

A fundamental study of phase separation in GaAs-Ge system for semiconductor fibers by post heat treatments

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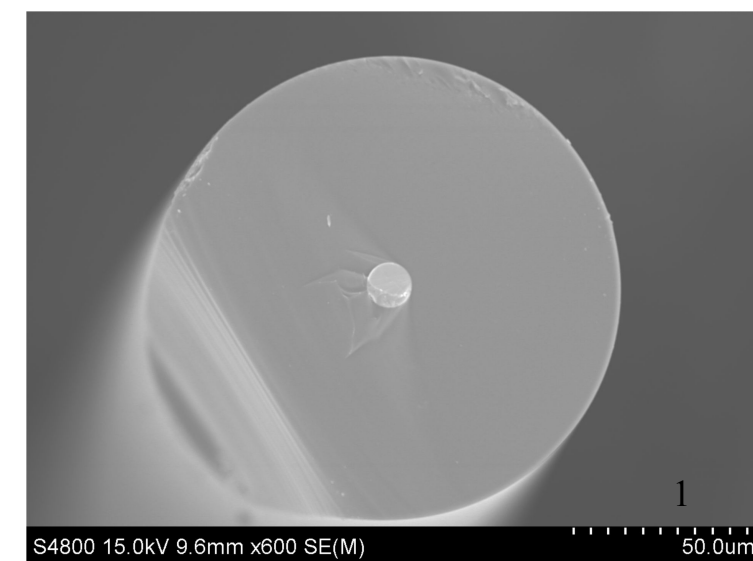
OBJECTIVE

This project studies the phase separation in GaAs-Ge systems when undergoing heat treatment. This will be done by heat treating a bulk GaAs-Ge sample, as well as, a cane containing a GaAs-Ge core. Samples will be heat treated for differing times and scanning electron microscopy (SEM) along with EDX will be used to analyze the elemental composition to show if any separation occurs. The goal of the project is a proof of concept of phase separation of GaAs to be used in future GaAs core optical fiber research.

INTRODUCTION & MOTIVATION

Advantages of semiconductor core

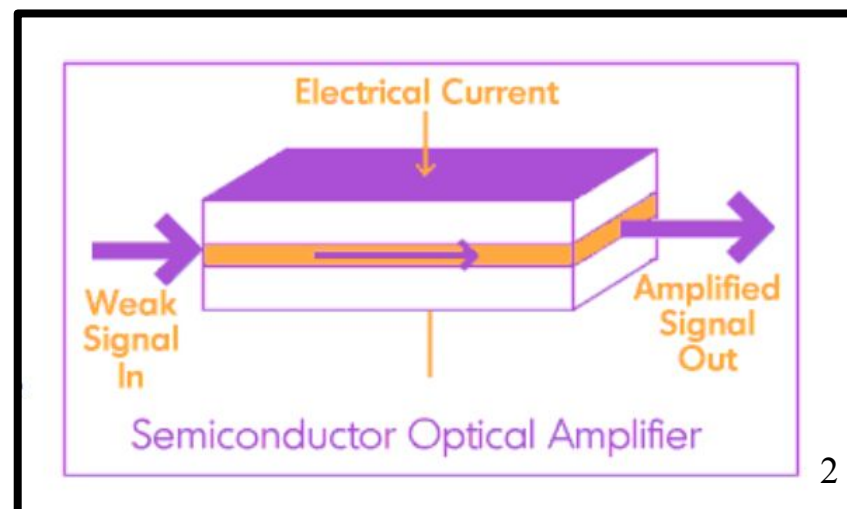
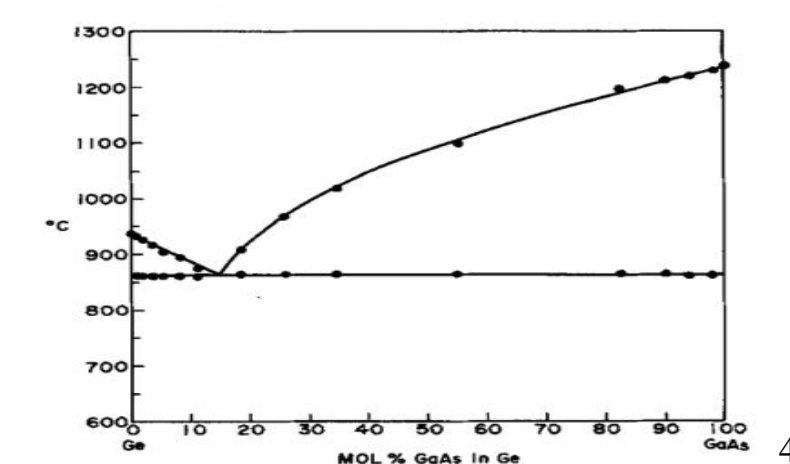
- ❖ Mid-wave and long-wave infrared waveguides
- ❖ Highly nonlinear
- ❖ Lower processing temperature



