The method of claim 20 wherein the amplitude of the voltage pulse is approximately between 100V and 30kV.

REMARKS

Pending Claims:

Claims 1-50 are currently pending in the present application. Claims 1, 6, 7, 20, 34, and 40 are amended by the present Amendment. Claims 41-50 are added by the present Amendment. No new matter is added by these amendments. Upon entry of the present Amendment, reconsideration of claims 1-40 and consideration of new claims 41-50 is respectfully requested.

Rejections under 35 U.S.C. §102(b) As Being Anticipated by Kouznetsov:

Claims 1, 5-10, 13, 14, 16, 19, 20, 22-31, 34, 37, 38, and 40 are rejected under 35 U.S.C. §102(b) as being anticipated by Kouznetsov (WO98/40532) (hereinafter "Kouznetsov"). Independent claims 1, 7, 20 and 40 are herein amended to more clearly recite the invention. No new matter is added by these amendments.

To anticipate a claim under 35 U.S.C. §102, a single reference must teach every aspect of the claimed invention either explicitly or impliedly. Any feature not directly taught by the reference must be inherently present in the reference. Thus, a claim is anticipated by a reference only if each and every element of the claim is described, either expressly or inherently, in a single prior art reference.

Independent Claim 1 and Dependent Claims 5-10, 13, 14, 16, and 19

The Applicant respectfully submits that Kouznetsov does not describe each and every element of independent claim 1 as currently amended. Independent claim 1 has been amended to recite a magnetically enhanced sputtering source having a power supply that generates a voltage pulse that produces an electric field between an anode and a cathode assembly. An amplitude and a rise time of the voltage pulse is chosen to increase the excitation rate of ground state atoms that are present in the weakly-ionized plasma to create a multi-step ionization process. The multi-step ionization process includes exciting the ground state atoms to generate excited atoms, and then ionizing the excited atoms in the weakly-ionized plasma. This amendment is supported by the originally-filed specification of the present application. See, for example, paragraphs 59-

69 of the originally-filed specification. The Applicant submits that no new matter is added by the amendments to independent claim 1.

The Applicant believes that there is no description in Kouznetsov of a power supply that generates a voltage pulse having an amplitude and a rise time that are chosen to increase an excitation rate of ground state atoms that are present in a weakly-ionized plasma to generate a multi-step ionization process. Instead, the Applicant believes that the pulsed power source described in Kouznetsov generates a gas having a fully ionized state using a single-step ionization process. According to Kouznetsov, the pulsed power source used in his apparatus provides "pulses in such a way, i.e. that so much power is developed in each pulse, that in the application of such a pulse, for a very short time during the start of the pulse, the state of the gas located at the region in which the electrons are trapped by the magnetic field will very rapidly reach a fully ionized state…" See, for example, Kouznetsov page 5, lines 1-4. The application of a very large voltage pulse (2,000 Volts) having a fast rise time appears to fully ionize the gas by direct ionization from electrons located in the region having crossed electric and magnetic fields. See, for example, Kouznetsov page 12, lines 22-26.

The Applicant respectfully submits that there is no description in Kouznetsov of a power supply that generates a voltage pulse which creates a multi-step ionization process that includes generating excited atoms from ground state atoms that are present in the weakly ionized plasma, and then ionizing the excited atoms in the weakly-ionized plasma as claimed in amended claim 1. Instead, the Applicant believes that the ionization process described in Kouznetsov is a single-step ionization process known as direct ionization by electron impact.

In view of the above remarks, the Applicant respectfully submits that Kouznetsov does not describe each and every element of independent claim 1 as currently amended, either expressly or inherently. Therefore, the Applicant submits that Kouznetsov does not anticipate independent claim 1 as currently amended under 35 U.S.C. §102(b). Thus, the Applicant submits that independent claim 1 as currently amended is allowable. The Applicant also submits that dependent claims 5-10, 13, 14, 16, and 19 are allowable as depending from an allowable base claim.

