Study of Optical Absorption and Quality of Amorphous Silicon and Nanocrystalline Silicon Thin Films Using Photothermal Deflection Spectroscopy and Electron Spin Resonance

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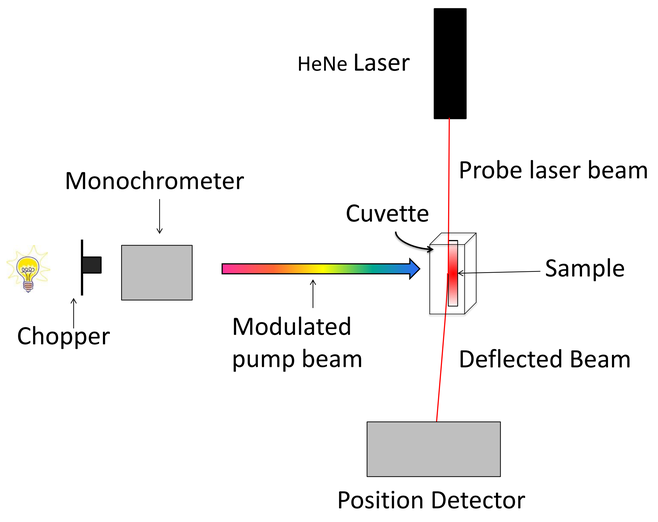
IMPORTANCE OF NANOCRYSTALLINE SILICON

- Amorphous Si (a-Si) and crystalline Si (c-Si) have been extensively studied and their optoelectronic properties characterized.
- It is important now to understand how these two phases interact in nanocrystalline Si (nc-Si) thin films.
- Nanocrystalline Si is of considerable interest for optoelectronic, display, and photovoltaic applications.
- To obtain information about absorption and defects, this study uses photothermal deflection spectroscopy (PDS) and electron spin resonance(ESR).

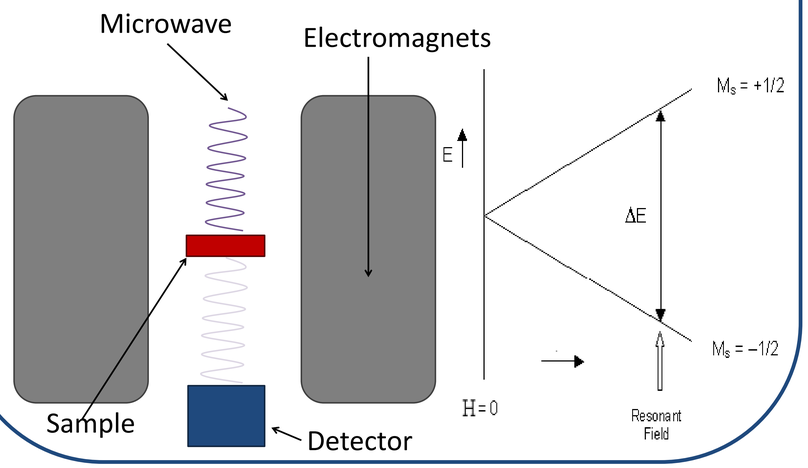
PHOTOTHERMAL DEFLECTION SPECTROSCOPY(PDS)

- Optical characterization technique used to obtain the absorption coefficient(α).
- Light absorbed by sample is reemitted as heat to the surrounding medium(CCl_4) changing its refractive index. This change is what is detected to elucidate absorption.
- More sensitive than standard reflection and transmission measurements for collecting sub-band gap absorption values.



