PATENT

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APPLICANT:	Chistyakov		
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FILING DATE:	July 18, 2005	EXAMINER:	Rodney Glenn McDonald
TITLE:	HIGH DEPOSITION RATE SPUTTERING		

Commissioner for Patents
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AMENDMENT AND RESPONSE

Sir:

The following Amendment and Response is responsive to the Office Action mailed on April 21, 2010 in the above-identified patent application. Authorization to charge Attorney's charge card for the additional claim fees is given in the EFS-Web filing submission papers. Authorization is hereby given to charge any other proper fees to the Attorney's deposit account number 501211. Entry and consideration of the following remarks, and allowance of the claims, as presented, are respectfully requested.

Pending claims begin on page 2 of this paper.

Remarks begin on page 9 of this paper.

Amendments to the Claims

Please add claims 76-78 as follows:

1-30 Cancelled.

31. (Original) A sputtering source comprising:

a) a cathode assembly comprising a sputtering target that is positioned adjacent to an anode; and

b) a power supply that generates a voltage pulse between the anode and the cathode assembly that creates a weakly-ionized plasma and then a strongly-ionized plasma from the weakly-ionized plasma without an occurrence of arcing between the anode and the cathode assembly, an amplitude, a duration and a rise time of the voltage pulse being chosen to increase a density of ions in the strongly-ionized plasma.

32. (Original) The sputtering source of claim 31 wherein the strongly ionized plasma at least partially converts neutral sputtered atoms into positive ions in order to enhance the sputtering process with ionized physical vapor deposition.

33. (Original) The sputtering source of claim 31 wherein the increase of the density of ions in the strongly-ionized plasma is enough to generate sufficient thermal energy in a surface of the sputtering target to cause a sputtering yield to be related to a temperature of the sputtering target.

34. (Original) The sputtering source of claim 33 wherein the sputtering yield is related to a temperature of a surface of the sputtering target.

35. (Original) The sputtering source of claim 33 wherein the thermal energy generated in the sputtering target does not substantially increase an average temperature of the sputtering target.

36. (Original) The sputtering source of claim 31 further comprising a gas flow controller that

controls a flow of the feed gas so that the feed gas diffuses the strongly-ionized plasma.

37. (Original) The sputtering source of claim 36 wherein the gas flow controller controls the flow of the feed gas to allow additional power to be absorbed by the strongly ionized plasma, thereby generating additional thermal energy in the sputtering target.

38. (Original) The sputtering source of claim 31 further comprising 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.

39. (Original) The sputtering source of claim 31 wherein the voltage pulse generated between the anode and the cathode assembly excites atoms in the weakly-ionized plasma and generates secondary electrons from the cathode assembly, the secondary electrons ionizing a portion of the excited atoms, thereby creating the strongly-ionized plasma.

40. (Original) The sputtering source of claim 31 wherein the power supply generates a constant power.

41. (Original) The sputtering source of claim 31 wherein the power supply generates a constant voltage.

42. (Original) The sputtering source of claim 31 wherein a rise time of the voltage pulse is chosen to increase an ionization rate of the strongly-ionized plasma.

43. (Original) The sputtering source of claim 31 wherein a distance between the anode and the cathode assembly is chosen to increase an ionization rate of strongly-ionized plasma.

44. (Original) The sputtering source of claim 31 wherein the rise time of the voltage pulse is in the range of approximately 0.01V/μsec to 1000V/μsec.

45. (Original) The sputtering source of claim 31 wherein the amplitude of the voltage pulse is in the range of approximately 1V to 25kV.

46. (Original) The sputtering source of claim 31 wherein a pulse width of the voltage pulse

is in the range of approximately 0.1μsec to 100sec.

47. (Original) A sputtering source comprising:

a) a cathode assembly comprising a sputtering target that is positioned adjacent to an anode;

b) a power supply that generates a voltage pulse between the anode and the cathode assembly that creates a weakly-ionized plasma and then a strongly-ionized plasma from the weakly-ionized plasma without an occurrence of arcing between the anode and the cathode assembly, an amplitude and a rise time of the voltage pulse being chosen to increase a density of ions in the strongly-ionized plasma; and

c) a substrate support that is positioned adjacent to the sputtering target; and

d) a bias voltage source having an output that is electrically coupled to the substrate support.