SEM image of germanium core optical fiber

Applications

- ❖ Solid-state electronics
- ❖ Nonlinear fibers
- ❖ IR transmission fibers



EXPERIMENTAL

GaAs-Ge System

	wt%	mol%	grams
GaAs	27.5	16	2.75
Ge	72.5	84	7.25

Bulk samples were fabricated by combining GaAs and Ge following the batch sheet above. The powder was then placed in silica glass tubes and vacuum was pulled. The crucibles were then heated in the furnace at 1200°C for 8 hours.

BULK



An example of a bulk sample inside a vacuum sealed, silica glass crucible. Vacuum is pulled to avoid having the sample oxidize during heat treatment.

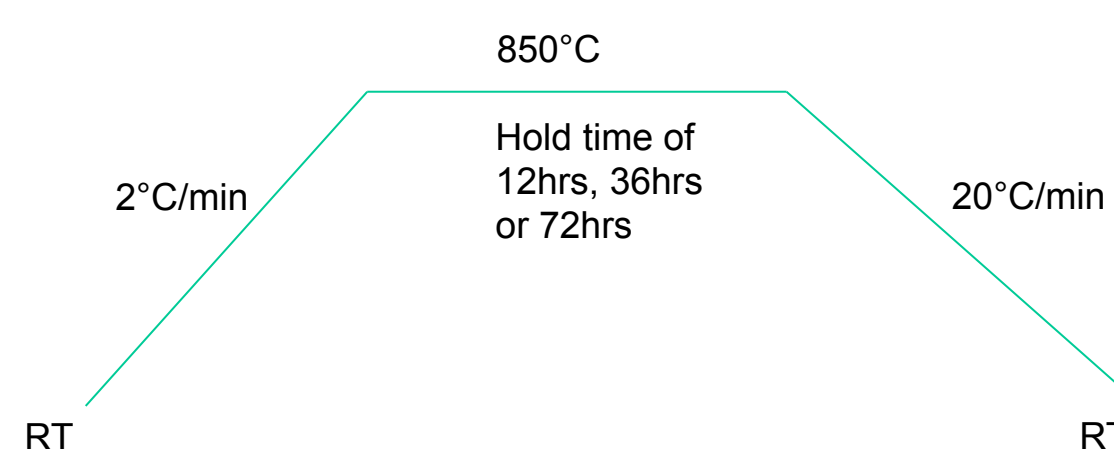
CANE

Draw Specifications

- ❖ Drawn at 990° c
- ❖ Outer diameter 3.5mm
- ❖ Core diameter 350 um

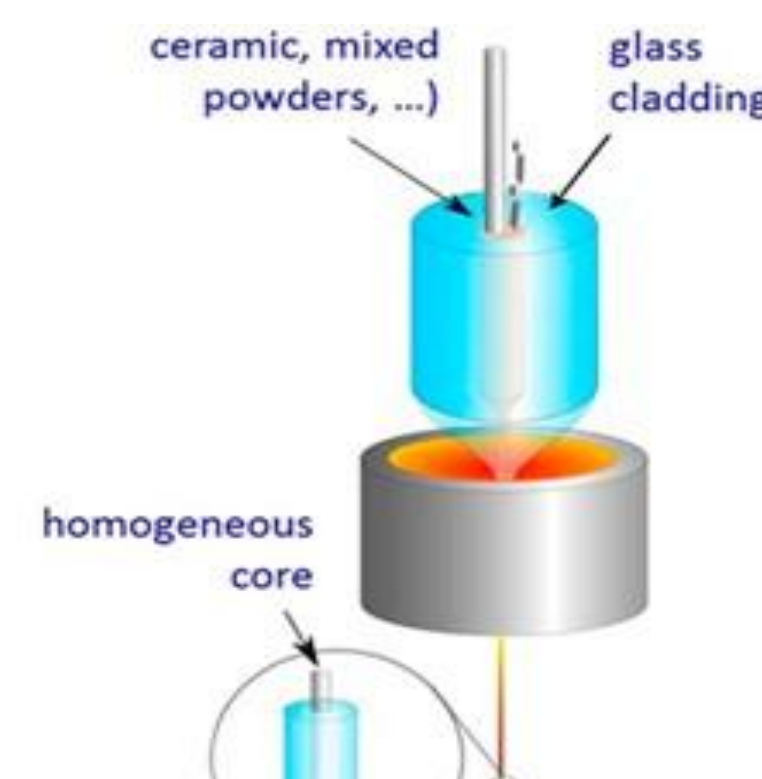


Heat Treatment of Cane/Bulk samples



Heat treatment was performed in air with a 2°C/min ramp up and were held at 850°C for 12,36, and 72 hours.

The method used for drawing fibers and canes is the molten core method. In the molten core method, the raw core material is placed inside a capillary preform; in this case Duran® and the entire preform is then placed in the draw tower furnace. The furnace is then set to a temperature where the cladding becomes soft and the core material is molten. This allows the fiber to draw down the tower with the core material using the preform as a crucible.