Independent Claim 20 and Dependent Claims 22-31, 34, 37, and 38

The Applicant respectfully submits that Kouznetsov does not describe each and every element of independent claim 20 as currently amended. Independent claim 20 is herein amended to recite the step of applying a voltage pulse to the weakly-ionized plasma. An amplitude and a rise time of the voltage pulse are chosen to increase an excitation rate of ground state atoms in the weakly-ionized plasma to create a multi-step ionization process. The multi-step ionization process generates excited atoms from ground state atoms in the weakly-ionized plasma, and then ionizes the excited atoms in the weakly-ionized plasma. This amendment is supported by the originally-filed specification of the present application. See, for example, paragraph 59-69 of the originally-filed specification. No new matter is added by the amendments to independent claim 20.

The Applicant believes that there is no description in Kouznetsov of a method of generating a strongly-ionized plasma using a multi-step ionization process as claimed in amended claim 20. Instead, as previously discussed, the Applicant believes that Kouznetsov describes a single-step ionization process whereby the application of a very large voltage pulse having a fast rise time creates a gas having a fully ionized state (See page 12, lines 22-26). The Applicant believes that the large voltage pulse described in Kouznetsov ionizes the gas by direct ionization from electrons located in the region of crossed electric and magnetic fields.

In view of the above remarks, the Applicant respectfully submits that Kouznetsov does not describe each and every element of independent claim 20 as currently amended, either expressly or inherently. Therefore, the Applicant submits that Kouznetsov does not anticipate independent claim 20 as currently amended. Thus, the Applicant submits that amended independent claim 20 and dependent claims 22-31, 34, 37, and 38 are allowable under 35 U.S.C. §102(b).

Rejections under 35 U.S.C. §102(b) as Being Anticipated by Mozgrin:

Claims 1, 4, 5, 7, 13, 14, 16, 19-25, 27-29, 32, 33, 37, and 40 are rejected under 35 U.S.C. §102(b) as being anticipated by Mozgrin et al. entitled "High Current Low-Pressure Quasi-Stationary Discharge in a Magnetic Field: Experimental Research", Plasma Physics

Reports, Vol. 21, No. 5, 1995, pp. 400-409 (hereinafter "Mozgrin"). Independent claims 1, 20 and 40 are herein amended to more clearly recite the invention. No new matter is added by these amendments.

To anticipate a claim under 35 U.S.C. §102, a single reference must teach every aspect of the claimed invention either explicitly or impliedly. Any feature not directly taught by the reference must be inherently present in the reference. Thus, a claim is anticipated by a reference only if each and every element of the claim is described, either expressly or inherently, in a single prior art reference.

Independent Claim 1 and Dependent Claims 4, 5, 7, 13, 14, 16, and 19

The Applicant respectfully submits that Mozgrin does not describe each and every element of independent claim 1 as currently amended. Independent claim 1 has been amended to recite a power supply generating a voltage pulse that produces an electric field between a cathode assembly and an anode. The voltage pulse has an amplitude and a rise time that are chosen to increase a rate of excitation of ground state atoms present in the weakly-ionized plasma to create a multi-step ionization process. The multi-step ionization process generates a strongly-ionized plasma from the weakly-ionized plasma by first exciting ground state atoms to generate excited atoms, and then by ionizing the excited atoms in the weakly-ionized plasma. This amendment is supported by the originally-filed specification of the present application. See, for example, paragraphs 59-69 of the originally-filed specification. The Applicant submits that no new matter is added by the amendments to independent claim 1.

The Applicant believes that there is no description in Mozgrin of a power supply that generates a voltage pulse having an amplitude and a rise time that are chosen to increase the excitation rate of ground state atoms present in the weakly-ionized plasma to create a multi-step ionization process. Instead, the Applicant believes that Mozgrin describes a pulsed discharge supply unit that generates a plasma with a prior art direct ionization process using very high-power pulses.