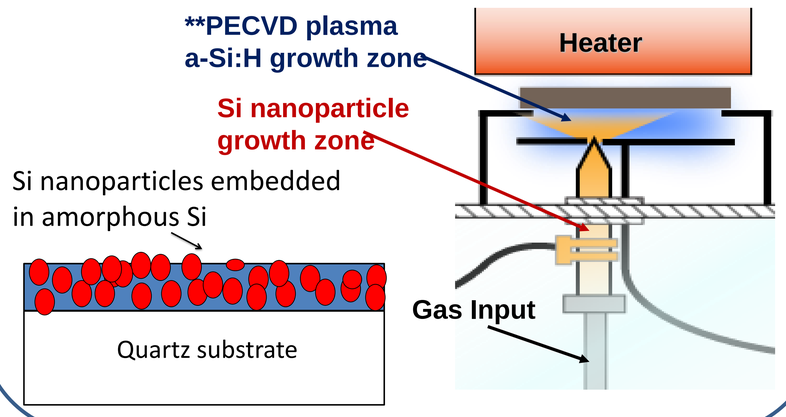
ELECTRON SPIN RESONANCE (ESR)

- This type of magnetic resonance spectroscopy detects only paramagnetic species (i.e. Unpaired electrons) which are considered defects.
- Applying a magnetic field splits the spin energy states of the electrons, referred to as Zeeman effect.
- When the microwave energy equals the energy separation of states resonance occurs and the electron becomes excited to a higher spin state.

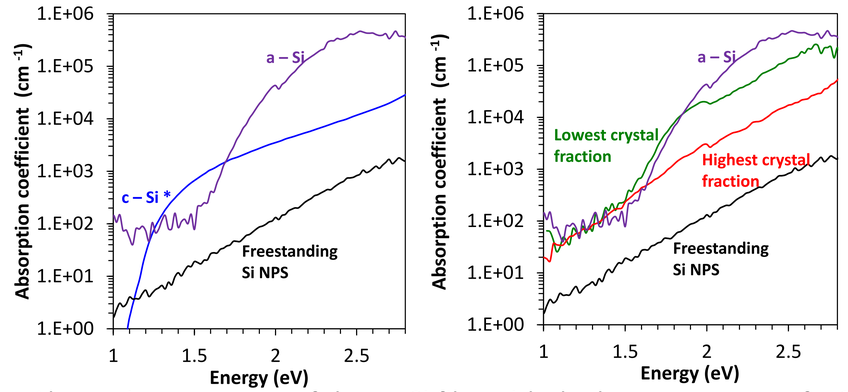


DEPOSITION TECHNIQUE FOR NANOCRYSTALINE THIN FILMS

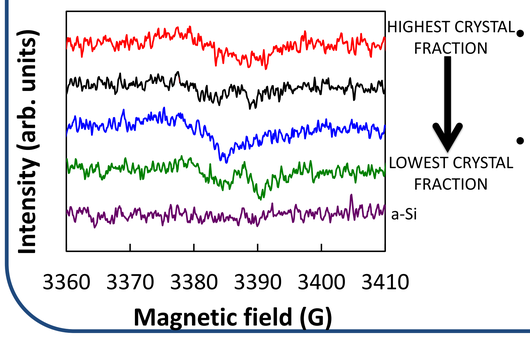
- Films used were deposited using plasma enhanced chemical vapor deposition(PECVD) reactor.
- Two reactors are used to decouple the deposition of amorphous and c-Si nanoparticles.



ABSORPTION AND DEFECT ANALYSIS RESULTS



- Absorption spectrum of the nc-Si film with the lowest amount of c-Si nanoparticles resembles that of a-Si.
- Absorption spectrum of the nc-Si film with the highest amount of c-Si nanoparticles resembles that of free standing Si nanoparticles. The absorption is higher likely due to a-Si filling.



- The peaks in the data shows that the materials are not defect free.
- Based on past results we assume the defects are probably Si dangling bonds on the surface of nanoparticles.

POSSIBILITIES FOR FURTHER INSIGHT

PDS

- A more accurate measurement of the thickness of samples would provide more accurate values for the absorption.
- With more films spanning from crystalline to amorphous, a clearer trend between the phases absorption spectrum can hopefully be seen.

ESR

- By comparing the data collected to a standard, calculations can be done to obtain defect densities.

ACKNOWLEDGEMENTS AND REFERENCES

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- *Green,Martin A.,2008,*Solar Energy Materials and Solar cells*,**92**
- **C.Kendrick, et. al. 2014 *Solar Energy Materials and Solar Cells*,**124**
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