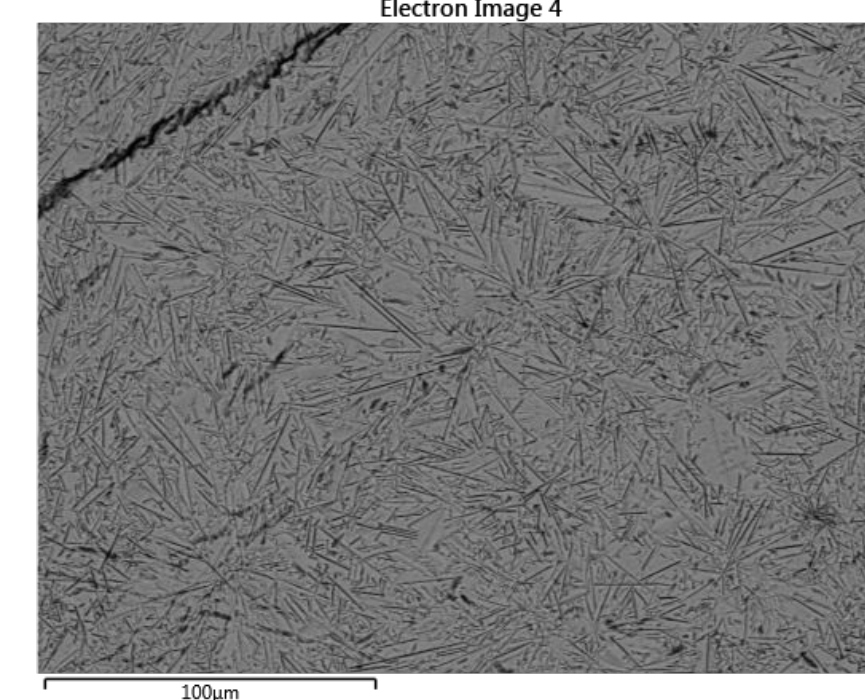


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RESULTS

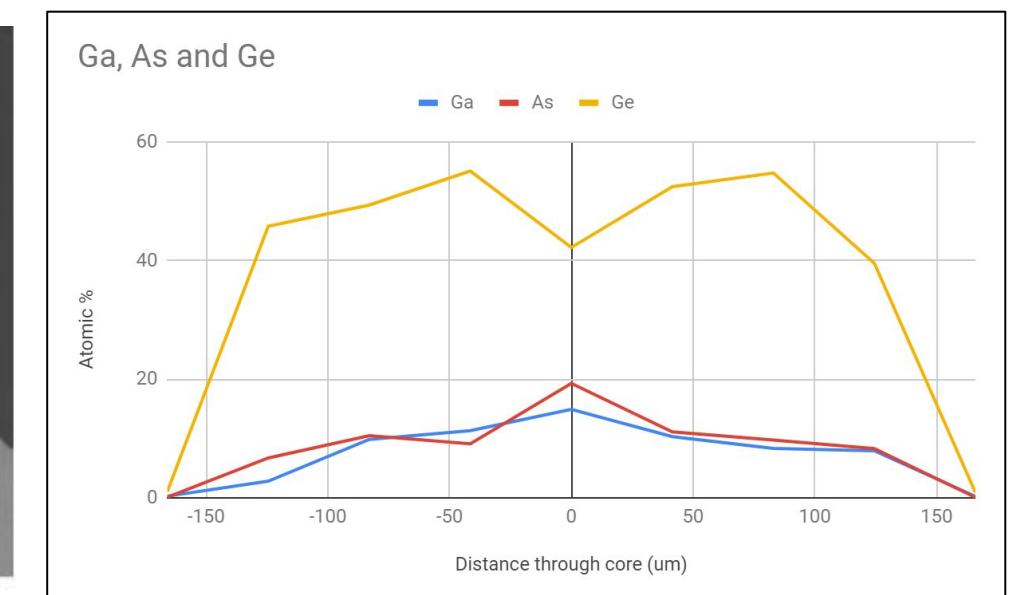
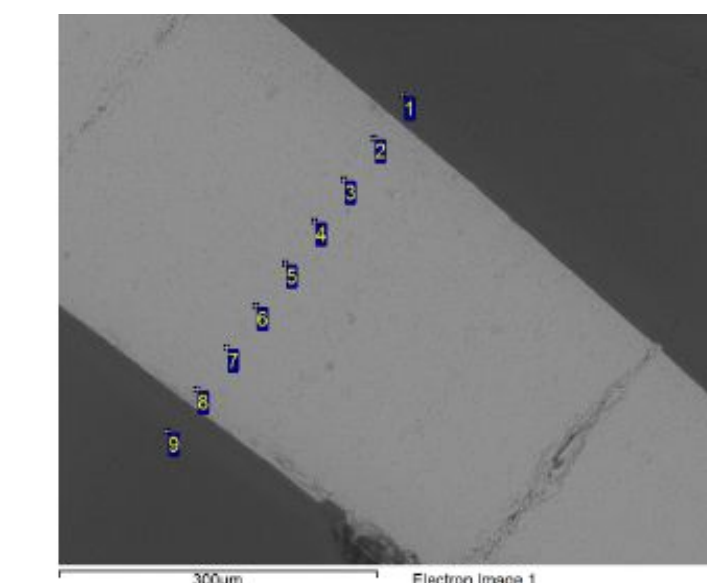
NON-HEAT TREATED



EDX performed on non-heat treated sample to confirm that elemental percentages stayed consistent after melting

