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Pulsed IR Laser Crystallized Amorphous Silicon Thin Films for Photovoltaics

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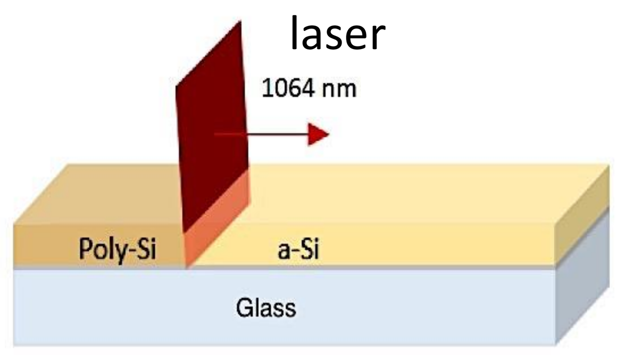
Introduction

In this work, nanosecond pulsed IR laser crystallization process of amorphous Silicon (a-Si) thin films coated over glass substrate and obtained crystallinity qualities are studied. Amorphous Si thin films are deposited with various thickness over solar grade glass substrates and a 1064 nm wavelength, nanosecond pulsed laser is used with different scanning parameters in the crystallization process of these films. Laser crystallized films are investigated via Raman spectroscopy and optical microscopy. Crystallized films' material qualities are compared while varying process parameters, such as pulse overlap percentages and deposited pulse energies [1]. Besides, different intermediate dielectric film layers were employed between the a-Si thin film and the glass substrate and their effects on crystallinity was investigated [2]. Our motivations are 1) improvement of crystal qualities for use in solar cell technology in order to enhance the efficiency of thin film silicon solar cells, and 2) decrease the manufacturing costs by employing commercially available pulsed marker lasers. Different than the available literature, the pulsed nature of the utilized laser allows us to study the crystallization dynamics in detail and enable more precise control over crystallization process.

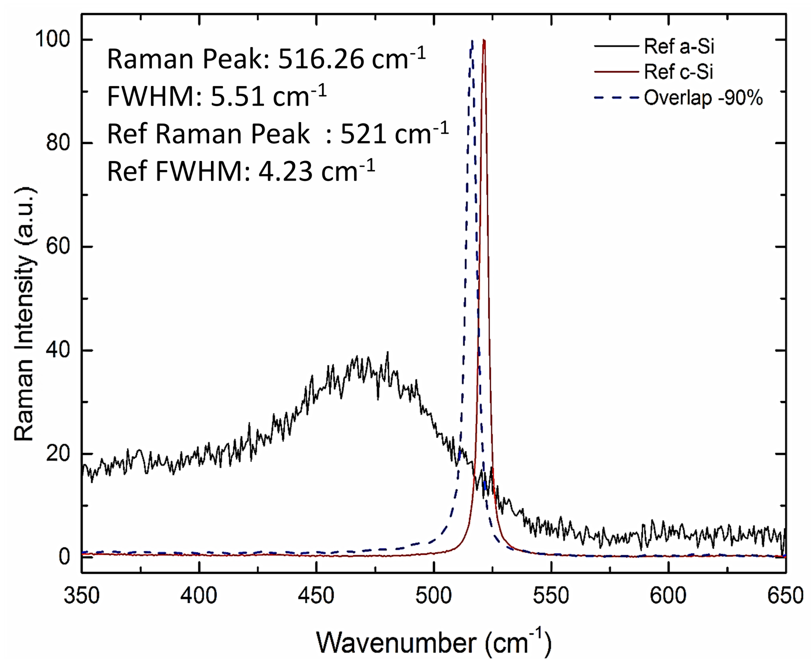
Method



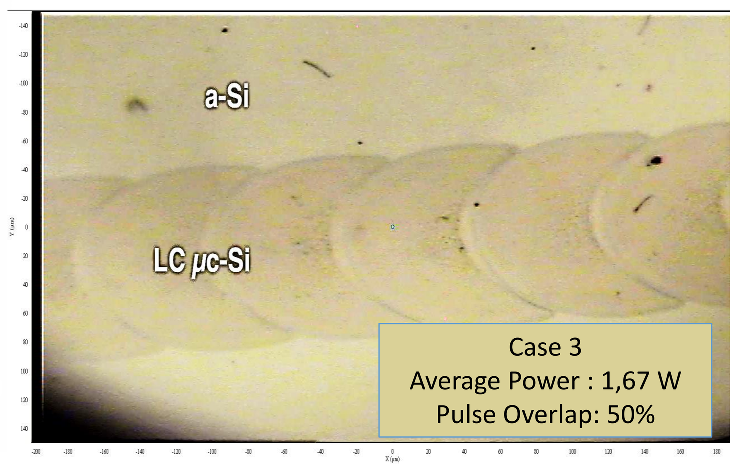
A 1064 nm wavelength, nanosecond pulsed laser irradiates the a-Si thin film with intense pulses in time and the a-Si thin film over the glass substrate is heated by optical absorption [3,4]. In order to transform the a-Si to poly-crystalline silicon (poly-Si), a specific energy level should be exceeded. If this energy amount is transferred to the a-Si thin film, the film gets molten and crystalline silicon grains are seeded and grown during solidification [5].