48. (Original) The sputtering source of claim 47 wherein the increase of the density of ions in the strongly-ionized plasma is enough to generate sufficient thermal energy in a surface of the sputtering target to cause a sputtering yield to be related to a temperature of the sputtering target.

49. (Original) The sputtering source of claim 48 wherein the sputtering yield is related to a temperature of a surface of the sputtering target.

50. (Original) The sputtering source of claim 48 wherein the thermal energy generated in the surface of the sputtering target does not substantially increase an average temperature of the sputtering target.

51. (Original) The sputtering source of claim 47 wherein the voltage pulse generated between the anode and the cathode assembly excites atoms in the weakly-ionized plasma and generates secondary electrons from the cathode assembly, the secondary electrons ionizing a portion of the excited atoms, thereby creating the strongly-ionized plasma.

52. (Original) The sputtering source of claim 47 wherein the power supply generates a constant power.

53. (Original) The sputtering source of claim 47 wherein the power supply generates a constant voltage.

54. (Original) The sputtering source of claim 47 wherein a rise time of the voltage pulse is chosen to increase an ionization rate of the strongly-ionized plasma.

55. (Original) The sputtering source of claim 47 wherein a distance between the anode and the cathode assembly is chosen to increase an ionization rate of strongly-ionized plasma.

56. (Original) The sputtering source of claim 47 wherein the rise time of the voltage pulse is in the range of approximately 0.01V/μsec to 1000V/μsec.

57. (Original) The sputtering source of claim 47 wherein the amplitude of the voltage pulse is in the range of approximately 1V to 25kV.

58. (Original) The sputtering source of claim 47 wherein a pulse width of the voltage pulse is in the range of approximately 0.1μsec to 100sec.

59. (Original) The sputtering source of claim 47 wherein a distance from the sputtering target to the substrate support is in the range of approximately 1cm to 100cm.

60. (Original) The sputtering source of claim 47 wherein the bias voltage source comprises an RF power source.

61. (Original) The sputtering source of claim 47 further comprising a gas flow controller that controls a flow of the feed gas so that the feed gas diffuses the strongly-ionized plasma.

62. (Original) The sputtering source of claim 61 wherein the gas flow controller controls the flow of the feed gas to allow additional power to be absorbed by the strongly ionized plasma, thereby generating additional thermal energy in the sputtering target.

63. (Original) The sputtering source of claim 47 further comprising 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.

64. (Original) A method for high deposition rate sputtering, the method comprising:

a) generating a voltage pulse between the anode and the cathode assembly comprising a sputtering target, the voltage pulse creating a weakly-ionized plasma and then a strongly-ionized plasma from the weakly-ionized plasma without an occurrence of arcing between the anode and the cathode assembly; and

b) adjusting an amplitude and a rise time of the voltage pulse to increase a density of ions in the strongly-ionized plasma.

65. (Original) The method of claim 64 wherein the applying the voltage pulse to the cathode assembly generates excited atoms in the weakly-ionized plasma and generates secondary electrons from the sputtering target, the secondary electrons ionizing the excited atoms, thereby creating the strongly-ionized plasma.

66. (Original) The method of claim 64 wherein the ions in the strongly-ionized plasma cause a surface layer of the sputtering target to evaporate.

67. (Original) The method of claim 64 wherein the rise time of the voltage pulse is in the range of approximately 0.01V/μsec to 1000V/μsec.

68. (Original) The method of claim 64 wherein the amplitude of the voltage pulse is in the range of approximately 1V to 25kV.

69. (Original) The method of claim 64 wherein a pulse width of the voltage pulse is in the range of approximately 0.1μsec to 100sec.

70. (Original) The method of claim 64 wherein the adjusting an amplitude and a rise time of the voltage pulse increases the density of ions in the strongly-ionized plasma enough to generate sufficient thermal energy in a surface of the sputtering target to cause a sputtering yield to be related to a temperature of the sputtering target.

71. (Original) The method of claim 70 wherein the sputtering yield is non-linearly related to the temperature of the sputtering target.