The Applicant believes that the quasi-stationary discharge described in Mozgrin is formed with a prior art ionization process known as direct ionization by electron impact and does not use the multi-step ionization process of the present invention. For example, the current and voltage characteristics (CVC) shown in FIG. 4 of Mozgrin indicate to the Applicant that the quasi-stationary discharge described in Mozgrin is formed by direct ionization. The CVC shown in FIG. 4 of Mozgrin includes four parts.

Part 1 of the CVC shown in FIG. 4 of Mozgrin is a low current (0.2A) discharge regime that is a pre-ionization stage of the quasi-stationary discharge. The pre-ionization stage is generated using a high-voltage power supply unit that produces a high-voltage, low-current discharge between two electrodes to create a pre-ionized plasma. The pre-ionized plasma includes ions that are generated by a typical direct ionization process.

Part 2 of the CVC shown in FIG. 4 of Mozgrin is a high-current, high-voltage discharge regime having a discharge current that is in the range of 0.2A-15A and a discharge voltage that is in the range of 350V-500V. The plasma discharge appears to be a typical magnetron plasma discharge that is commonly generated in plasma processing systems. The plasma discharge is formed by using a square voltage pulse. There is no description in Mozgrin related to Part 2 of the CVC of choosing an amplitude and a rise time of the voltage pulse in order to increase a rate of excitation of ground state atoms to create excited atoms in a multi-step ionization process as claimed in amended independent claim 1. In fact, there is no description in Mozgrin of choosing an amplitude and a rise time of a voltage pulse to change the plasma discharge conditions. Mozgrin describes varying the plasma discharge conditions by changing the pressure and magnetic field strength, but does not mention varying the plasma discharge conditions by changing the amplitude and the rise time of the voltage pulse. See Mozgrin page 403 lines 8-13.

Part 3 of the CVC shown in FIG. 4 of Mozgrin is a high-current discharge regime in which the discharge voltage remains stationary at 90V over a current that is in the range of 15A-1,000A. Part 3 of the CVC corresponds to a prior art magnetron discharge for high-pressure (10^{-1} torr) plasma processing. The voltage drops sharply in this regime until the current reaches a quasi-stationary value that maintains the discharge power at a constant value. There is no description related to Part 3 of the CVC of choosing an amplitude and a rise time of a voltage pulse to increase a rate of excitation of ground state atoms to create excited atoms in a multi-step ionization process as claimed in amended independent claim 1.

Part 4 of the CVC shown in FIG. 4 of Mozgrin is a high-current, low-voltage arc discharge regime having a current that is greater than 1kA and a voltage that is in the range of 10-30V. Arc discharges are generally undesirable for most plasma processing applications. Arc discharges are observed in conventional magnetrons when too much power applied to the plasma. There is no description related to Part 4 of the CVC of choosing an amplitude and a rise time of a voltage pulse to increase a rate of excitation of ground state atoms to create excited atoms in a multi-step ionization process as claimed in amended independent claim 1.

Thus, the Applicant submits that there is no teaching or suggestion of increasing an excitation rate of ground state atoms in a weakly-ionized plasma to generate a multi-step ionization process in either Part 1, Part 2, Part 3, or Part 4 of the CVC of Mozgrin. In view of the above remarks, the Applicant respectfully submits that Mozgrin does not describe each and every element of independent claim 1 as currently amended, either expressly or inherently. Therefore, the Applicant submits that Mozgrin does not anticipate independent claim 1 as currently amended. Thus, the Applicant submits that amended independent claim 1 and dependent claims 4, 5, 7, 13, 14, 16, and 19 are allowable under 35 U.S.C. §102(b).

Independent Claim 20 and Dependent Claims 21-25, 27-29, 32, 33, and 37

The Applicant believes that Mozgrin does not describe each and every element of independent claim 20 as currently amended. Independent claim 20 is herein amended to recite the step of applying a voltage pulse to the weakly-ionized plasma where an amplitude and a rise time of the voltage pulse are chosen to increase an excitation rate of ground state atoms in the weakly-ionized plasma to create a multi-step ionization process. The multi-step ionization process includes exciting the ground state atoms to generate excited atoms, and then ionizing the excited atoms within the weakly-ionized plasma to create ions that sputter target material from the sputtering target.

