

SILVER SELENIDE FILM STOICHIOMETRY AND MORPHOLOGY CONTROL IN SPUTTER DEPOSITION

FIELD OF THE INVENTION

[0001] The invention relates to the field of resistance variable memory devices formed using a chalcogenide glass and, in particular, to an improved method of depositing a silver-selenide film on a chalcogenide glass.

BACKGROUND OF THE INVENTION

[0002] Chalcogenide materials are presently of great interest for use in resistance variable memory devices compared to memory technologies currently in use, due to potential advantages in switching characteristics, non-volatility, memory speed, reliability, thermal characteristics, and durability. Research in this area is reported in the articles "High Speed Memory Behavior and Reliability of an Amorphous As_2S_3 Film doped with Ag" by Hirose et al., Phys. Stat. Sol. (1980), pgs. K187-K190; "Polarity-dependent memory switching and behavior of Ag dendrite in Ag-photodoped amorphous As_2S_3 films" by Hirose et al., Journal of applied Physics, Vol. 47, No. 6 (1976), pgs. 2767-2772; and "Dual Chemical Role of Ag as an Additive in Chalcogenide Glasses" by Mitkova et al., Physical Review Letters, Vol. 83, No. 19 (1999), pgs. 3848-3851, the disclosures of which are incorporated herein by reference.

[0003] In many memory cell designs employing chalcogenide materials, a film of silver-selenide (Ag_2Se) is incorporated with a chalcogenide material layer. The silver-selenide film is important for electrical performance. Accordingly, silver-selenide deposition is an important aspect of fabricating the resistance variable memory device. Most available research in silver-selenide deposition is limited and evaporation deposition is normally chosen for silver-selenide film formation.

[0004] Silver-selenide deposition by evaporation has an attendant problem because the dissociative properties of silver-selenide make it impossible to achieve precision stoichiometries of silver-selenide. It is believed that in evaporation

techniques, as the silver starts to diffuse to a lower concentration, it begins to agglomerate. As the silver is tied up in clusters or agglomerates, selenium is more readily available for evaporation in the beginning of the evaporation process. Thus, during evaporation techniques, selenium is evaporated more quickly, causing the deposition target to become silver-rich. Near the end of the evaporation process little to no selenium is left for deposition onto the substrate, leaving mostly silver available for deposition. Thus substantial amounts of selenium are deposited on the substrate followed by deposition of primarily silver. Accordingly, the evaporation technique therefore does not uniformly deposit the silver-selenide and controlling the stoichiometry and surface morphology of evaporated silver-selenide is difficult.

[0005] Furthermore, evaporation deposition is not conducive to industrial application. Sputter deposition is more readily available for industrial processes and sputter deposition has many advantages compared to evaporation deposition techniques. For example, sputter deposition provides better film thickness and quality control.

[0006] Generally, sputter deposition, or sputtering, is performed by placing a substrate in a deposition chamber which is evacuated or pressurized to a desired pressure. A particle stream of the film material usually generated from a target is then generated within the chamber and the deposition occurs by condensation of the particles onto the substrate. In another sputtering technique, often referred to as ion beam bombardment sputtering, a high-energy source beam of ions is directed toward the target. The force of the bombarding ions imparts sufficient energy to the atoms of the target to cause the energized atoms to leave the target and form a particle stream. The resulting deposition upon the substrate forms a thin film.

[0007] Due to the high diffusion property of silver, low melting point of selenium, and the memory properties of silver-selenide, controlling the stoichiometry and morphology of the silver-selenide film during sputter deposition is

difficult. For instance, silver-selenide bulk material is conductive, but its conductivity (about thousands $\text{ohm}^{-1}\text{cm}^{-1}$) is relatively lower than that of most metals. Also, silver concentration is critical for electrical performance of the device, thus it is necessary to maintain the silver concentration close to about 66.7 atomic weight percent (herein after represented “%”). With silver concentrations higher than about 67.5%, many nodular defects are formed in and/or on the silver-selenide film. The size of these defects can be about a tenth of a micrometer, which could have severe negative impact on sub micron device fabrication. Although the exact mechanism by which these defects are formed are unknown, it is believed that these defects are caused by excess silver, beyond the desired stoichiometric silver concentration requirements of the silver-selenide film.

