Single Crystal Growth of Diamond And Its Optical Characterization

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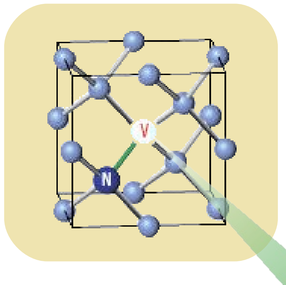
Motivation

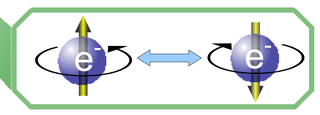
Quantum Computing



Nitrogen impurities form point defects in diamond crystal lattice

Nitrogen Vacancy center serves as a stable **qubit** at room temperature

Unpaired Electron spins can be manipulated with magnetic stimuli and detected optically



Goal: Single crystal diamond with high growth rate

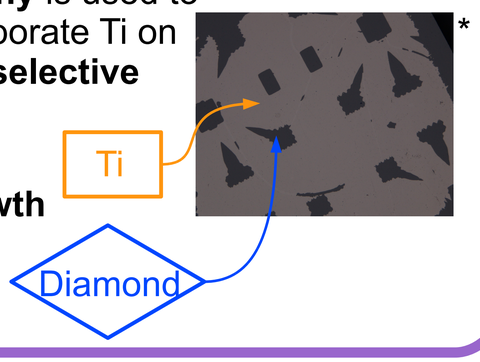
Methods

Diamond Substrate Preparation

1. Evaporate Titanium Mask

Photolithography is used to pattern and evaporate Ti on to substrate for **selective growth**

Under selective growth, the **growth rate** can be determined



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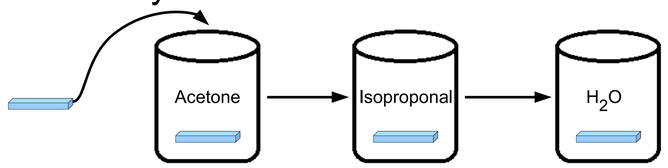
Methods cont.

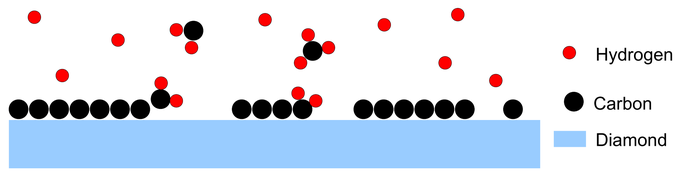
2. Chemical Cleaning

Substrate is cleaned to remove contaminant particles by ultrasonic cavitation



3. Hydrogen Etching

Substrate is exposed to hydrogen plasma to etch non-diamond species



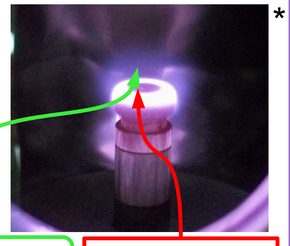
Diamond Growth

4. Chemical Vapor Deposition

Methane gas is used as a carbon source for diamond growth

Parameters:

- Temperature
- Pressure
- CH_4 concentration



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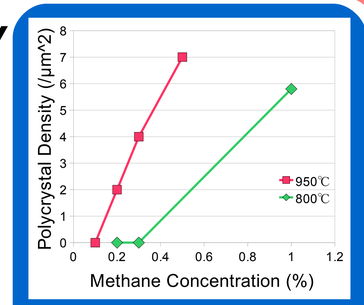
Results

Polycrystal Density

Determined using images taken using an optical microscope with a Nomarski filter



Growth Rate

Determined by surface profiler before and after growth

Surface Profiler

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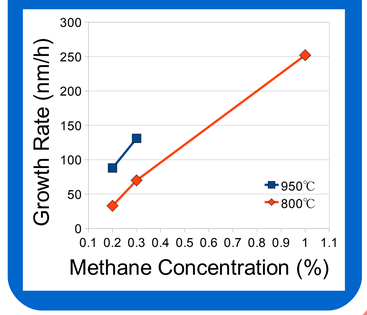

Conclusions

Single crystal diamond was successfully grown homoepitaxially with thickness up to 1 μm

Growth rate increases with higher temperature and methane concentration

Polycrystal formation is directly related to contaminant particles, making substrate preparation important, and increases with higher temperature and methane concentration

FUTURE WORK

Characterization using cathode luminescence, Raman spectroscopy, and photoluminescence

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References

1. David D. Awschalom *et. al*, "The Diamond Age of Spintronics", Scientific American, **297 (**2007)