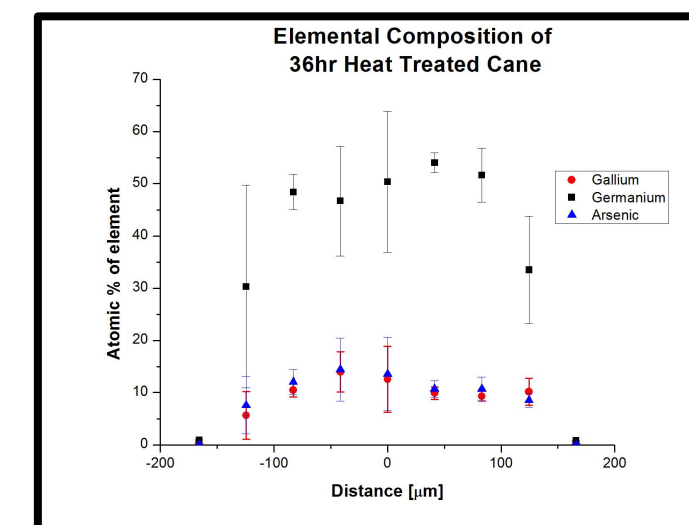
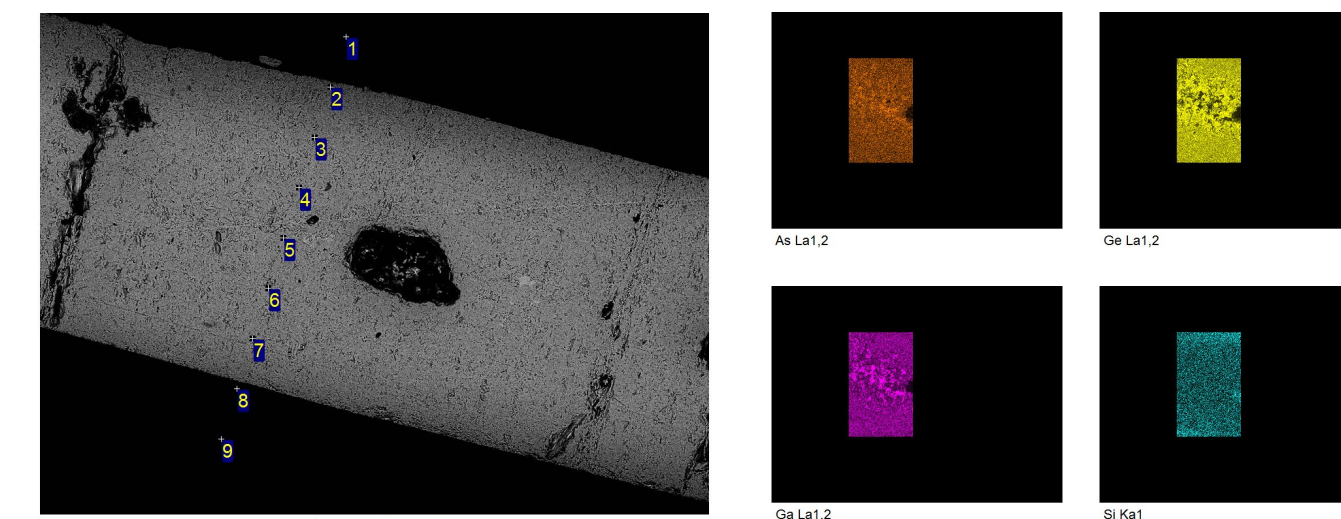
		Atomic	%	
Spectrum Label	O	Ga	Ge	As
Map Sum Spectra	2.04	12.19	75.24	10.53