The Applicant respectfully submits that there is no description in Mozgrin of applying a voltage pulse to a weakly-ionized plasma where an amplitude and a rise time of the voltage pulse are chosen to increase an excitation rate of ground state atoms in the weakly-ionized plasma to create a multi-step ionization process as claimed in amended claim 20. In view of the above remarks, the Applicant respectfully submits that Mozgrin does not describe each and every element of independent claim 20 as currently amended, either expressly or inherently. Therefore, the Applicant submits that Mozgrin does not anticipate amended independent claim 20 and dependent claims 21-25, 27-29, 32, 33, and 37 under 35 U.S.C. §102(b). Thus, the Applicant submits that amended independent claim 20 and dependent claims 21-25, 27-29, 32, 33, and 37 are allowable.

Rejections under 35 U.S.C. §103(a) As Being Unpatentable Over Kouznetsov:

Claims 1-3 are rejected under 35 U.S.C. §103(a), as being unpatentable over Kouznetsov. The Office Action states that Kouznetsov discloses substantially all of the features of the claimed invention except that the constant power and the constant voltage are not discussed. The Office Action further states that the constant power and constant voltage are provided by the power supply in the crossed E and B field region since the power and the voltage must be constant during this period to produce a state of full ionization. The Office Action concludes that it would have been obvious to have utilized constant power and voltage as taught by Kouznetsov because it allows for producing a state of full ionization.

Independent claim 1 has been amended to recite a power supply that generates a voltage pulse that produces an electric field between a cathode assembly and an anode. The voltage pulse has an amplitude and a rise time that are chosen to increase a rate of excitation of ground state atoms present in the weakly-ionized plasma to create a multi-step ionization process. The Applicant submits that there is no teaching or suggestion in Kouznetsov of such a power supply. In fact, there is no mention of excited atoms in the Kouznetsov reference. Instead, the Applicant believes that the Kouznetsov reference describes a process for transitioning a gas to an ionized state using a single-step ionization process in a conventional magnetron sputtering device (See page 5, lines 20-26). The process described in the Kouznetsov reference appears to use direct ionization to transition a gas from a state of glow discharge, to a state of arc discharge, and finally to a fully ionized state (See page 5, lines 6-8).

According to Kouznetsov, this fully ionized state is realized with a "rather high, substantially constant voltage when the gas is in the highly ionized state of crossing electric and magnetic fields, as long as the input voltage is sufficient to sustain this state." (See Kouznetsov page 5, lines 33-35). The Applicant believes that there is no teaching or suggestion in Kouznetsov of a power supply that generates a voltage pulse that creates a multi-step ionization process.

In view of the above remarks, the Applicant submits that amended independent claim 1 is not obvious under 35 U.S.C. §103(a) in view of the Kouznetsov reference. The Applicant also submits that dependent claims 2-3 are allowable as depending from an allowable base claim.

Rejections under 35 U.S.C. §103(a) As Being Unpatentable Over Mozgrin:

Claims 1-3, 17, 20, and 39 are rejected under 35 U.S.C. §103(a), as being unpatentable over Mozgrin. The Office Action states that Mozgrin discloses substantially all features of the claimed invention except that the constant power, constant voltage, and the ionization source being a UV source, an X-ray source, an electron beam source and an ion beam source are not discussed. The Office Action further states that the constant power and constant voltage are provided at the height of the square waveform to produce a plasma density higher than the pre-ionization plasma density. The Office Action concludes that it would have been obvious to have utilized constant power and voltage because it allows for production of a higher density of plasma than during the pre-ionization.

Independent Claim 1 and Dependent Claims 2-3 and 17

Independent claim 1 has been amended to recite a power supply that generates a voltage pulse that produces an electric field between a cathode assembly and an anode. The voltage pulse has an amplitude and a rise time that are chosen to increase a rate of excitation of ground state atoms present in the weakly-ionized plasma to create a multi-step ionization process.

