Investigation of areas of low conductivity in coatings of $Ge_2Sb_2Te_5$ (GST) on a metallic base

James Brady

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Advisor: Dr. Richard Vanfleet

1. Abstract:

We conducted SEM and TEM imaging of some specific Ge2Sb2Te5 samples in order to investigate the previously discovered areas of low resistance. The theory was that the areas may have been the result of crystalline seeds. We found no evidence of crystalline seeds.

2. Introduction:

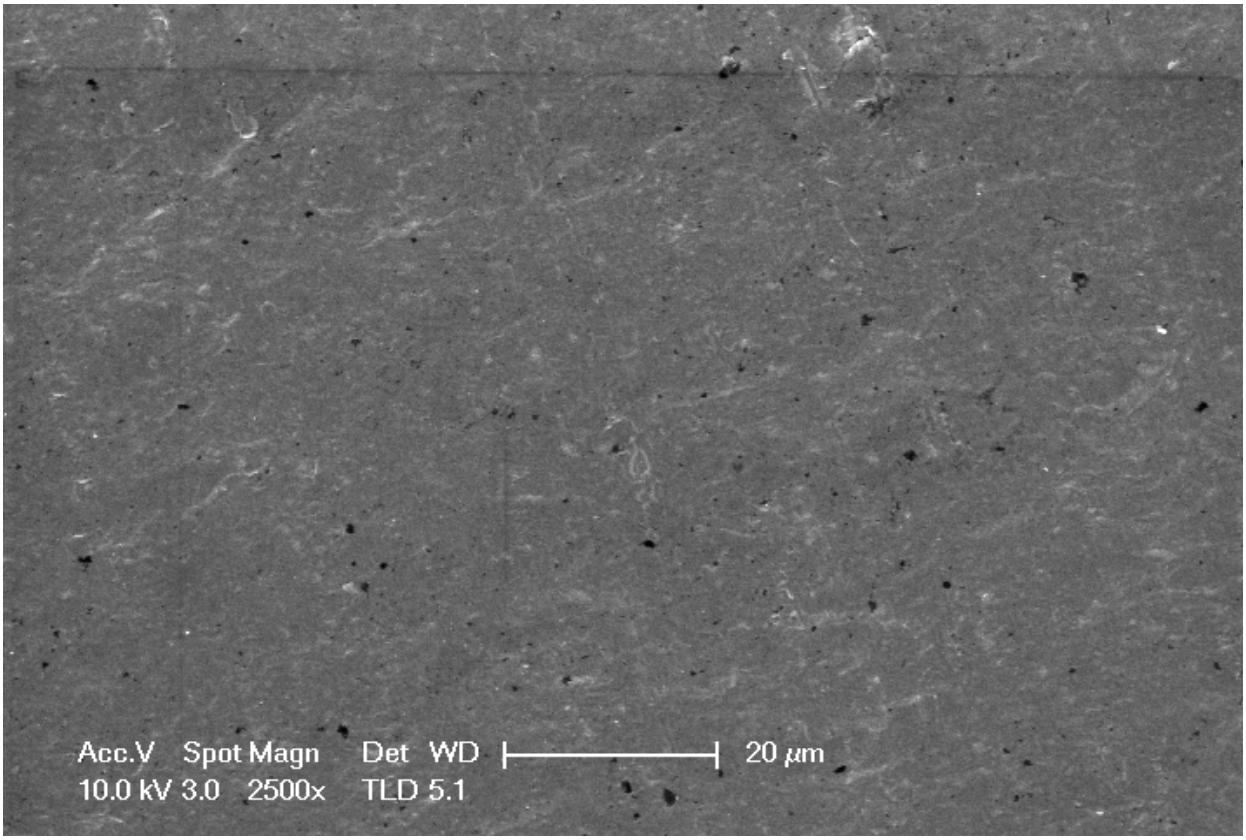
GST is currently used as the storage portion of CD and DVD mass storage devices due to its ability to transition from an amorphous state to a crystalline state when heated above 150C and then back to an amorphous state when heated above 400C. The Current technique is to use a laser to heat the material to cause the phase changes, and similarly use a laser to scan for the variation in optical properties between the two different states. The overall goal of this current research is to create a method for storing data that utilizes the electrical properties of this same compound rather than its optical properties. In other words, to be able to use an electrical circuit to read and write mass data rather than a laser. The advantage would be a possible denser storage of information as well as the reduced cost in being able to read and write that information.