12 HOUR TREATMENT



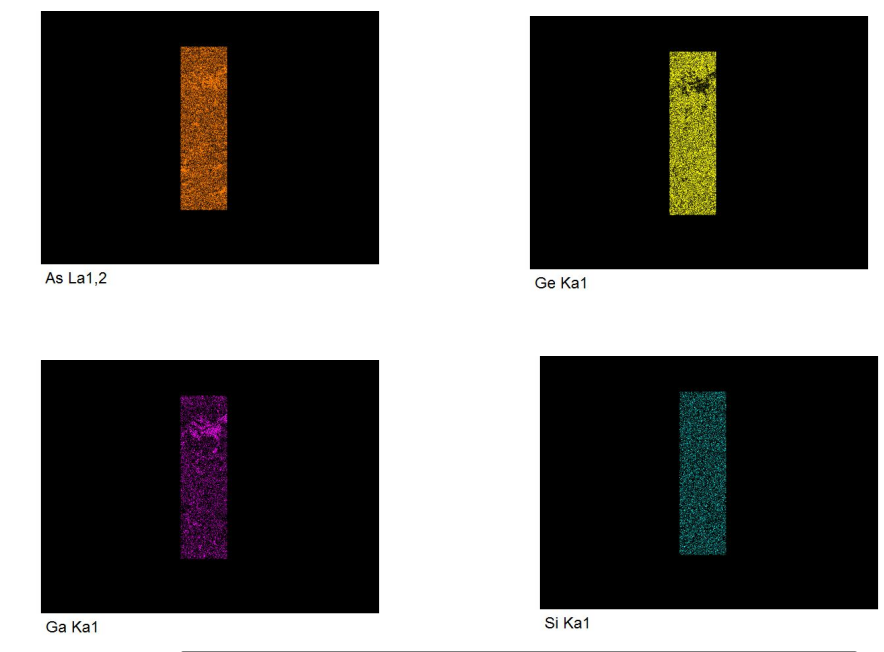
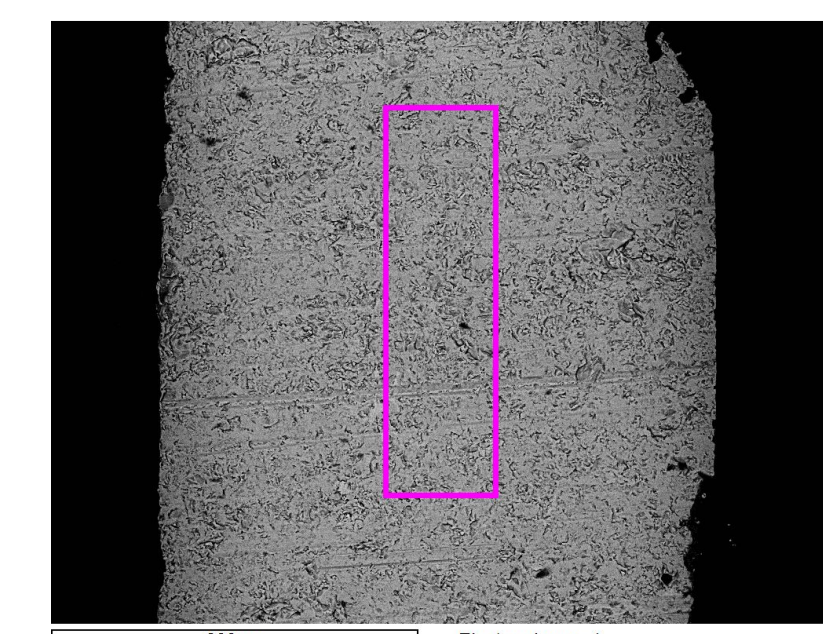
SEM and EDX of 12 hour sample showed no evidence of phase separation

36 HOUR TREATMENT

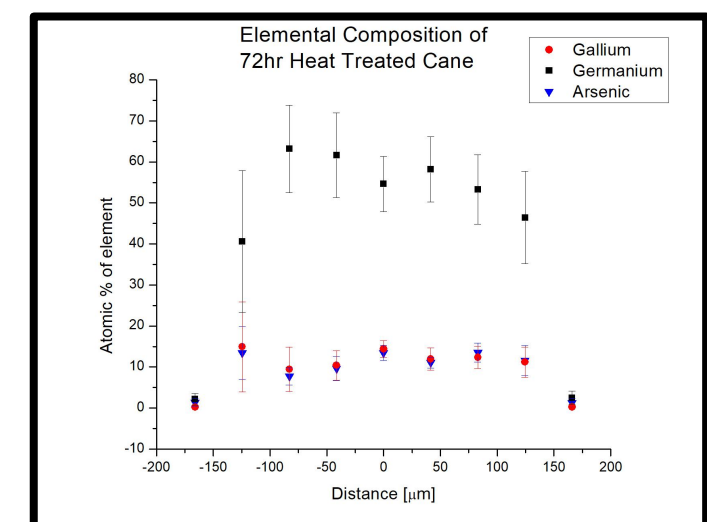


With EDX of 36 hour sample we begin to see possible separation transversely, with GaAs moving towards the outer edges of the core

72 HOUR TREATMENT



The 72 hour treated sample showed the same transverse separation as the 36 hour sample but now we begin to see GaAs separating into clustered areas throughout the core



CONCLUSIONS

- ❖ Phase separation observed in cane with long (36+ hour) heat treatment times with no separation found at treatment times less than 36 hours
- ❖ Transverse separation observed in 36 and 72 hour samples
- ❖ Separation into GaAs clustered areas observed in 72 hour treatment time
- ❖ Elemental movement in the system is done by GaAs with no movement seen with Ge

FUTURE WORK

- ❖ Perform heat treatment for longer than 72 hours to test if clustered GaAs separation is continued
- ❖ Send cane sample to NTNU to be post-fiber processed with CO₂ laser tapering to get a more controlled separation
- ❖ Draw treated cane into fiber to test optical properties

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