72. (Original) The method of claim 64 further comprising applying a bias voltage to a substrate support that is positioned adjacent to the sputtering target.

73. (Original) The method of claim 64 further comprising generating a magnetic field proximate to the sputtering target, the magnetic field trapping electrons proximate to the sputtering target.

74. (Original) The method of claim 64 further comprising diffusing the weakly-ionized plasma with a volume of the feed gas while ionizing the volume of the feed gas to create additional weakly-ionized plasma.

75. (Original) The method of claim 64 further comprising exchanging a volume of feed gas to diffuse the strongly-ionized plasma while applying the voltage pulse to the cathode assembly to generate additional strongly-ionized plasma from the volume of the feed gas.

76. (New) A sputtering source comprising:

a) a cathode assembly comprising a sputtering target that is positioned adjacent to an anode; and

b) a power supply that generates a voltage pulse between the anode and the cathode assembly that creates a weakly-ionized plasma and then a strongly-ionized plasma from the weakly-ionized plasma without an occurrence of arcing between the anode and the cathode assembly, an amplitude of the voltage pulse being chosen to increase a density of ions in the strongly-ionized plasma.

77. (New) A sputtering source comprising:

a) a cathode assembly comprising a sputtering target that is positioned adjacent to an anode; and

b) a power supply that generates a voltage pulse between the anode and the cathode assembly that creates a weakly-ionized plasma and then a strongly-ionized plasma from the weakly-ionized plasma without an occurrence of arcing between the anode and the cathode assembly, a duration of the voltage pulse being chosen to increase a density of ions in the strongly-ionized plasma.

78. (New) A sputtering source comprising:

a) a cathode assembly comprising a sputtering target that is positioned adjacent to an anode; and

b) a power supply that generates a voltage pulse between the anode and the cathode assembly that creates a weakly-ionized plasma and then a strongly-ionized plasma from the weakly-ionized plasma without an occurrence of arcing between the anode and the cathode assembly, a rise time of the voltage pulse being chosen to increase a density of ions in the strongly-ionized plasma.

REMARKS

Interview Summary

The Applicant and the Applicant's attorney thank Examiner McDonald for his time during the telephone interview on June 22, 2010. During the interview, the proposed response and the description of the apparatus described in the Kouznetsov reference were discussed.

Pending Claims

Claims 1-30 have been cancelled. Claims 31-78 are pending. New claims 76-78 have been added. The Applicant respectfully requests reconsideration of the pending claims in light of the arguments presented herein.

Rejection Under 35 U.S.C. §102

Claims 31-46 and 73-75 are rejected Under 35 U.S.C. §102(e) as being anticipated by WO 02/103078A1 to Kouznetsov (hereinafter "Kouznetsov").

Independent Claim 31

The Office Action states that Kouznetsov describes all the elements recited in independent claim 31. More specifically, the Office Action states that Kouznetsov describes a power supply that generates a voltage pulse between the anode and the cathode assembly that creates a weakly-ionized plasma and then a strongly-ionized plasma from the weakly-ionized plasma without an occurrence of arcing between the anode and the cathode assembly, an amplitude, a duration and a rise time of the voltage pulse being chosen to increase a density of ions in the strongly-ionized plasma.

The Applicant respectfully traverses the rejection under 35 U.S.C §102 for the following reasons. First, Kouznetsov does not describe apparatus that generate a voltage pulse between the anode and the cathode assembly that creates a weakly-ionized plasma and then a strongly-ionized plasma from the weakly-ionized plasma. Instead, Kouznetsov describes methods and apparatus for generating two separate and independent pulses. Second, Kouznetsov does not teach that strongly-ionized plasma is generated from the weakly-ionized plasma without an occurrence of arcing between the anode and the cathode assembly wherein the amplitude, the duration and the rise time of the voltage pulse is chosen to increase a density of ions in the strongly-ionized plasma. Instead, Kouznetsov teaches that occurrences of arcing between the anode and the cathode assembly depend on the magnetic field configuration and the strength and the time difference between the first and the second pulses.

