CHARACTERIZATION OF DEFECT DENSITY OF VARYING CRYSTAL VOLUME FRACTION IN NANO CRYSTALLINE SILICON

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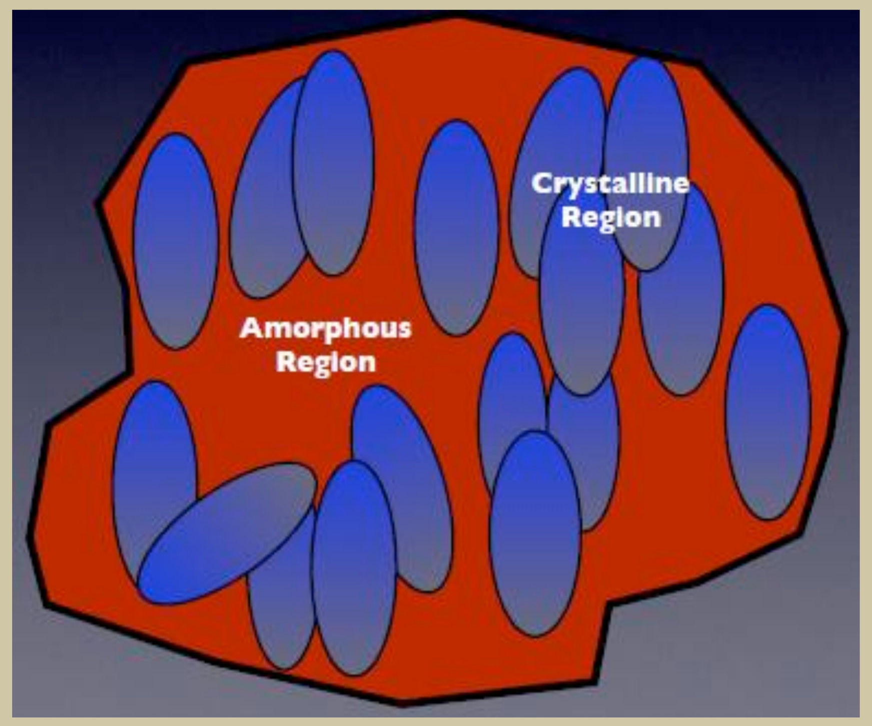
MINES

Objective: To determine how the volume fraction of nano crystalline silicon affects the number of defects caused by dangling bond spins

Introduction

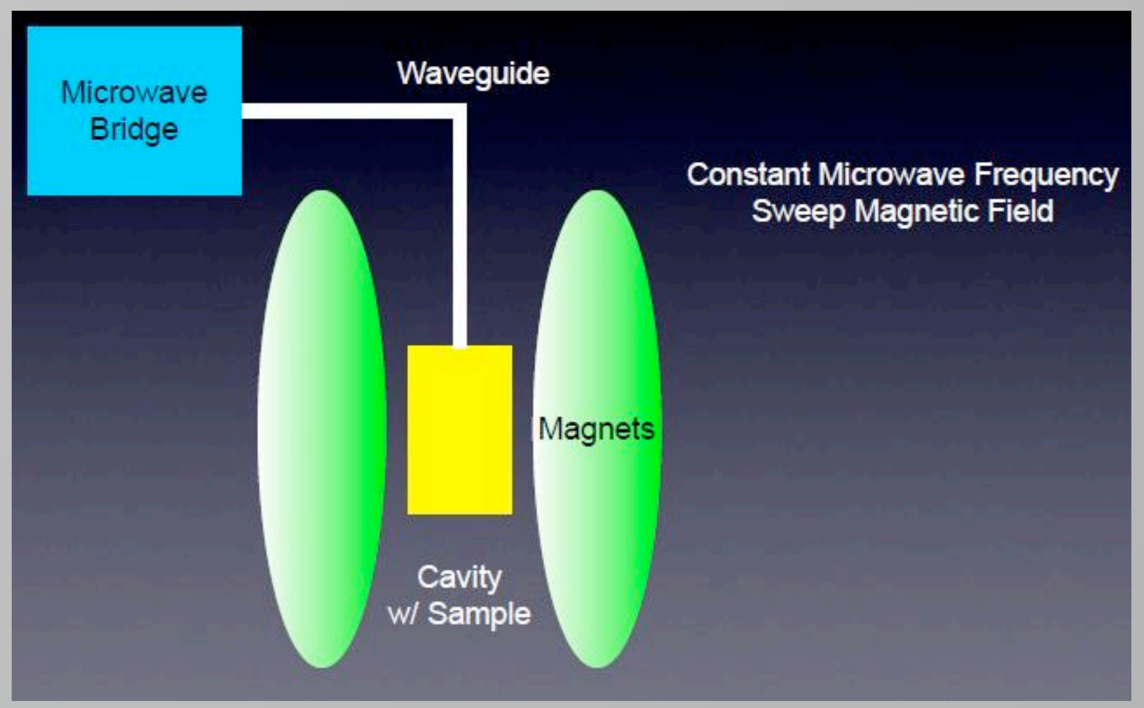
- ➢Two samples: LCT 8023, LCT 7990
- ➢LCT 8023: 65% nano crystalline, approximately 1 micron film thickness, 23nm x 2,8nm crystallite, 10^{-2} cm^3 volume
- ➢LCT 7990: 80% nano crystalline, approximately 1 micron film thickness, 21nm x 4.2nm crystallite, 10^{-2} cm^3 volume
- ➢All testing done at room temperature