The Applicant submits that there is no teaching or suggestion in Mozgrin of a power supply that generates a voltage pulse having an amplitude and a rise time that are chosen to increase an excitation rate of ground state atoms in a weakly-ionized plasma to generate a multi-step ionization process. Instead, as previously described herein, the Applicant submits that Mozgrin describes a method for generating a plasma using a direct ionization by electron impact (See page 402, col. 2, lines 13-48 to page 403, col. 1, lines 1-13).

In view of the above remarks, the Applicant submits that amended independent claim 1 is not obvious under 35 U.S.C. §103(a) in view of the Mozgrin reference. The Applicant also submits that dependent claims 2-3 and 17 are allowable as depending from an allowable base claim.

Independent Claim 20 and Dependent Claim 39

Independent claim 20 has been amended to recite the step of applying a voltage pulse to the weakly-ionized plasma where an amplitude and a rise time of the voltage pulse are chosen to increase an excitation rate of ground state atoms in the weakly-ionized plasma to create a multi-step ionization process. The multi-step ionization process includes exciting the ground state atoms to generate excited atoms, and then ionizing the excited atoms within the weakly-ionized plasma to create ions that sputter target material from the sputtering target.

The Applicant submits that there is no teaching or suggestion in Mozgrin of applying a voltage pulse to a weakly-ionized plasma where the voltage pulse has an amplitude and a rise time that are chosen to increase an excitation rate of ground state atoms in a weakly-ionized plasma to generate a multi-step ionization process. Instead, the Applicant submits that Mozgrin describes a method for generating a plasma using direct ionization by electron impact. There is simply no teaching or suggestion in Mozgrin of choosing an amplitude and a rise time of a voltage pulse to increase an excitation rate of ground state atoms in a weakly-ionized plasma.

In view of the above remarks, the Applicant submits that amended independent claim 20 is not obvious under 35 U.S.C. §103(a) in view of the Mozgrin reference. The Applicant also submits that dependent claim 39 is allowable as depending from an allowable base claim.

Rejections under 35 U.S.C. §103(a) Over Kouznetsov in view of Chiang:

Claims 1, 10-12, 15, 20, and 34-36 are rejected under 35 U.S.C. §103(a), as being unpatentable over Kouznetsov in view of U.S. Patent No. 6,398,929 to Chiang et al. (hereinafter

"Chiang"). The Office Action states that Kouznetsov discloses substantially all features of the claimed invention except that the temperature control of the substrate is not discussed, biasing the substrate is not discussed, and applying DC power to the target is not discussed. The Office Action further states that Chiang describes supplying cooling gas to the backside of the wafer, biasing the wafer holder, and biasing the target with a DC power supply.

Independent Claim 1 and Dependent Claims 10-12 and 15

Independent claim 1 has been amended to recite a power supply that generates a voltage pulse that produces an electric field between a cathode assembly and an anode. The voltage pulse has an amplitude and a rise time that are chosen to increase a rate of excitation of ground state atoms present in the weakly-ionized plasma to create a multi-step ionization process.

The Applicant submits that there is no teaching or suggestion in Kouznetsov of a power supply that generates a voltage pulse having an amplitude and a rise time that are chosen to increase a rate of excitation of ground state atoms present in the weakly-ionized plasma to create a multi-step ionization processs. There is no mention of exciting ground state atoms in the Kouznetsov reference. Instead, the Applicant believes that the Kouznetsov reference describes a process for transitioning a gas to an ionized state using a single-step ionization process in a conventional magnetron sputtering device (See page 5, lines 20-26). The process described in the Kouznetsov reference appears to use direct ionization to transition a gas from a state of glow discharge, to a state of arc discharge, and finally to a fully ionized state (See page 5, lines 6-8).

In view of the above remarks, the Applicant submits that amended independent claim 1 is not obvious under 35 U.S.C. §103(a) over Kouznetsov in view of Chiang. The Applicant also submits that dependent claims 10-12 and 15 are allowable as depending from an allowable base claim.