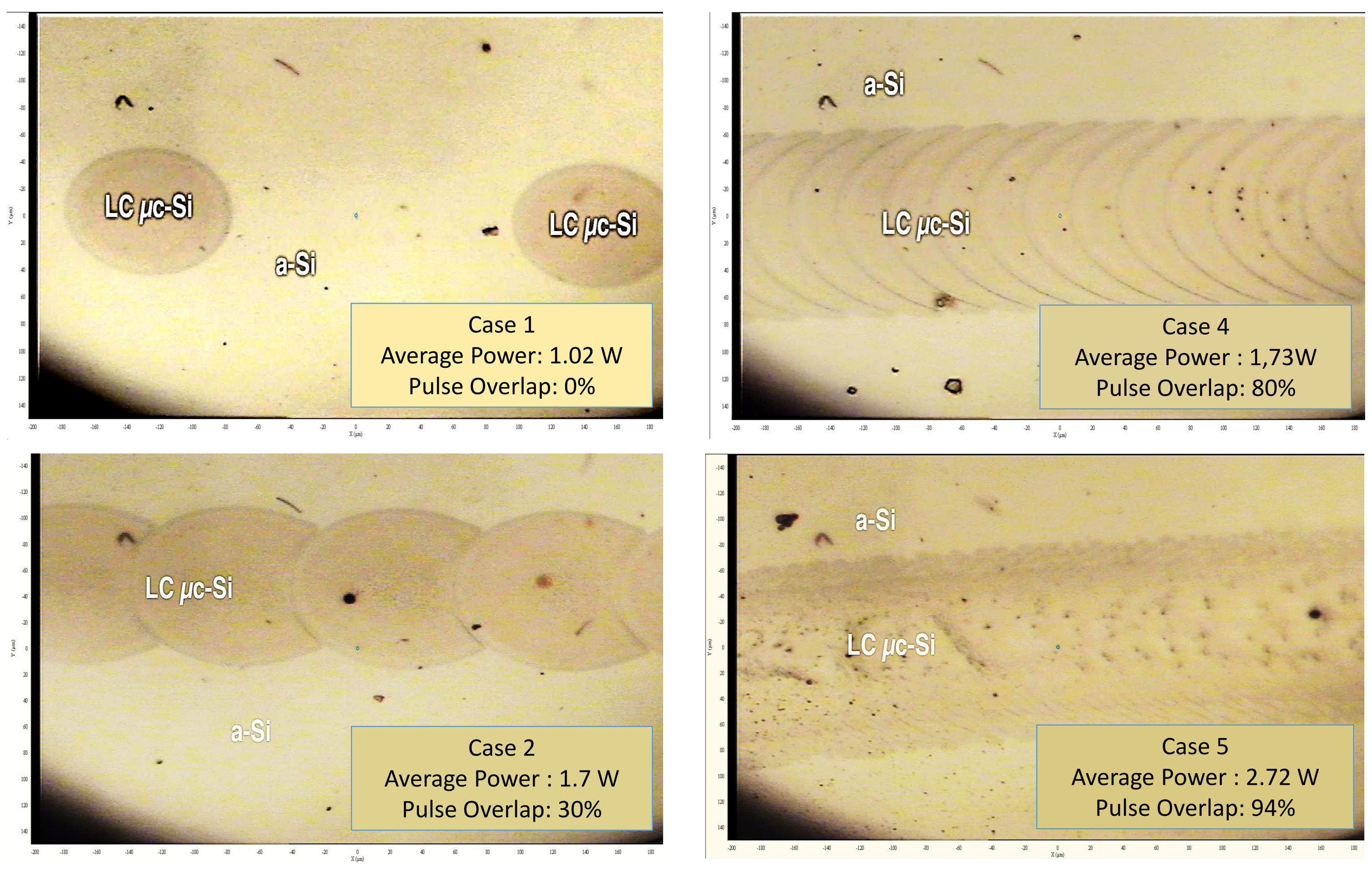
Experiment

Laser Pulse Overlap Studies in Crystallization



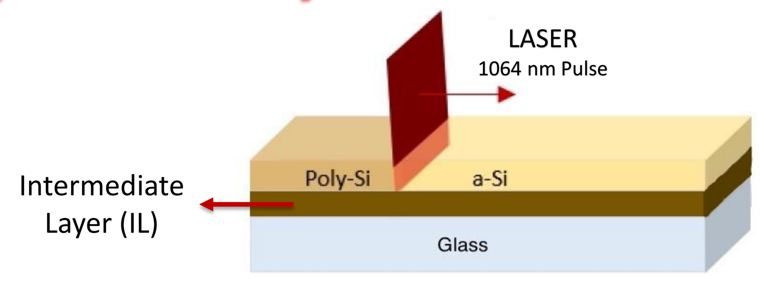
Laser Operation Parameters
Laser Wavelength: 1064 nm