[0008] Conventional sputtering methods also result in deposited silver-selenide films whose structures are nearly exclusively comprised of beta silver-selenide. For optimal device performance, however, it is desirable to produce silver-selenide film comprising both alpha and beta silver-selenide.

[0009] It would be desirable to have an improved method of depositing a silver-selenide film. It would also be desirable to have a method of controlling the stoichiometry and morphology of silver-selenide for sputter deposition. It would further be desirable to have a method of forming sputter deposited silver-selenide comprising both alpha and beta silver-selenide.

BRIEF SUMMARY OF THE INVENTION

[0010] An exemplary embodiment of the present invention includes a method of depositing a silver-selenide film on a substrate. The method includes using a low pressure sputter deposition process. Preferred sputter deposition processes include RF sputtering or pulse DC sputtering. Preferably, the sputter deposition will occur in pressures ranging from about 0.3 mTorr to about 10 mTorr. The invention is particularly useful for depositing a silver-selenide film with better stoichiometric precision. The invention is also particularly useful for sputter

depositing a silver-selenide film while avoiding nodular defect formation throughout and on the surface of the silver-selenide film. Finally, under sputter pressures of about 10 mTorr and sputter powers of less than about 250W, the invention is also useful for depositing silver-selenide films comprising both alpha and beta silver-selenide.

[0011] These and other features and advantages of the invention will be better understood from the following detailed description, which is provided in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1(a) is an SEM image of a pulse DC sputter deposited silver-selenide film deposited using a pressure of 20 mTorr.

[0013] FIG. 1(b) is an SEM image of a pulse DC sputter deposited silver-selenide film deposited using a pressure of 10 mTorr.

[0014] FIG. 1(c) is an SEM image of a pulse DC sputter deposited silver-selenide film deposited using a pressure of 3 mTorr.

[0015] FIG. 2 shows two x-ray diffraction scans of deposited silver selenide films sputtered under different sputter pressures and powers.

DETAILED DESCRIPTION OF THE INVENTION

[0016] In the following detailed description, reference is made to various specific structural and process embodiments of the invention. These embodiments are described with sufficient detail to enable those skilled in the art to practice the invention. It is to be understood that other embodiments may be employed, and that various structural, logical and electrical changes may be made without departing from the spirit or scope of the invention.

[0017] The term “silver-selenide” is intended to include various species of silver-selenide, including some species which have a slight excess or deficit of silver, for instance, Ag_2Se , Ag_{2+x}Se , and Ag_{2-x}Se .

[0018] The term “chalcogenide glass” is intended to include various composition structures based on elements from Group VIA (S, Se, Te, Po, O) alone or in combination with elements from group IV (Si, Ge) and/or group V (P, As, Sb, Bi).

[0019] The present invention relates to a process for depositing silver-selenide. In accordance with the invention, low pressures, of for example, 0.3 mTorr to about 10 mTorr, are used to sputter deposit silver-selenide. Also in accordance with the invention, silver-selenide is preferably deposited using an RF sputtering process or pulse DC sputtering process.

[0020] Silver-selenide itself has electrical memory properties, i.e. conductivity, and sputter deposition processes normally involve strong current, voltage and ion bombardment. Therefore, both electrical and thermal effects from the sputter deposition process can influence the silver-selenide sputter target and deposited silver-selenide film. For the above reason, sputter deposition requires consideration on how to apply electrical power to silver-selenide targets.

[0021] Since the conductivity of silver-selenide is relatively lower than that of most metals, D.C. sputtering has not worked. Regular DC magnetron sputtering attempts have not been effective, primarily because the plasma is not easily ignited.