More specifically, Kouznetsov describes methods and devices for producing metal, gas, and/or gas-metal plasma flows with an electrical discharge. The electrical discharges have a first period with a low electrical current passing between the anode and cathode for producing a metal vapor by magnetron sputtering, and a second period with a high electrical current passing between the anode and cathode for ionizing metal vapor that was produced in the first pulse. The first period of the electrical discharge has a first discharge voltage and a first discharge current and the second period of the electrical discharge has a second discharge voltage and a second discharge current.

The first and second periods of the electrical discharge are generated with two distinctly different pulses. Kouznetsov FIGS. 3a, 3b, 4, 5, and 9 all show separate sputtering and ionizing pulses. Kouznetsov states that the ionizing discharge starts immediately after the sputtering pulse or with some, relatively small time delay after the end of the sputtering pulse. See, for example, Kouznetsov FIG. 5 that clearly shows a time delay between the sputtering pulse and the ionizing pulse. Kouznetsov further states on page 5, line 29-32 that the parameters of the first and second pulses and the time delay between the end of the first pulse and the beginning of the second pulse are defined by the requirements imposed by the high ionization of sputtered vapor blobs.

In addition, Kouznetsov describes only power supply configurations that generate sputtering pulses that are separate and independent from ionizing pulses. See Kouznetsov FIGS. 8A-8C and the associated description in Kouznetsov page 21, lines 14-30. FIG. 8A illustrates a first power supply configuration showing a first power supply PS-1 that generates the sputtering pulses and a second power supply PS-2 that generates the ionizing pulses. FIG. 8B illustrates a second power supply configuration showing a single power supply and a timing circuit. The timing circuit is used to generate a first triggering pulse that initiates the sputter pulse and then a second triggering pulse that initiates a separate and independent ionization pulse. FIG. 8C illustrates a third power supply configuration showing two power supplies and a triggering circuit. The third power supply configuration includes a pulsed power supply electrically connected in parallel with a DC power supply. The DC power supply generates a DC signal that causes sputtering. A timing circuit is used to trigger the pulsed power supply to generate the ionizing pulse. Therefore, the Applicant submits that the power supply configurations described in connection with FIGS. 8A-C all generate either a pulse or a DC waveform that creates sputtering, and then a separate and independent pulse that creates ionization.

Furthermore, Kouznetsov teaches that occurrences of arcing between the anode and the cathode assembly depend on the magnetic field configuration and on the strength and the time difference between the low current discharges and the high current discharges. See, for example, Kouznetsov page 6, lines 33-34, which states that arc suppression can be achieved using a now discovered phenomenon of dependence of arc formation on the plasma confinement properties of the magnetron magnetic configuration and on the time between discharges. Kouznetsov emphasizes on page 7, lines 3-4, that in order to achieve efficient arc suppression, it is necessary to use a magnetic field having a high strength.

More specifically, Kouznetsov teaches on page 24, lines 6-8 that after the discharge has been ignited, the magnetic field intensity and the repetition frequency of the pulses are adjusted to obtain discharges without any concentrated arc formation. Kouznetsov describes on page 17, lines 2-31, parameters of the discharge device that are used to avoid arc formation. The parameters include the maximum radial strength of the magnetic field at the sputtering surface of cathode. In addition, the parameters include the pulse repetition frequency of the low and high current discharges. The Kouznetsov method and apparatus requires the use of additional external pre-ionization to generate low and high current pulse discharges at pulse repetition rate that are less than 20 Hz. According to Kouznetsov, under these conditions without external pre-ionization, the discharges have a random occurrence and appear in the form of contracted arc discharges. See Kouznetsov page 17, lines 20-23.

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.