(Image provided by: Kristin Kiriluk)

Why is nano crystalline useful for solar cells?

- ➢Collects longer wavelengths that other photovoltaic material cannot absorb in a tandem cell
- ➢Increase efficiency
- ➢Stable Material: Doesn't degrade over time



(Image provided by: Kristin Kiriluk)

Theory:
EPR (Electron Paramagnetic Resonance)

- ➢Used to find dangling bonds – defects
- ➢Two large electromagnets and a cavity where the sample is kept
- ➢Static electromagnetic field from microwave vs sweeping magnetic field
  - ❖ Microwave frequency: ~9.5GHz
  - ❖0 – 7k G-field
- ➢Every electron has a magnetic moment
- ➢Low energy – moment aligns parallel
- ➢High energy – moment aligns anti-parallel
- ➢Absorption of energy – transition between low and high
- ➢Signal appears when the energy difference of unpaired electron spins = microwave radiation energy
- ➢First derivative of absorption curve plotted

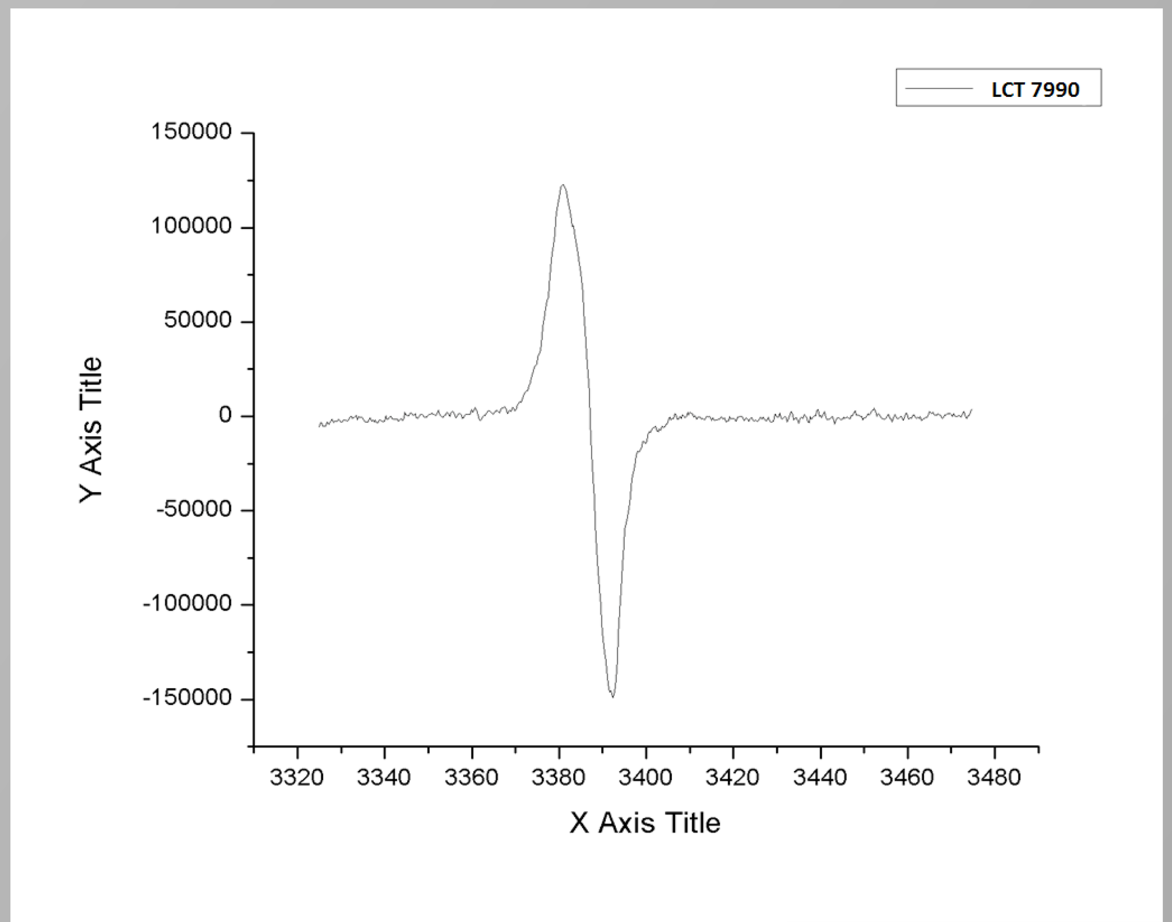
Procedure

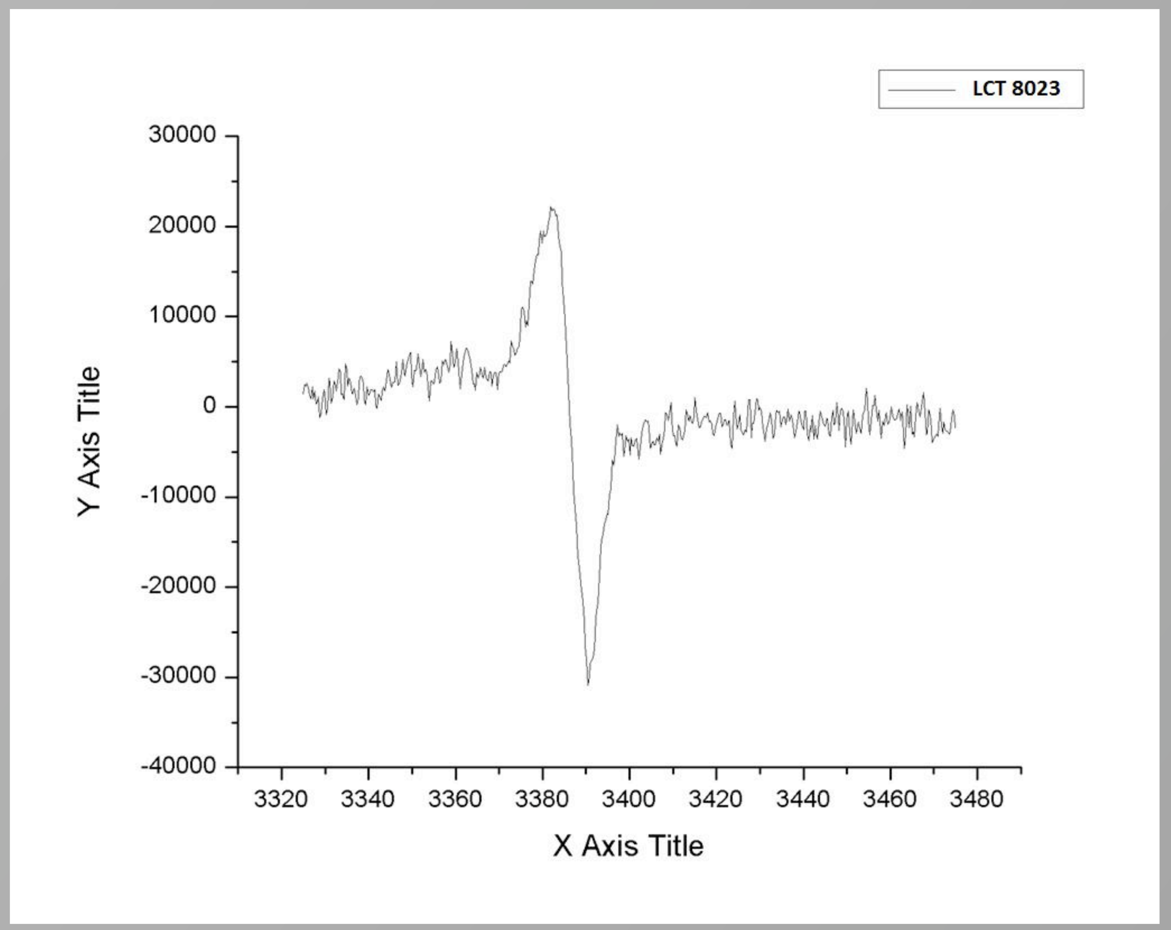
- ➢Powder sample
- ➢Take background spectra
- ➢Prep sample
- ➢Adjust ESR tube so that the sample is in the center of the cavity
- ➢Perform power dependency experiment
- ➢Run appropriate number of scans
- ➢Calculate spin density
- ➢Calculate defects/crystallite (how many crystallites per one spin)