[0022] Depending on the target age, sputter deposition at higher pressures, e.g., about 20 mTorr or greater, result in films with either lower or higher silver concentrations than the desired stoichiometric silver concentration of about 66.7%. It has been observed that high pressure deposition, e.g., about 20 mTorr or greater, of relatively new targets using RF or pulse DC magnetron sputter deposition result in silver-selenide films having silver concentrations of only about 60%, which is

much lower than the desired stoichiometric silver concentration of 66.7%. It has also been observed that high pressure deposition, e.g., about 20 mTorr or greater, of relatively old targets using RF or pulse DC magnetron sputter deposition result in silver-selenide films having silver concentrations higher than about 67.5%.

[0023] The inventors have discovered that RF or pulse DC magnetron sputter deposition processes at low pressures ranging from about 0.3 mTorr to about 10 mTorr may be used to deposit more precise stoichiometric silver-selenide films while avoiding nodular defects formation in the film. It has also been discovered that the silver-selenide target composition changes over the lifetime of the target, and that the use of a low pressure sputter deposition process allows for precise stoichiometric deposits from both old and new silver-selenide targets.

[0024] FIG. 1 shows SEM images of substrates formed of production grade silicon wafers with silicon nitride films having a pulse DC sputter deposited silver-selenide film of about 500 Angstroms thick. The silver-selenide films shown in FIG. 1 were pulse DC sputter deposited using a Denton Vacuum Discovery® 24 at 200 kHz with a 1056 ns pulse width, and a constant power supply of 150 W. A silver-selenide target having a stoichiometric silver concentration of about 66.7% was used to deposit the silver-selenide film. Comparing the SEM images of the pulse DC sputter deposited silver-selenide films at various pressures indicate that low pressure sputter deposition ranging from about 0.3 mTorr to about 10 mTorr reduces and eliminates nodular defect formations. It was observed that a silver-selenide film deposited using high pressure, i.e., about 20 mTorr, has a silver concentration higher than about 67.5% and has nodular defect formations on the surface and through out the film as shown in FIG. 1(a); as shown in FIG. 1(b) a deposited silver-selenide film formed using a low pressure of 10 mTorr has relatively few nodular defect formations; and as shown in FIG. 1(c) a deposited film using an even lower pressure of 3 mTorr has a smooth surface with no nodular defects.

[0025] In accordance with a first embodiment of the invention, a silver-selenide target is sputter deposited using an RF sputter deposition process at a low pressure ranging from about 0.3 mTorr to about 10 mTorr, and more preferably about 2 mTorr to about 3 mTorr, to provide a silver-selenide film having little to no nodular defects and a silver concentration of about equivalent to the silver concentration of a silver-selenide target used to sputter deposit the silver-selenide film. For example, where a silver-selenide target having a silver concentration of about 66.7% is used in the RF sputter deposition process, the deposited silver-selenide film will have a silver concentration of less than about 67.5% and preferably about 67% and more preferably about 66.7%. A process in accordance with the first embodiment of the invention may be used for silver-selenide targets of any age, while still providing a sputter deposited silver-selenide film having a silver concentration about equivalent to that of the silver-selenide target used to deposit the silver-selenide film.

[0026] In a sputtering process in accordance with the first embodiment of the invention, the sputtering deposition generally takes place in a chamber. An initial base vacuum pressure is established first. The initial base vacuum pressure may be any suitable pressure, including pressures higher than about 10 mTorr, which may help ignite the plasma. During the sputtering process, process gas should be maintained at a pressure ranging from about 0.3 mTorr to about 10 mTorr, and preferably ranging from about 2 mTorr to about 3 mTorr. The process gas may be any suitable sputtering process gas, for example, krypton, xenon, helium, neon, argon or combinations thereof. The preferred process gas is argon. Although not wishing to be limited by to any particular amounts of power, power applied during the sputtering process preferably may range, for example, between about 100 watts to about 500 watts and is most preferably about 150 watts. Power density and power requirements may vary and depend on the chosen system or size of the target. For example, targets four inches or larger may require more power. The preferred RF frequency is between about 100 kHz and about 20 MHz and is preferably 13.5

MHz. An exemplary sputter deposition system is the Denton Vacuum Discovery® 24.

