Geranium Telluride Synthesis

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ABSTRACT

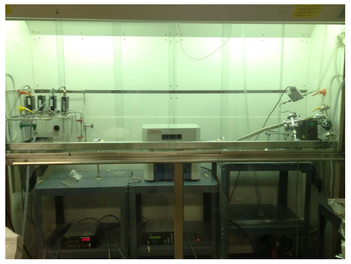
Germanium telluride or GeTe is a compound that shows ferroelectric and semimetallic properties. Due to those properties it is a candidate to transform thermoelectric and computing industries. Germanium telluride can be synthesized into nanowires which can be used as the next transistor and improve efficiency of thermoelectric generators.

Germanium telluride nanowire can be made using CVD or chemical vapor deposition. Inert gasses hydrogen and argon are passed through an evacuated tube. A ceramic boat of germanium telluride alloy powder is placed in the tube with a silicon chip 10-13 centimeters down wind. The silicon chip is coated with a 3nm layer of gold. The tube is then heated up to a temperature around 600ºC to 700ºC. The germanium telluride vaporizes and is collected on the gold silicon chip. At that point the gold is aqueous and the GeTe goes into solution. The solution becomes super saturated and GeTe nanowires precipitate out in the form of nanowires.

Research regarding the perfection of this method will aid mass production and manufacturing of germanium telluride nanowires.

CVD

1.

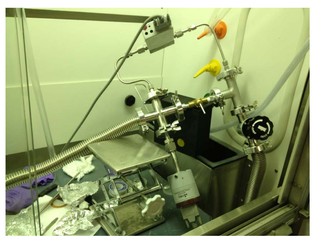


2.

3.

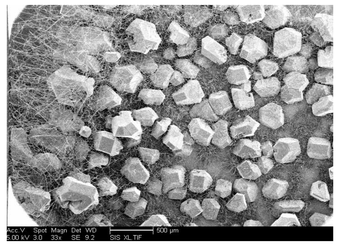
4.

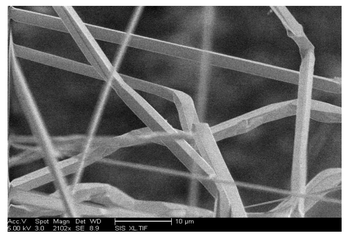
5.



1) CVD machine 2) Argon and hydrogen gas tanks 3) Gas control unit 4) furnace 5) pressure regulator and vacuum

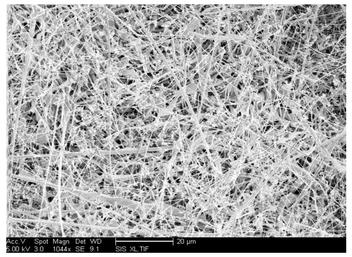
Parameters

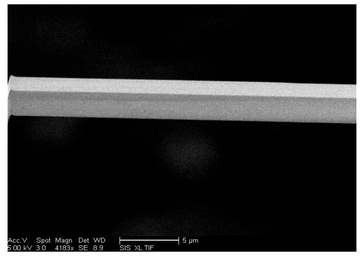




Sample 1. T=650°C, P=120 Torr, 100sccm → 15sccm, T=3hr, 12 cm from Substrate (Chip)
High amounts of GeTe powder

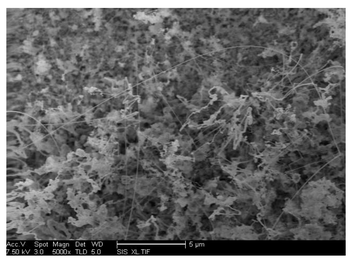
High amounts of powder allowed GeTe crystals to form and large GeTe wires microns wide.

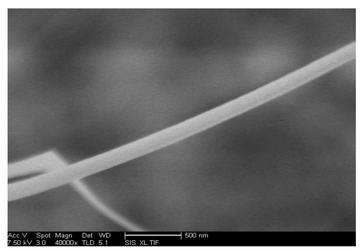




Sample 2. T=650°C, P=120 Torr, 100sccm → 15sccm, T=3hr, 11 cm from Substrate (Chip)
Moderate amounts of GeTe powder, possible contamination, pressure surpassed 180 torr in heat up.

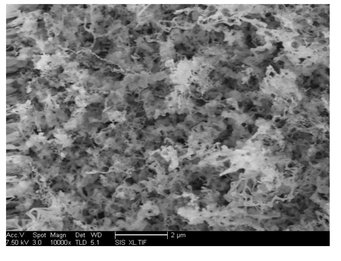
Parameters yielded high amount but low quality GeTe wires micrometers wide.

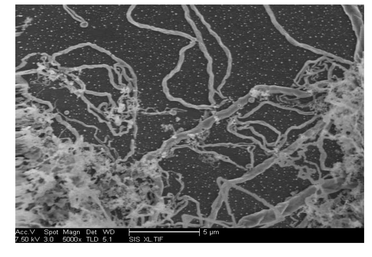




Sample 3. T=650°C, P=120 Torr, 100sccm → 15sccm, T=3hr, 11 cm from Substrate (Chip)
Pressure stayed low throughout heat up (never surpassed 120 torr),

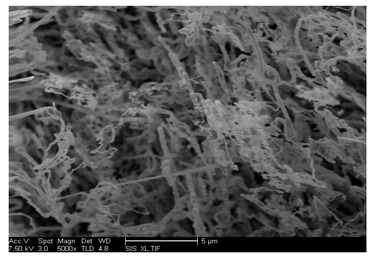
Produced low amount of high quality nanowires(100nm diameter)

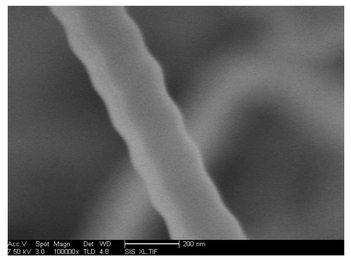




Sample 4. T=650°C, P=120 Torr, 100sccm → 15sccm, T=3hr, 14 cm from Substrate (Chip)
Ran simultanesouly with another chip.

Not enough GeTe powder for both chips to successfully grow.





Sample 5. T=630°C, P=120 Torr, 15sccm → 15sccm, T=3hr, 13 cm from Substrate (Chip)
Constant gas flow, pressure overshot

Wires have strange characteristics and not usable.

CONCLUSIONS AND FUTURE DIRECTIONS

- **Refine CVD technique for GeTe nanowires.**
- Parameters in sample 2 and 3 produced the most promising results.
  - Find middle ground parameters for sample 2 and 3 to maximize quality and quantity of wires.
- Manipulate high quality wires and test GeTe nanowire properties.
- Develop efficient extraction technique.
- Use wires for more efficient thermoelectric generators and phase change transistors.

References

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- Synthesis of thin silicon nanowires using gold-catalyzed chemical vapor deposition r. stanley williams t.i. kamins s. sharma (2005)
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- X. Vapor–Liquid–Solid and Vapor–Solid Growth of Phase-Change Sb2Te3 Nanowires and Sb2Te3/GeTe Nanowire Heterostructures Jin Seok Lee, Sarah Brittman, Dong Yu, and Hongkun Park (2008)