The Applicant submits that Kouznetsov does not teach every aspect of the claimed invention either explicitly or impliedly because Kouznetsov does not teach apparatus that generate a voltage pulse between the anode and the cathode assembly that creates a weakly-ionized plasma and then a strongly-ionized plasma from the weakly-ionized plasma in the same pulse and does not teach that strongly-ionized plasma is generated from the weakly-ionized plasma without an occurrence of arcing between the anode and the cathode assembly wherein the amplitude, the duration and the rise time of the voltage pulse is chosen to increase a density of ions in the strongly-ionized plasma. Instead, Kouznetsov describes a power supply configuration that generates either a pulse or a DC waveform that creates sputtering and deposition, and a separate and independent pulse that creates ionization. Also, Kouznetsov does not describe choosing an amplitude, a duration, and a rise time of the voltage pulse that increases a density of ions in the strongly-ionized plasma without the occurrence of arcing between the anode and the cathode assembly. In contrast, Kouznetsov describes varying the magnetic field intensity and the repetition frequency of the pulses to obtain discharges without any concentrated arc formation. Kouznetsov also describes the use of an external ionization source to eliminate arc formation at low repetition rates. See Kouznetsov page 17, lines 20-23.

Therefore, the Applicant submits that independent claim 31 is allowable over Kouznetsov and that dependent claims 32-46 are allowable as depending from an allowable base claim.

Independent Claim 64

Independent claim 64 recites a method for high deposition rate sputtering that includes the steps of generating a voltage pulse between the anode and the cathode assembly that creates a weakly-ionized plasma and then a strongly-ionized plasma from the weakly-ionized plasma without an occurrence of arcing between the anode and the cathode assembly; and adjusting an amplitude and a rise time of the voltage pulse to increase a density of ions in the strongly-ionized plasma.

As described in connection with the rejection of independent claim 31, Kouznetsov does not describe generating a voltage pulse between the anode and the cathode assembly that creates a weakly-ionized plasma and then a strongly-ionized plasma from the weakly-ionized plasma. Instead, Kouznetsov describes a power supply configuration that generates either a pulse or a DC waveform that creates sputtering, and a separate and independent pulse that creates ionization. Also, Kouznetsov does not describe adjusting an amplitude, a duration, and a rise time of the voltage pulse that increases a density of ions in the strongly-ionized plasma without the occurrence of arcing between the anode and the cathode assembly.

Therefore, the Applicant submits that independent claim 64 is allowable over Kouznetsov and that dependent claims 65-75 are allowable as depending from an allowable base claim.

Rejection Under 35 U.S.C. §103

Claims 47-59, 61-63 and 72 are rejected under 35 U.S.C. §103(a) as being unpatentale over Kouznetsov in view of WO 01/98553 also to Kouznetsov (hereinafter "Kouznetsov '553).

Regarding independent claims 47, the Office Action states that Kouznetsov discloses all the elements of claim 47, but does not disclose the bias.

Independent claim 47 recites a sputtering source including a power supply that generates a voltage pulse between the anode and the cathode assembly that creates a weakly-ionized plasma and then a strongly-ionized plasma from the weakly-ionized plasma without an occurrence of arcing between the anode and the cathode assembly, where an amplitude and a rise time of the voltage pulse are chosen to increase a density of ions in the strongly-ionized plasma.

To be unpatentable under 35 U.S.C. §103(a), the differences between the subject matter sought to be patented and the prior art must be such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art. To establish prima facie obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art.

As described in connection with the rejection of independent claim 31, Kouznetsov does not describe the claimed power supply. Instead, Kouznetsov describes a power supply configuration that generates either a pulse or a DC waveform that creates sputtering, and a separate and independent pulse that creates ionization. Also, Kouznetsov does not describe choosing an amplitude, a duration, and a rise time of the voltage pulse that increases a density of ions in the strongly-ionized plasma without the occurrence of arcing between the anode and the cathode assembly.

Therefore, the Applicant submits that independent claim 47 is not obvious over Kouznetsov in view of Kouznetsov '553 and is allowable over the prior art of record. In addition, the Applicant submits that dependent claims 48-63 are allowable as depending from an allowable base claim.

In addition, as described above, the Applicant submits that independent claim 64 is allowable over Kouznetsov. Therefore, dependent claim 72 is allowable as depending from an allowable base claim.

CONCLUSION

Claims 31-75 are currently pending in the present application. The Applicant respectfully requests reconsideration of the pending claims in light of the arguments made in this Amendment and Response. The undersigned attorney welcomes the opportunity to discuss any outstanding issues, and to work with the Examiner toward placing the application in condition for allowance.

Respectfully submitted,

Date: June 23, 2010
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