[0027] In accordance with a second embodiment of the invention, silver-selenide is sputter deposited using a pulse DC sputter deposition process at low pressures ranging from about 0.3 mTorr to about 10 mTorr to provide a silver-selenide film having a silver concentration of about equivalent to the silver concentration of a silver-selenide target used to sputter deposit the silver-selenide film. For example, where a silver-selenide target having a silver concentration of about 66.7% is used in the pulse DC sputter deposition process the deposited silver-selenide film will have a silver concentration of less than about 67.5% and preferably about 67% and more preferably about 66.7%. A low pressure of from about 4 to about 5 mTorr is preferred. There is a difference between RF sputter deposition and pulse DC sputter deposition in that for pulse DC sputtering a deposition pressure of from about 4 to about 5 mTorr, produces a deposited silver-selenide film having a silver concentration substantially equivalent to the silver concentration of the silver-selenide target, for example 66.7%. However, generally low pressure deposition provides smoother sputter deposited silver-selenide films having a more precise silver-selenide stoichiometry. The preferred low pressure used may vary depending on the condition of the target, for example, age of the target.

[0028] Similar to the process described above in accordance with the first embodiment of the invention, the sputtering deposition in accordance with the second embodiment also takes place in a chamber, for example, in a Denton Vacuum Discovery® 24, where a suitable initial base vacuum pressure is established first and a suitable process gas is employed. However, in accordance with the second embodiment, during the sputtering process, the process gas should be maintained at a pressure ranging from about 0.3 mTorr to about 10 mTorr, and preferably ranging from about 4 mTorr to about 5 mTorr. Although not wishing to be limited by to any particular amounts of power, the power applied during the sputtering process preferably may range, for example, between about 100 watts to about 500 watts and

is most preferably 150 watts and the preferred pulse DC frequency may range, for example, between about 100 kHz and about 250 kHz and is preferably about 200 kHz. However, power density and power requirements may vary and it will depend on the chosen system and/or size of the target. For example, targets four inches or larger may require more power. The pulse width should range from about 1000 ns to about 1200 ns and is preferably about 1056 ns.

[0029] Although the exact mechanism to explain the origin of experimental observations is unknown there is a connection between sputter pressure, ion kinetic energy, scattering induced energy reduction, and/or RF and pulse DC plasma electrical properties. For practical application, the inventors propose to use an RF sputter deposition process or pulse DC sputter deposition process at lower pressure to deposit better precision stoichiometric silver-selenide films and avoid nodular defect formations on the film. Accordingly, pressure may be varied within the low pressure range of from about 0.3 mTorr to about 10 mTorr to fine tune the silver concentration of the silver-selenide film. The power sources may be varied as well. This is of great importance in device fabrication in that many devices require elemental concentrations slightly deviated (i.e., $\pm 2\%$ at. concentration) from the preferred value of about 66.7%. Accordingly, since low pressure sputter deposition can also be used on relatively old targets while still providing more precise stoichiometric concentrations of silver, the invention expands the target lifetime thus reducing process costs.

[0030] According to the present invention, in addition to controlling the stoichiometry and morphology of silver-selenide during sputter deposition, it is also desirable to control the crystalline structure of the deposited silver-selenide.

[0031] Silver selenide (e.g. Ag_2Se) is well known for its low temperature phase transition point of 406 K (about 130°C). At temperatures below 406 K, Ag_2Se forms an orthorhombic structure, known as the "beta phase." At temperatures above 406 K (about 133°C), Ag_2Se undergoes a structural change in

which the Se forms a body-centered cubic sublattice, while the Ag undergoes a melting transition. In this so-called “alpha phase” or “superionic phase,” the Ag ions exhibit liquid-like diffusion. At around 1170 K (897 °C), the Se sublattice will also undergo a melting transition.

[0032] In accordance with the present invention, it is desirable for the deposited silver-selenide film to be formed of a mixture of the alpha and beta silver selenide phases. Such mixture is critical for the optimal performance of certain devices formed from silver-selenide films. According to the present invention, silver-selenide films containing both alpha and beta phases may be formed via a sputtering process under conditions of relatively lower power/higher pressure.

