the incorporation of impurities from the sputter targets into the thin film absorber layers can also cause inconsistent and unreliable device characteristics. By way of example, impurities can act as trap levels (which would vary based on different impurities and their relative concentrations) in the band gap. Furthermore, the sputter targets themselves should have adequate density in order to minimize arcing and defect generation during the deposition process, as these can limit the process yield.

SUMMARY

[0003a] In a first aspect, there is provided a sputter target structure for depositing semiconducting chalcogenide films, comprising:

a target body having a target body composition that comprises $Cu_{1-x}(Se_{1-y-z}S_yTe_z)_x$, wherein:

the value of x is greater than or equal to approximately 0.5;

the value of y is between approximately 0 and approximately 1, inclusive;

the value of z is between approximately 0 and approximately 1, inclusive; and

the total amount of Se, S, and Te phases in the target body composition comprise less than 50 volume percent of the target body composition.

[0003b] In a second aspect, there is provided a method comprising

providing one or more ingots that collectively contain materials for producing a sputter target having a sputter target composition that comprises $Cu_{1-x}(Se_{1-y-z}S_yTe_z)_x$, wherein:

the value of x is greater than or equal to approximately 0.5;

the value of y is between approximately 0 and approximately 1, inclusive;

the value of z is between approximately 0 and approximately 1, inclusive; and

the total amount of Se, S, and Te phases in the target body composition comprise less than 50 volume percent of the target body composition;

melting the one or more ingots;

pouring the melted materials of the one or more ingots into a mold; and

controlling a cooling rate of the materials poured into the mold to control solidification of the materials.

[0003c] In a third aspect, there is provided a method comprising

providing one or more powders that collectively contain materials for producing a sputter target having a sputter target composition that comprises $Cu_{1-x}(Se_{1-y-z}S_yTe_z)_x$, wherein:

the value of x is greater than or equal to approximately 0.5;

the value of y is between approximately 0 and approximately 1, inclusive;

the value of z is between approximately 0 and approximately 1, inclusive; and

the total amount of Se, S, and Te phases in the target body composition comprise less than 50 volume percent of the target body composition;

melting the one or more powders;

pouring the melted materials of the one or more powders into a mold; and

controlling a cooling rate of the materials poured into the mold to control solidification of the materials.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Figure 1 shows an equilibrium Cu-Se phase diagram.

[0005] Figure 2 shows an equilibrium Cu-S phase diagram.

[0006] Figure 3 shows an equilibrium Cu-Te phase diagram.

[0007] Figure 4 shows an example characteristic X-ray diffraction pattern obtained with an example sputter target.

[0008] Figure 5 shows a flowchart illustrating an example process for manufacturing an example sputter target.

[0009] Figure 6 shows a flowchart illustrating an example process for manufacturing an example sputter target.

[0010] Figures 7A and 7B illustrate diagrammatic top and cross-sectional side views, respectively, of an example sputter target.

DESCRIPTION OF EXAMPLE EMBODIMENTS

[0011] The present disclosure generally relates to sputter targets suitable for use in photovoltaic applications, and particularly, to the manufacture of low melting point sputter targets for depositing semiconducting chalcogenide films for such applications.

[0012] Copper indium gallium diselenide (e.g., $Cu(In_{1-x}Ga_x)Se_2$, where x is less than or equal to approximately 0.7), copper indium gallium selenide sulfide (e.g., $Cu(In_{1-x}Ga_x)(Se_{1-y}S_y)_2$, where x is less than or equal to approximately 0.7 and y is less than or equal to approximately 0.99), and copper indium gallium disulfide (e.g., $Cu(In_{1-x}Ga_x)S_2$, where x is less than or equal to approximately 0.7), each of which is commonly referred to as a "CIGS" material, have been successfully used in the fabrication of thin film absorbers in photovoltaic cells largely due to their relatively large absorption coefficients. In fact, photovoltaic cells having photovoltaic efficiencies greater or equal than approximately 20% have been manufactured using copper indium gallium diselenide absorber layers. Efforts to minimize the defect density in the absorber layer(s) (hereinafter referred to as "absorber layer" or "absorber")