Crystallization of Germanium for the Use in Low-cost Solar Cells

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Back to the Future REU – Summer 2010

Introduction

The most efficient solar cells to date use germanium wafers a s a base. However, germanium is an expensive element, which costs $950 per kilogram. Silicon, a secondary material used in solar cells, costs only$2.65 per kilogram. However, by using silicon rather than germanium the efficiency of the solar cell decreases. In order to reduce the cost of germanium solar cells it may be possible to use thin germanium crystals (several nanometers thick) rather than wafers (several hundred microns thick). Decreasing the thickness decreases the amount of material needed to support the solar cell reducing the cost in turn.

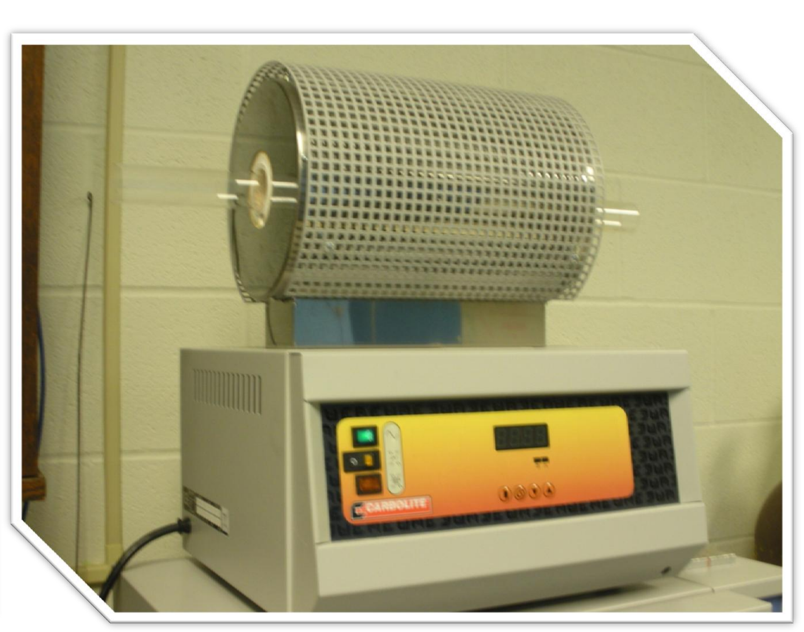
Research Objectives

- Crystallize germanium samples through annealing
- Examine the amount of crystallization, as well as the size of crystallized grains
- Determine if they are theoretically large enough to hold solar cells
- Determine an optimal crystal growth temperature, and if the temperature is in a cost-effective range

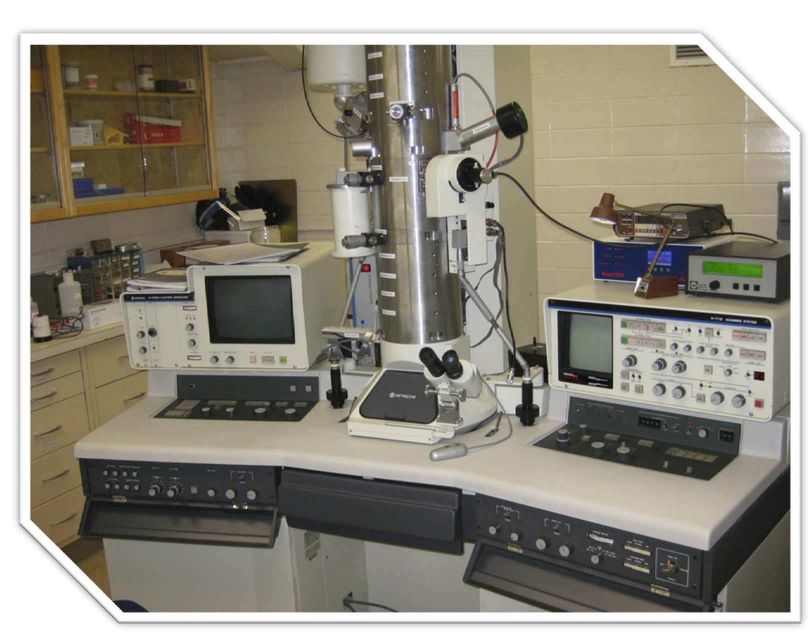
Procedure

- Deposit a thin film of germanium on TEM molybdenum grids using a vacuum evaporator (Fig. 1)
- Anneal the grids using a tube furnace at various temperatures and times (Fig. 2)
- Analyze the resulting crystallization the Transmission Electron Microscope (TEM) (Fig. 3)
- Further analysis may be done using computer software to determine an accurate size of the germanium grains