[0033] FIG. 2 shows two x-ray diffraction (XRD) scans 200, 220 of sputter deposited silver selenide films. Scan 1 shows an XRD scan 200 of a silver selenide film sputter deposited at a sputter power of 350 W and an argon sputter gas flow rate of 50 sccm, which corresponds to a sputter gas pressure of about 7 mTorr. Scan 2 shows an XRD scan 220 of a silver selenide film sputter deposited at a sputter power of 350 W and an argon sputter gas flow rate of 75 sccm, which corresponds to a sputter gas pressure of about 10 mTorr. The scans 200, 220 show that, under the latter conditions, alpha and beta peaks appear around 23 and 37 degrees in a glancing mode 2θ XRD scan.

[0034] While not being limited by theory, based on the XRD scans 200, 220, it appears that a lower energy impact of silver selenide with the substrate during sputtering yields more alpha phase silver selenide in the deposited film. Lower sputter power and higher sputter pressure decrease the kinetic energy imparted to the sputtered silver selenide molecules, thus resulting in a lower energy impact of silver selenide with the substrate. Furthermore, it also appears that heating the substrate to an a temperature above room temperature (about 25 C) also enhances the alpha phase in the deposited film.

[0035] While the crystalline structure of silver selenide (i.e. mixture of alpha and beta phases) is important for the optimal performance of devices employing such films, the film stoichiometry and texture (e.g. smoothness) also affect device performance as described above. Thus, to the extent decreases in sputter power or increases in sputter pressure result in films exhibiting a rough surface or undesired stoichiometry, a balance in the sputter power and pressure parameters must be struck in order to produce smooth selenide films of the desired stoichiometry and whose structures exhibit both alpha and beta phases. However, it should be emphasized that, independent of the process method used to produce the film, it is desirable to have the alpha phase present in deposited silver selenide films.

[0036] In accordance with a third exemplary embodiment of the invention, a silver selenide film is sputter deposited under sputter conditions such that the structure of said silver selenide film comprises both the alpha phase and beta phases. Specifically, silver selenide is sputter deposited using a sputter power of less than about 250W and a sputter pressure of at least about 10 mTorr. Furthermore, under sputter conditions wherein the sputter power is less than about 250W and the sputter pressure is about 10 mTorr, a silver selenide film comprising both the alpha and beta structural phases, having a silver concentration approximately equivalent to the silver concentration of a silver-selenide sputter target, and being free of surface defects may be formed on a substrate.

[0037] While exemplary embodiments of the invention have been described and illustrated, various changes and modifications may be made without departing from the spirit or scope of the invention. Accordingly, the invention is not limited by the foregoing description, but is only limited by the scope of the appended claims.

CLAIMS

[0038] What is claimed as new and desired to be protected by Letters Patent is:

1. A method of depositing silver-selenide comprising:
providing a silver-selenide sputter target in a sputter deposition chamber;
introducing a sputter gas into said chamber, wherein said sputter gas is maintained at a pressure of about 0.3 mTorr to about 10 mTorr; and
conducting a sputtering process on said target to produce a deposited silver-selenide film.
2. The method of claim 1, wherein said deposited silver-selenide film has a silver concentration of about equal to a silver concentration of said silver-selenide target.
3. The method of claim 2, wherein said silver-selenide target has a silver concentration of about 66.7%.
4. The method of claim 3, wherein said deposited silver-selenide film has a silver concentration of less than about 67.5%.
5. The method of claim 3, wherein said deposited silver-selenide film has a silver concentration of about 67%.
6. The method of claim 3, wherein said deposited silver-selenide film has a silver concentration of about 66.7%.