3. Experiments:

The specific sample we have and researched is GST deposited on a metal foil. The sample originated in Craig Taylors program at the Colorado School of Mines and was studied by Colin Ingerfeld's group at Weber State. A conductive AFM study was done of the supposedly amorphous film. Many points of low electrical resistance between the surface and substrate were found. These anomalies could be crystalline seeds, or some other types of impurity. The

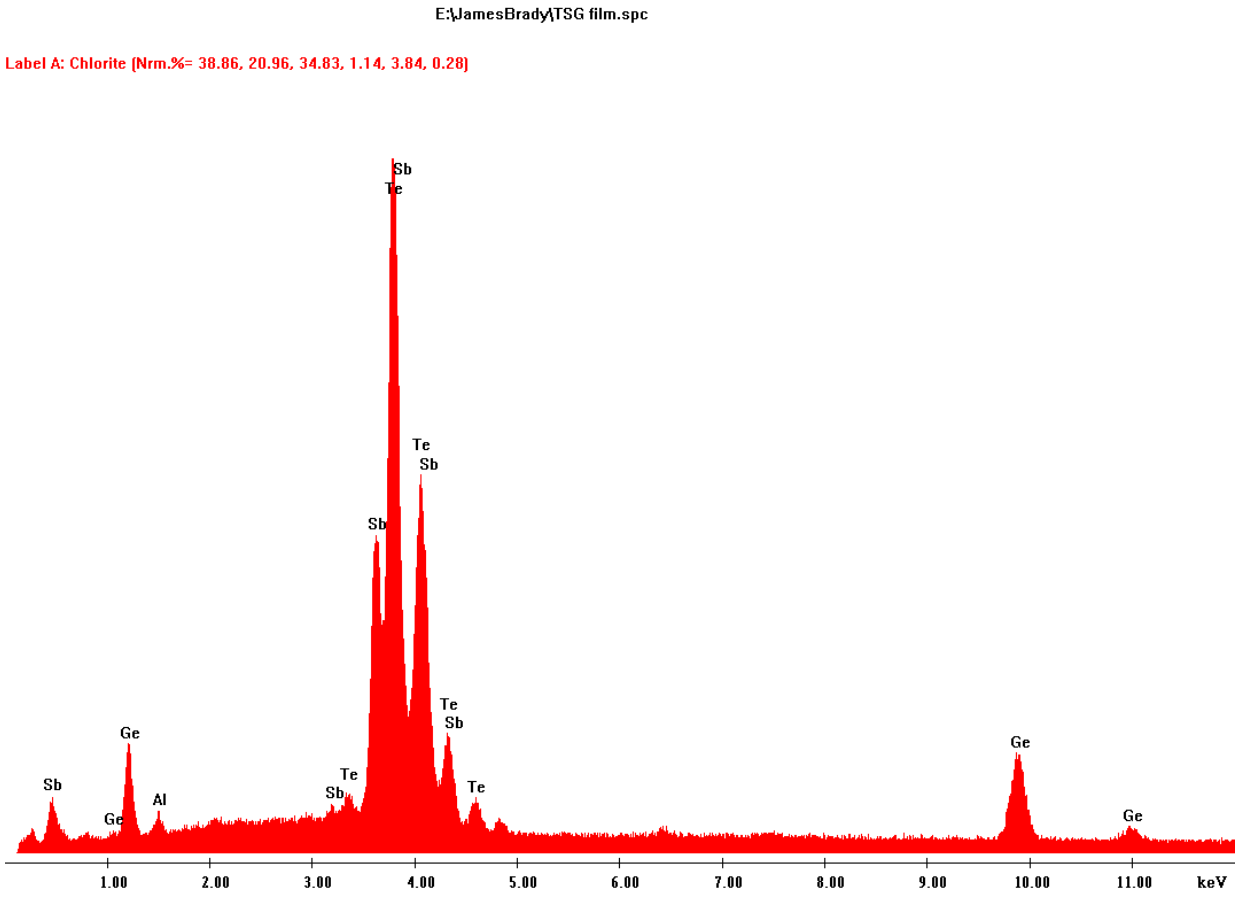
problem is that regardless of what these impurities are, because they are associated with a change is resistance; their presence makes accurate data storage impossible.