(Fig. 1) JEE-4X/5B Vacuum Evaporator from Jeol Technics LTD



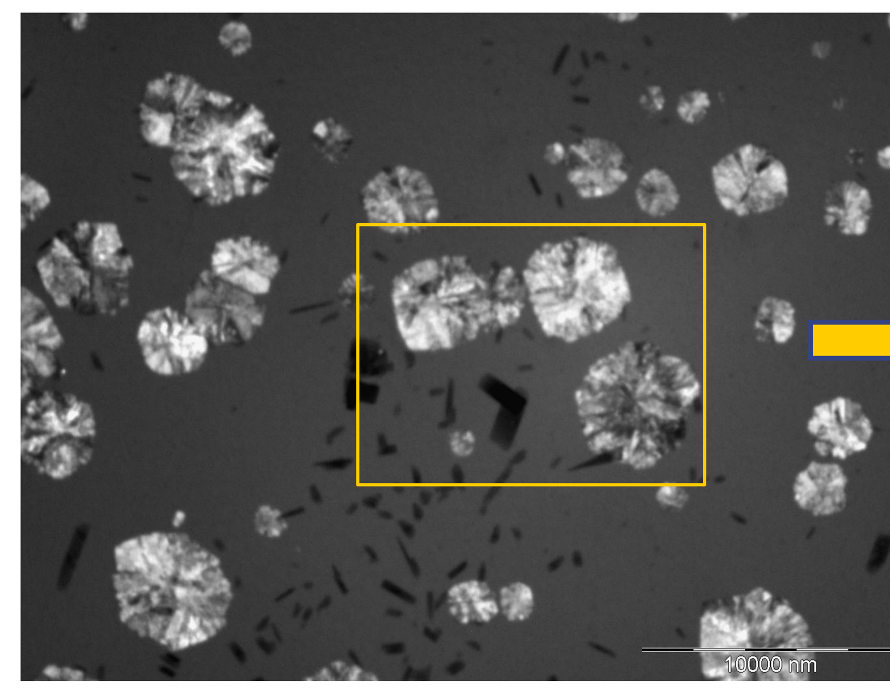
(Fig. 2) Carbolite MTF 12/38/250 tube furnace