7. The method of claim 2, wherein said silver-selenide film has substantially no nodular defects.
8. The method of claim 1, wherein said sputter deposition process is an RF sputter deposition process.
9. The method of claim 8, wherein said sputter pressure ranges from about 2 mTorr to about 3 mTorr.
10. The method of claim 1, wherein said sputter deposition is performed using a sputter power ranging from about 100 watts to about 500 watts.
11. The method of claim 10, wherein said power is about 150 watts.
12. The method of claim 8, wherein said deposition process is performed using a frequency between about 100 kHz and about 20 MHz.
13. The method of claim 12, wherein said frequency is about 13.5 MHz.
14. The method of claim 1, wherein said sputter deposition process is a pulse DC sputter deposition process.
15. The method of claim 14, wherein said pressure is between from about 4 mTorr to about 5 mTorr.
16. The method of claim 14, wherein said deposition process is performed using a frequency between about 100 kHz and about 250 kHz.

17. The method of claim 16, wherein said frequency is about 200 kHz.
18. The method of claim 14, wherein said sputter deposition process is performed using a pulse width ranging from about 1000 ns to about 1200 ns.
19. The method of claim 18, wherein said pulse width is about 1056 ns.
20. A method of controlling a stoichiometry of a sputter deposited silver-selenide film comprising:
sputter depositing a silver-selenide film having a predetermined silver concentration using a sputter deposition pressure in a range from about 0.3 mTorr to about 10 mTorr; and
varying said sputter deposition pressure within said range while depositing said silver-selenide film.
21. The method of claim 20, wherein said silver-selenide film has a silver concentration of less than about 67.5%.
22. The method of claim 21, wherein said silver-selenide film has a silver concentration of about 67%.
23. The method of claim 21, wherein said silver-selenide film has a silver concentration of about 66.7%.
24. The method of claim 21, wherein said silver-selenide film has substantially no nodular defects.

25. The method of claim 20, wherein said sputter depositing is performed using a power ranging from about 100 watts to about 300 watts.
26. The method of claim 25, wherein said power is about 150 watts.
27. The method of claim 20, wherein said sputter depositing is performed using an RF sputter deposition process.
28. The method of claim 27, wherein said RF sputter deposition process is performed using a frequency of about 100 kHz to about 20 MHz.
29. The method of claim 28, wherein said frequency is about 13.5 MHz.
30. The method of claim 20, wherein said sputter depositing is performed using a pulse DC sputter deposition process.
31. The method of claim 30, wherein said pulse DC sputter deposition process is performed using a frequency of about 100 kHz to about 250 kHz.
32. The method of claim 31, wherein said frequency is about 200 kHz.
33. The method of claim 30, wherein said pulse DC sputter deposition process is performed using a pulse width ranging from about 1000 ns to about 1200 ns.

34. The method of claim 33, wherein said pulse width is about 1056 ns.
35. A method of depositing silver-selenide comprising:
providing a silver-selenide sputter target having silver concentration of about 66.7%,
maintaining a sputter deposition pressure of about 0.3 mTorr to about 10 mTorr; and
performing an RF sputter process on said silver-selenide sputter target, wherein said RF sputter process forms a deposited silver-selenide film.
36. The method of claim 35, wherein said silver-selenide film has a silver concentration of less than about 67.5% while.
37. The method of claim 35, wherein said silver-selenide film has a silver concentration of about 67%.
38. The method of claim 35, wherein said silver-selenide film has substantially no nodular defects.
39. The method of claim 35, wherein said pressure is about 2 mTorr to about 3 mTorr.
40. The method of claim 35, wherein said RF sputter deposition process is performed using power ranging from about 100 watts to about 300 watts.
41. The method of claim 40, wherein said power is about 150 watts.