SEM and TEM imaging was done in an attempt to classify the impurities, and specifically to look for possible seeds. Both plane view and cross view TEM samples were prepared, as well as several SEM samples. After analysis no evidence of crystalline seeds were discovered, what was discovered were shallow pits along the surface of the GST. (The black spots on the SEM image below.)



When these spots were first discovered it was speculated that they may be the impurities that we were searching for. So the first thing we did was do a spectral analysis of several of them in an

attempt to verify their composition. The results are in the table below.



It was clear from this data that the material present in the pits was still GST as indicated. We now suspected that they may be the crystalline seeds, but after closer imaging it was apparent that the dark spots were in fact pits in the sample. Cross sectional views showed that these pits were present both on top of the sample as well as in-between the sample and the substrate leading us to the conclusion that the pits were present in the original rather than forming later due to some type of contamination of the sample. Usually these pits were shallow, but several were discovered to be the entire depth of the sample creating a hole in the GST layer. Now these types of holes should cause an area of higher resistance rather than lower and thus are probably

not the cause of our anomalies. However, they also will create problems in the attempt to use GST deposited on this particular substrate using the current technique.

4. Results and Discussion

To further investigate the areas of low conductivity I suggest a micro-Raman scattering spectroscopy be attempted on the sample. Specifically looking on the samples areas of low conductivity, if there is a reading at 150 cm^{-1} that represents the Te Te stretching and is a sign that the structure is not crystallized; therefore the absence of such a reading could be an indication that an impurity is present including a crystalline seed. The presence of such a band would indicated that the sample is still GST and in an amorphous state.

The presence of the pits may have occurred during the initial sample preparation. There are currently three main techniques for depositing GST samples: D. C. Magnetron Sputtering, evaporation, and ion plating it is unknown which technique was used to prepare the current sample, but the other two techniques should be investigated in order to possibly find a technique that may work better for this different type of substrate. It has been documented that partial states exist and a different type of sample preparation may be more successful in producing a more consistent layer of GST. There are also a couple of other materials that may work rather than GST on this particular type of substrate, that have similar characteristics to GST; AIST ($Ag_6In_{4.8}Sb_{60.8}Te_{28.7}$) and $ZnS-SiO_2$. Both compounds have been analyzed, and found to have similar capabilities to GST, it is possible one of them may be deposited more efficiently on the metal substrate.

A recent study by a group from China claims to have successfully used GST sandwiched between two metal sidewalls rather than simply layered over a single one in order to write and

read data using only the electrical properties. They claimed to use a 5V pulse for 100ns and a 10V pulse for 10ns (Reset). I have not been able to obtain a copy of their paper, but careful analysis of their procedures may give us some insight in to correcting our own.

Conclusion:

We conducted SEM and TEM imaging of some specific Ge2Sb2Te5 samples in order to investigate the previously discovered areas of low resistance. The theory was that the areas may have been the result of crystalline seeds. We found no evidence of crystalline seeds.