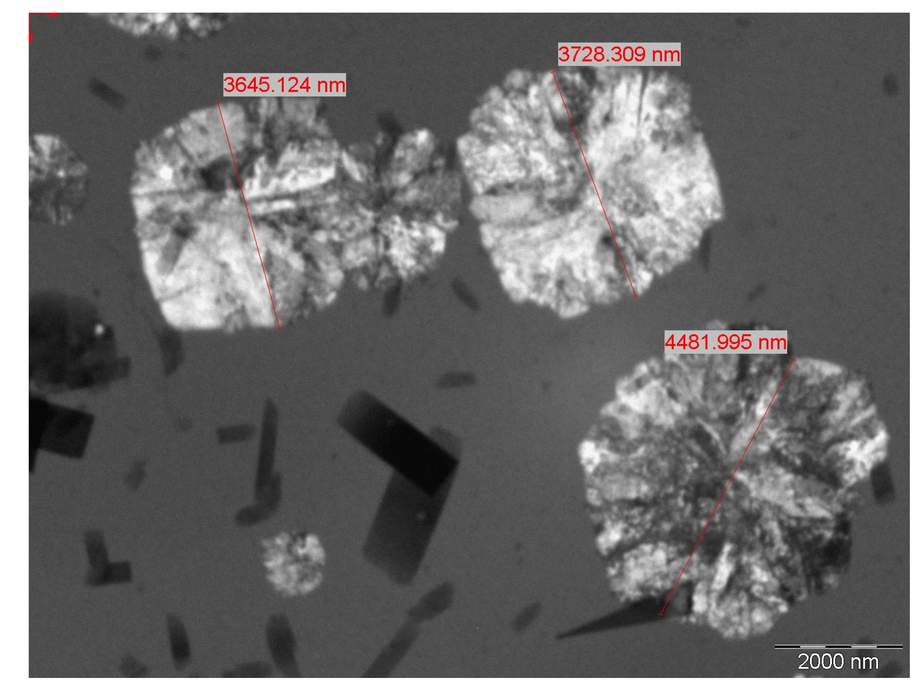
(Fig. 3) Hitachi H-7110 TEM

Results

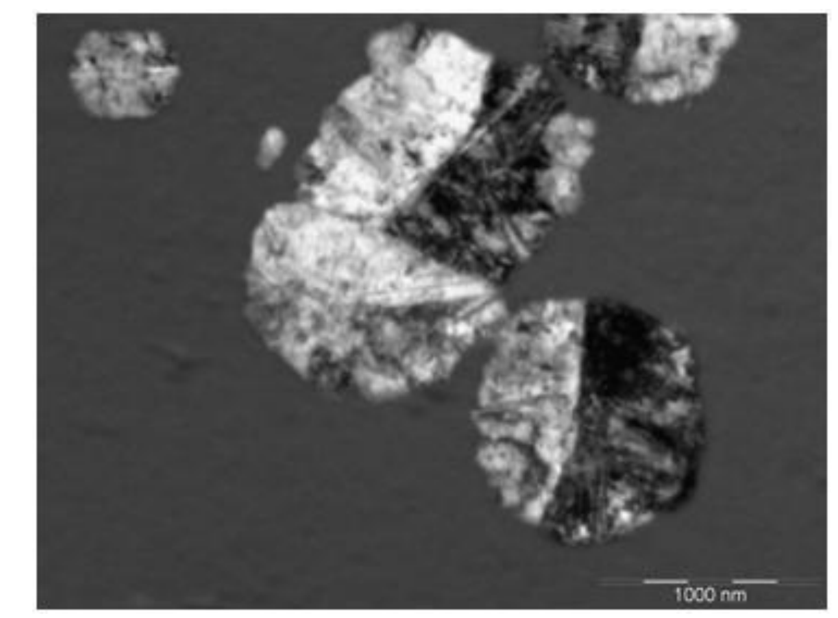
- Crystallization occurred above 400˚ C in the Tube furnace (Fig. 4, Fig. 5)
- The largest grains seemed to grow at 450˚ C with grains exceeding 7µm (Fig. 7)
- Grains seemed to have a radial symmetry, sometimes resulting in interesting features (Fig. 6)



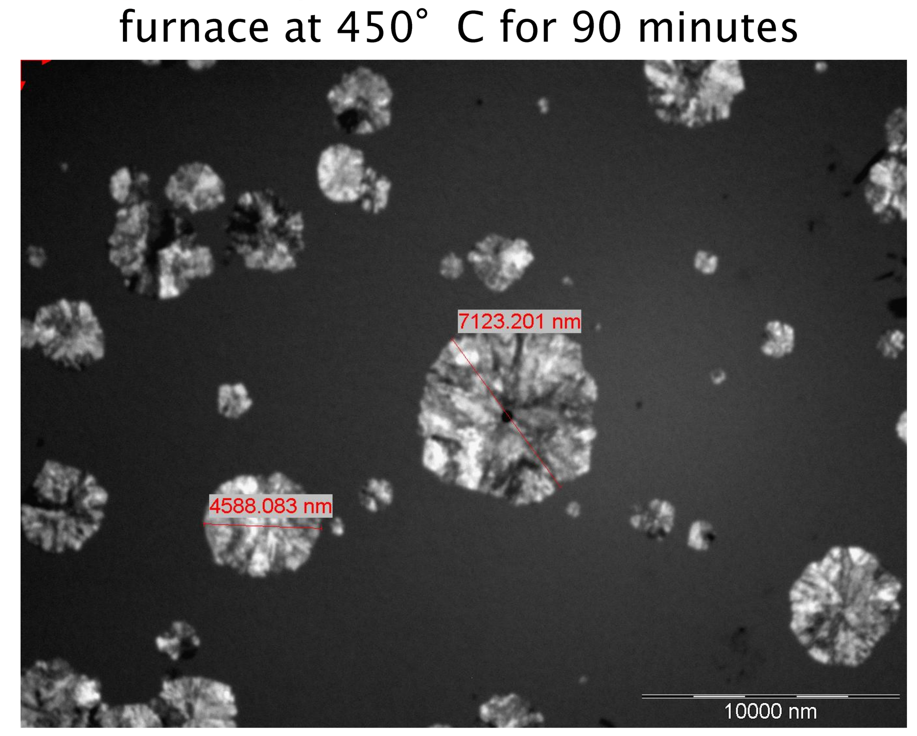
(Fig.4) Sample E3 annealed in the tube furnace at 450˚ C for 90 minutes



(Fig. 5) Magnification of Fig. 4



(Fig. 6) Sample D2a annealed in the tube furnace at 400˚ C for 2 hours



(Fig. 7) Sample E3 in a different location, same magnification as Fig.4

Conclusions

The optimal temperature for growing large crystals in the tube furnace was at 450˚ C, which can be obtained easily in a commercial or academic setting without incurring excessive costs due to the heating process.

In relation to the size of the grains, silicon solar cells using crystallized thin films have grain sizes of about 50µm with a 10-15µm thickness. Since the size of the germanium grains did not exceed 10µm, the grains may be able to hold a solar cell, but probably should be larger.

Future Work

- Test more samples to get a more complete data set
- Design a method for the most efficient evaporation deposition
- Determine what effect H-passivation may have on the size of germanium grains (H-passivation increases the size of silicon crystals)
- Implement this method into practical uses such as solar cells

Special Thanks to Dr. Phil Ahrenkiel, Dr. Michael West, and Dr. Alfred R. Boysen
Research Made Possible by: National Science Foundation Grant #0852057 –REU Site: Back to the Future