42. The method of claim 35, wherein said RF sputter deposition process is performed using a frequency of about 100 kHz to about 20 MHz.
43. The method of claim 42 wherein said frequency is about 13.5 MHz.
44. A method of depositing silver-selenide comprising:
providing a sputtering a silver-selenide target having a silver concentration of about 66.7%; and
performing a pulse DC sputter deposition process at a pressure ranging from about 0.3 mTorr to about 10 mTorr, wherein said DC sputter deposition process forms a deposited silver-selenide film.
45. The method of claim 44, wherein said silver-selenide film has a silver concentration of less than about 67.5%.
46. The method of claim 44, wherein said silver-selenide film has a silver concentration of about 67%.
47. The method of claim 44, wherein said silver-selenide film has a silver concentration of about 66.7%.
48. The method of claim 45, further comprising forming a silver-selenide film having substantially no nodular defects from said sputtered target.
49. The method of claim 44, wherein said pressure is about 4 mTorr to about 5 mTorr.

50. The method of claim 44, wherein said pulse DC sputter deposition process is performed using a frequency from about 100 kHz to about 250 kHz.
51. The method of claim 50, wherein said frequency is about 200 kHz.
52. The method of claim 44, wherein said pulse DC sputter deposition process is performed using a pulse width ranging from about 1000 ns to about 1200 ns.
53. The method of claim 52, wherein said pulse width is about 1056 ns.
54. A method of depositing silver-selenide comprising:
providing a silver-selenide sputter target having a silver concentration of about 66.7%;
performing a sputter process using silver-selenide sputter target to form a silver-selenide film having a silver concentration of less than about 67.5%.
55. The method of claim 54, wherein said sputter depositing is performed using a deposition pressure of about 0.3 mTorr to about 10 mTorr.
56. The method of claim 55, wherein said sputter depositing is performed using a RF sputter deposition process.

57. The method of claim 56, wherein said RF sputter deposition process is performed using a sputter deposition pressure of about 2 mTorr to about 3 mTorr.
58. The method of claim 54, wherein said sputter depositing is performed using a pulse DC sputter deposition process.
59. The method of claim 58, wherein said pulse DC sputter deposition is performed using a sputter deposition pressure of about 4 mTorr to about 5 mTorr.
60. A sputter deposited silver-selenide film deposited at a pressure of from about 0.3 mTorr to about 10 mTorr, said film having substantially no nodular defects.
61. The film of claim 60, wherein said sputter deposited silver-selenide film is deposited using a silver-selenide target having a silver concentration of less than about 67.5%.
62. The film of claim 61, wherein said silver-selenide film has a silver concentration of about 66.7%.
63. The film of claim 61, wherein said film has a silver concentration of about 67%.
64. The film of claim 60, wherein said silver-selenide film is RF sputter deposited.
65. The film of claim 63, wherein said pressure is about 2 mTorr to about 3 mTorr.

66. The film of claim 60, wherein said film is pulse DC sputter deposited.
67. The film of claim 66, wherein said pressure is about 4 mTorr to about 5 mTorr.
68. A sputter deposited silver-selenide film having a silver concentration of less than about 67.5%.
69. The film of claim 68, wherein said sputter deposited silver-selenide film is deposited using a silver-selenide target having a concentration of about 66.7%.
70. The film of claim 69, wherein said silver-selenide film has a silver concentration of about 67%.
71. The film of claim 69, wherein said silver-selenide film has a silver concentration of about 66.7%.
72. The film of claim 68, wherein said sputter deposited silver-selenide is RF sputter deposited.
73. The film of claim 68, wherein said sputter deposited silver-selenide is pulse DC sputter deposited.
74. A method of depositing silver-selenide comprising:
providing a silver selenide sputter target in a sputter deposition chamber;
introducing a sputter gas into said chamber;
conducting a sputtering process on said target to produce a deposited silver-selenide film, wherein said silver-selenide

comprises both alpha silver-selenide and beta silver-selenide.

75. The method of claim 74, wherein said sputter gas is maintained at a pressure of about 10 mTorr during said sputtering process.
76. The method of claim 74, wherein a sputter power of said sputtering process is maintained at less than about 250W during said sputtering process.
77. The method of claim 74, wherein said deposited silver-selenide film has a silver concentration of about equal to a silver concentration of said silver-selenide sputter target.
78. The method of claim 77, wherein said silver-selenide target has a silver concentration of about 66.7%.
79. The method of claim 74, wherein said silver-selenide film is substantially free of nodular defects.