Gallium Growth on Silicon (100)

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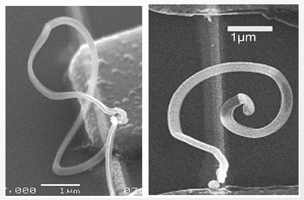
Abstract

The mission of the research conducted was to discover if manipulation of temperature, combined with varying levels of current and volts sent through a vacuum chamber, would create an ideal environment for the growth, and alteration of gallium micro dots when interacting with Silicon based samples. Results concluded that while micro growth was possible, the varying sizes, and shapes were primarily crystalline in nature and Gallium micro dots were found in far less quantities than expected. Further research to discover this phenomenon is being continued.

Background

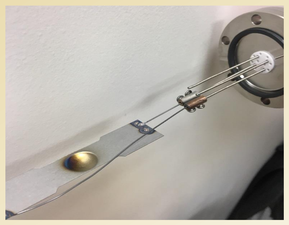
In silicone nanowire growth process, gold dots are frequently used. But with previous research showing that silicon nanowire can be grown on a tungsten wire with gallium nano-dots as the growth mechanism[1], gallium looks to be a possible alternative to gold in silicon nanowire fabrication. Continuing along this line of research we are testing to see if gallium nano-dots can be easily produced on a silicon substrate in preparation of silicon nanowire growth.



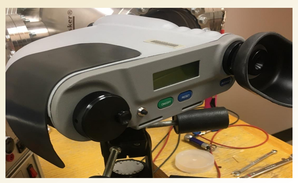
A.Reguer SEM Images Of SiNWs on SiO2 sample device using Gas catalyst solvent

Methods

Vacuum chamber

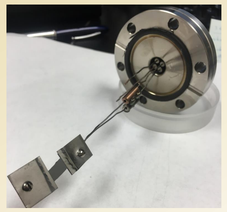


Gallium boat reservoir



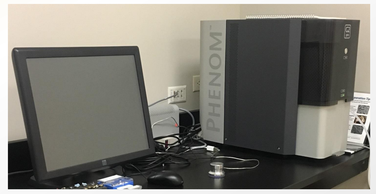
Optical pyrometer, used to determine temperature of silicone surface

- Silicon samples were cut to 5mm by 15mm
- Silicon placed in chamber with care taken to face silicone toward Gallium
- 900°C sample temperature
  - Determined with optical pyrometer



Silicon sample placed between two clips as shown

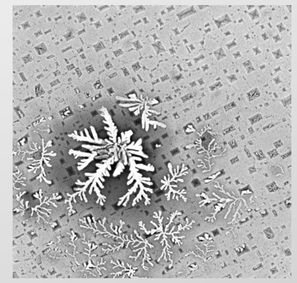
- Depressurize chamber below $3x10^{-6}$ Torr
- Gallium deposited by thermal evaporation
- Various times and deposition rates used during dosing
  - 30 sec – 30 min
- Scan using SEM for growth



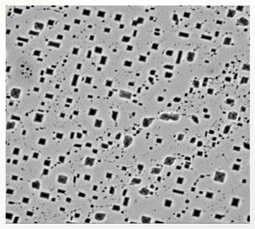
Phenom Pro Desktop SEM

Results

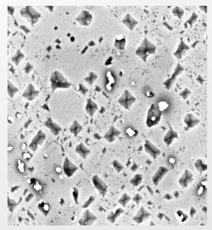
- Dosing the silicon samples with gallium resulted in varying amounts of gallium deposits on the silicon samples.
- Most samples displayed films of crystallographic growth of gallium. The most defined gallium crystal were found with deposition times between 10 and 20 minutes (see samples #3, #6, and #8). Also gallium crystals seemed to deteriorate past 30 minutes (see sample #1) but more experiment are needed to strengthen this.
- Gallium micro-dot formations were present, although spotty and usually near debris in most samples
- Gallium crystalline formations are found in far larger quantities than micro-dots in sample exposed to gallium for more than 5 minutes.
- Desired images of gallium nano dots when viewing samples under SEM (see sample #16).
- Found interesting growth on impurities present on sample during growth (see sample #11).



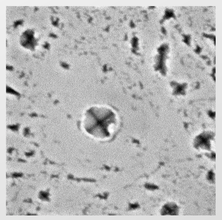
Unique gallium growth over crystals on sample #11



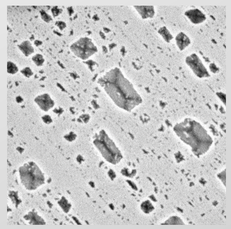
Gallium crystals on sample #1



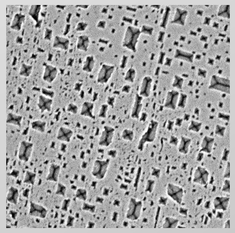
Gallium crystals on sample #3



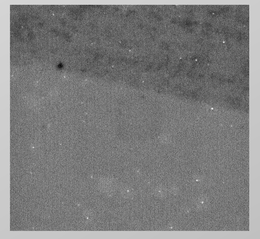
Circular gallium crystal on sample #5



Gallium crystals on sample #6



Gallium crystals on sample #8



Gallium nano dots found on sample #16

Conclusion

Results viewed on SEM scans demonstrated varying temperatures of ± 5°c of 900°, combined with a controlled fluctuated current in correlation with minimal to moderate quantities of gallium used, did create micro-structures. However, the results were highly crystalline in form and characteristic. Furthermore, nano-dot structures started forming around samples with deposition times of 30 sec. and gallium current > .3 Amps. This leads us to believe that the ideal conditions for gallium dot formation on a silicon substrate include; a high gallium evaporation and low exposure time before gallium build up occurs to form film and crystalline structures on silicone.

Future Work

After discovering unusual crystalline Gallium formations, further research to understand the conditions which create such structures will be explored to better determine cause and effect correlation. Also, a wider array of sample variety is needed at lower deposition times. This is needed to strengthen our conclusion that the best nano-dot growth occurs when dosing silicon samples with higher currents for shorter times than experimented. Future experiments would test the gallium nano dot formation on silicon nano wires.