Independent Claim 20 and Dependent Claims 34-36

Independent claim 20 has been amended to recite the step of applying a voltage pulse to the weakly-ionized plasma where an amplitude and a rise time of the voltage pulse are chosen to increase an excitation rate of ground state atoms in the weakly-ionized plasma to create a multi-step ionization process. The multi-step ionization process includes exciting the ground state atoms to generate excited atoms, and then ionizing the excited atoms within the weakly-ionized plasma to create ions that sputter target material from the sputtering target.

The Applicant submits that there is no teaching or suggestion in Kouznetsov of applying a voltage pulse to a weakly-ionized plasma where an amplitude and a rise time of the voltage pulse are chosen to increase an excitation rate of ground state atoms in the weakly-ionized plasma to create a multi-step ionization process. Instead the Applicant believes that Kouznetsov teaches a single-step ionization process whereby the application of a very large voltage pulse having a fast rise time creates a gas having a fully ionized state (See page 12, lines 22-26). The Applicant believes that the large voltage pulse described in Kouznetsov ionizes the gas by direct ionization from electrons located in the region of crossed electric and magnetic fields.

In view of the above remarks, the Applicant submits that amended independent claim 20 is not obvious under 35 U.S.C. §103(a) over Kouznetsov in view of Chiang. The Applicant also submits that dependent claims 34-36 are allowable as depending from an allowable base claim.

<u>Rejections under 35 U.S.C. §103(a) Over Kouznetsov in view of Kadlec:</u>

Claims 1 and 18 are rejected under 35 U.S.C. §103(a), as being unpatentable over Kouznetsov in view of Kadlec et al. (WO95/04368) (hereinafter "Kadlec"). The Office Action states that Kouznetsov discloses substantially all features of the claimed invention except that the use of an electromagnet is not disclosed. The Office Action further states that Kadlec suggests the use of electromagnets for sputtering.

Independent claim 1 has been amended to recite a power supply that generates a voltage pulse that produces an electric field between a cathode assembly and an anode. The voltage pulse has an amplitude and a rise time that are chosen to increase a rate of excitation of ground state atoms present in the weakly-ionized plasma to create a multi-step ionization process. As previously discussed, the Applicant submits that there is no teaching or suggestion in Kouznetsov of such a power supply and there is no mention of exciting ground atoms in the Kouznetsov reference.

In view of the above remarks, the Applicant submits that amended independent claim 1 is not obvious under 35 U.S.C. §103(a) over Kouznetsov in view of Kadlec. The Applicant also submits that dependent claim 18 is allowable as depending from an allowable base claim.

New Claims 41-50:

The Applicant submits that independent claim 1 is allowable as currently amended. The Applicant also submits that dependent claims 41-45 are allowable as depending from an allowable base claim. In addition, the Applicant submits that independent claim 20 is allowable as currently amended and dependent claims 46-50 are also allowable as depending from an allowable base claim.

CONCLUSION

Claims 1-50 are currently pending in the present application. Claims 1, 6, 7, 20, 34, and 40 are amended by the present Amendment. Claims 41-50 are added by the present Amendment. In view of the foregoing, reconsideration and allowance of all pending claims (i.e., claims 1-50) is respectfully requested.

The Commissioner is hereby authorized to charge the extension fee, the additional claims fee, and any other proper fees to Attorney's Deposit Account No. 501211.

If, in the Examiner's opinion, a telephonic interview would expedite prosecution of the present application, the undersigned attorney would welcome the opportunity to discuss any outstanding issues, and to work with the Examiner toward placing the application in condition for allowance.

Respectfully submitted,

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Reg. No. 40,137

Kurt Rauschenbach, Ph.D.
Attorney for Applicant
Rauschenbach Patent Law Group, LLC
Post Office Box 387
Bedford, MA 01730

Tel. No.: (781) 271-1503
Fax No.: (781) 271-1527