

Studies and Analysis of $\text{Ge}_x\text{Se}_{100-x}$ Based Spin Coated Chalcogenide Thin Films

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Since the mid-1950s, Chalcogenide glasses (ChG) have been a center of interest for the researchers because up to 5 % impurities do not affect their electrical performance, they are radiation hard and have various optical properties [1]. Based on these properties, chalcogenide glasses offer a wide range of applications, including phase change memory [3], temperature sensing [4], infrared laser power delivery, high-speed communications, ultra-fast switching [5]. A radiation sensing device based on Ag diffusion in $\text{Ge}_x\text{Se}_{100-x}$ ($x=30, 20$) chalcogenide glass thin vacuum evaporated films have been reported recently [6-7]. Undoped $\text{Ge}_x\text{Se}_{100-x}$ ChG has higher resistivity. When UV light is introduced into a double film of silver and $\text{Ge}_x\text{Se}_{1-x}$ chalcogenide glass film, Ag metal atoms react with UV light induced photons and create Ag^+ ions which drift into the undoped ChG and increase films conductivity [6-9]. Ge-Se based chalcogenide glasses were chosen because Ag has a higher diffusivity rate in them [7] and Ag ions have a very high mobility in it.

Our goal is to fabricate a similar radiation sensor using additive manufacturing technology. This technology comes up with the revolutionary change in many areas of industrial applications, medical complex equipment parts, and aerospace application [10]. It allows layer by layer fabrication of any desired pattern using different kinds of materials like polymers, metals, or glass. The main advantages of additive manufacturing technology over the traditional manufacturing include high resolution (20-50 μm) [11], low-cost process, enables complex geometric shape of the device, easy to cure. For this purpose, we have developed both Chalcogenide glass nano-particle ink [12] and dissolved ChG in different solvents. Usually amines were used to make dissolution based chalcogenide glass ink. Because of the high reactivity of amines with the parts of printers, we focused our initial studies on spin coated films. Different compositions of Ge-Se based chalcogenide glass thin films were deposited by spin coating on plasma treated dry oxidized SiO_2 surface. For example, $\text{Ge}_{20}\text{Se}_{80}$ was dissolved in Butylamine (BA) with concentration 0.803g of glass powder with 10 ml of BA solvent. After spin coating the deposited samples were annealed at 210°C in Ar-filled vacuum chamber. X-ray diffraction (XRD) data (Fig. 1) of the spin coated ($\text{Ge}_{20}\text{Se}_{80}$) film show several peaks for crystalline SiO_2 (DB no: 01-081-0069) and crystalline Se (DB no: 01-073-0465). We suggest that slow and hot dry oxidation process of the Si substrate on which the glasses are deposited is the reason behind the SiO_2 peaks. Scanning electron microscopy (SEM) shows that the films are quite rough (Fig. 2).

To understand the effect of dissolution on spin coated films X-ray diffraction (XRD) and scanning electron microscopy (SEM) are important tools. It is expected that data from these characterization methods could be used to optimize the process and produce better films. In a further development of the work we are planning to study in details the dissolution kinetics, as well as the properties of printed films and build radiation sensing devices based on them. We will study their performance and calibrate to obtain correct radiation data based on measured volt-ampere characteristics of the radiation sensing devices.

References:

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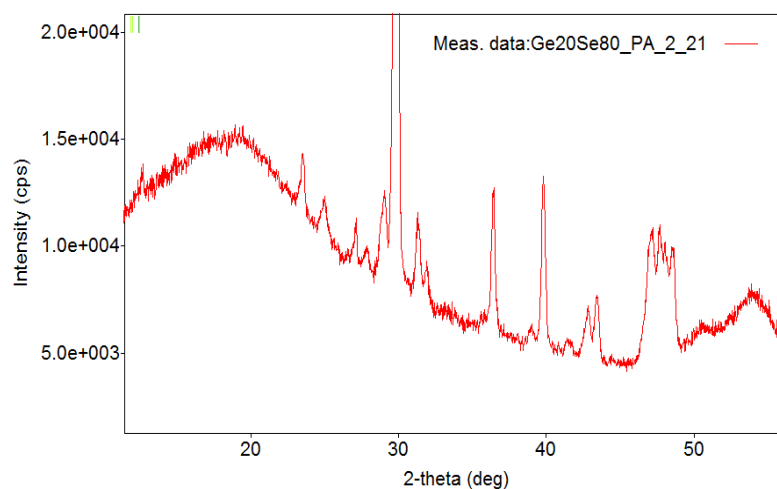


Figure 1. XRD plot of spin coated $\text{Ge}_{20}\text{Se}_{80}$ film. The plot indicates the presence of crystalline Se in the film and crystalline SiO_2 in the substrate.

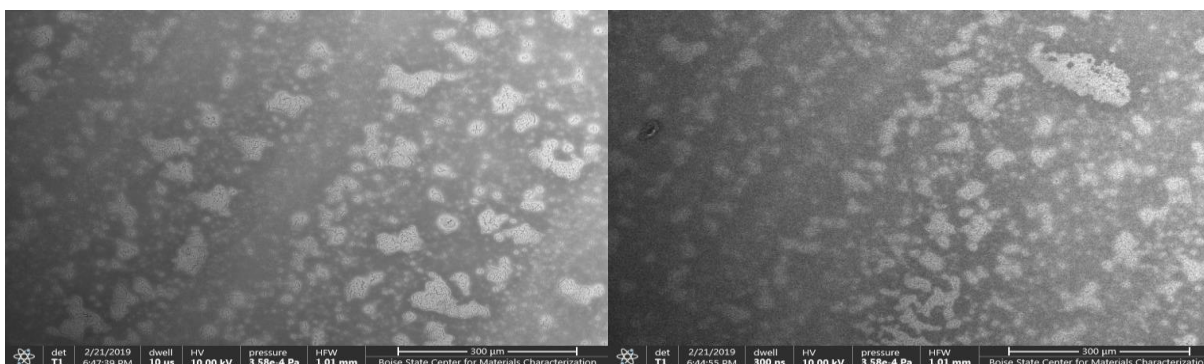


Figure 2. SEM micrograph of spin coated $\text{Ge}_{20}\text{Se}_{80}$ (Right) and $\text{Ge}_{30}\text{Se}_{70}$ (Left). SEM shows that the films are quite rough in nature.