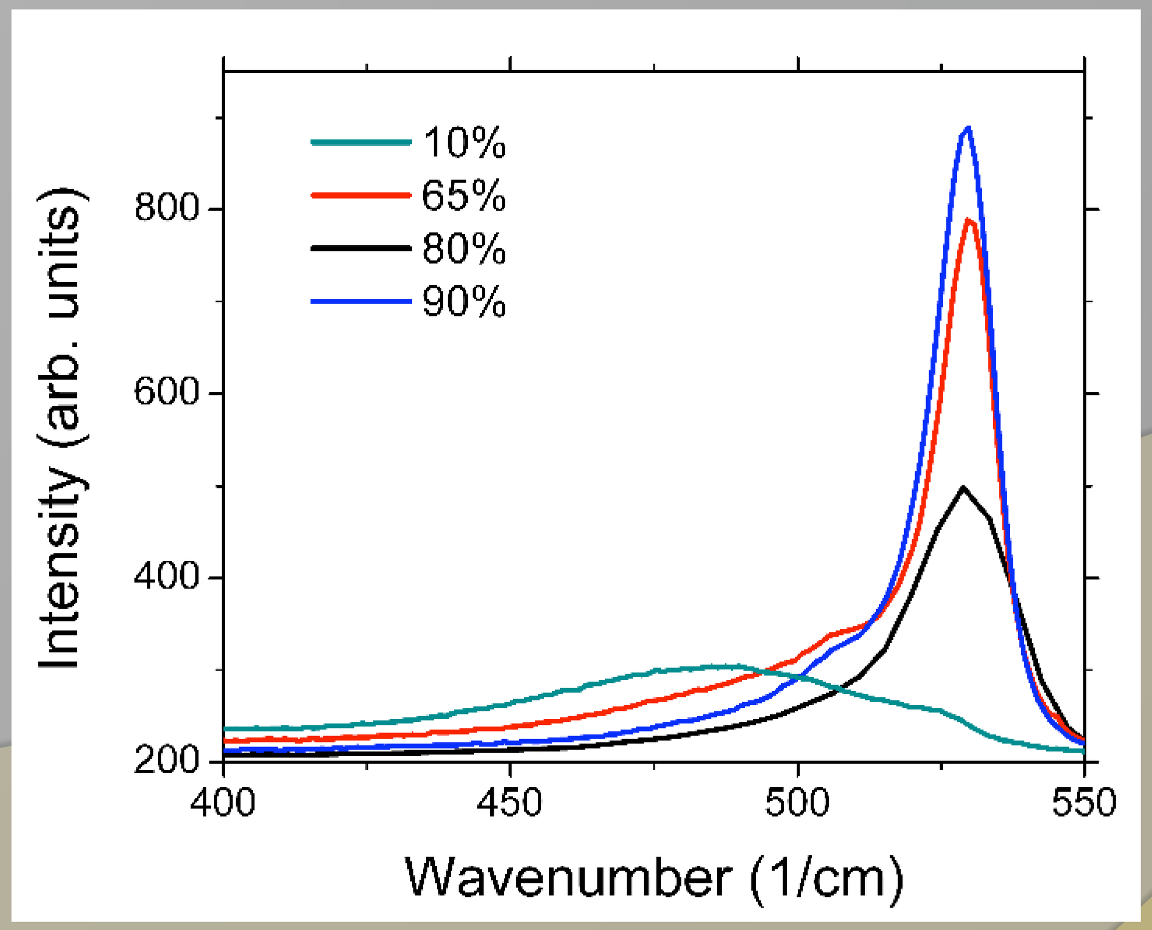
Raman Scattering:

- ➢Vibration modes used to find volume fraction
- ➢Broader peak – smaller crystals

*Note: Only the data from the 65% and 80% line was used in this experiment. Other data was conducted in another experiment.







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Discussion

➢LCT 8023:
- Spin Density: 1.16 $x10^{16}$ $spins/cm^3$
- Crystallites:4.59 $x10^{16}$ crystallites
- Spins: 7.54 $x10^{13}$ spins
- Crystallites per 1 spin: 609 crystals/spin

➢LCT 7990:
- Spin Density: 1.27 $x10^{16}$ $spins/cm^3$
- Crystallites: 2.75 $x10^{16}$ crystallites
- Spins: 1.02 $x10^{14}$ spins
- Crystallites per 1 spin: 270 crystals/spin

Conclusion

- ➢The number of spins per nano crystal increases with increasing nano crystal volume fraction
- ➢More spins are created as the number of crystallites increases
- ➢Solar cells with a high % of nano crystallites are of poor quality

Acknowledgements

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Pictures of EPR machine, Raman scattering and crystallite particles provide by: Kristin Kiriluk, former doctoral student of physics at the Colorado School of Mines