Pulse Energy : 34 μJ
Pulse Width (FWHM): 203 ns
Fluence: 4.51 J/cm^2

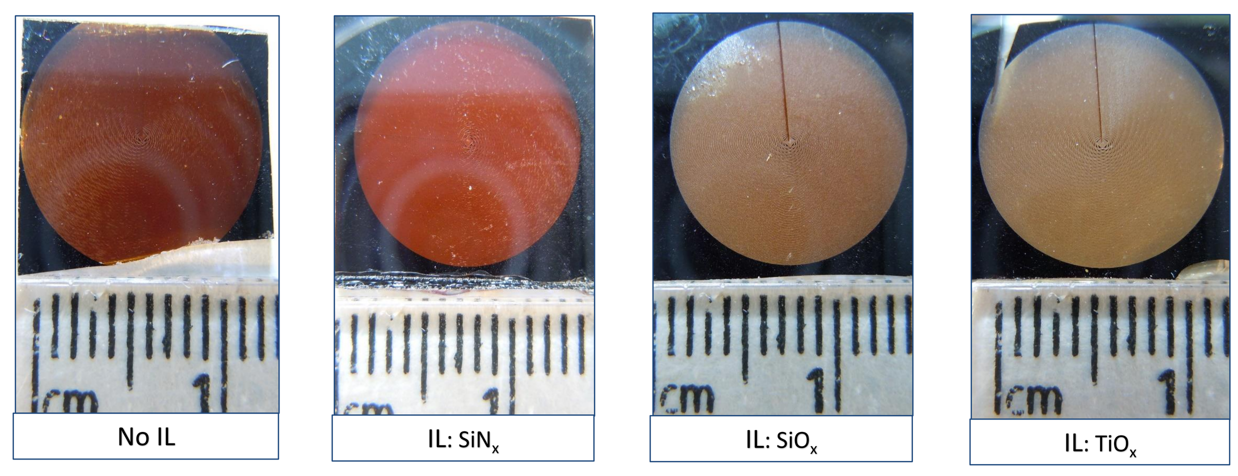


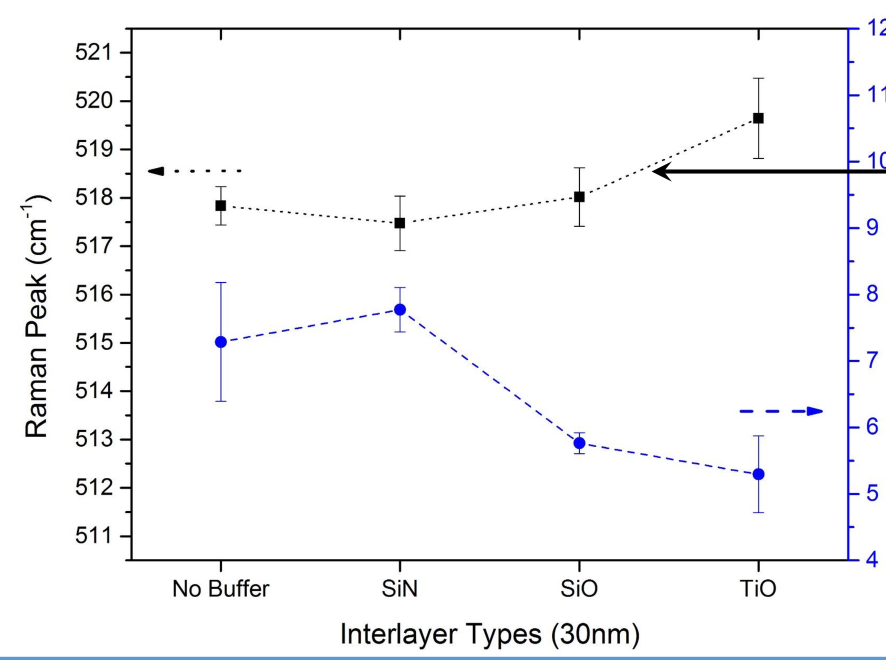


Effect of Interlayers on Crystallization

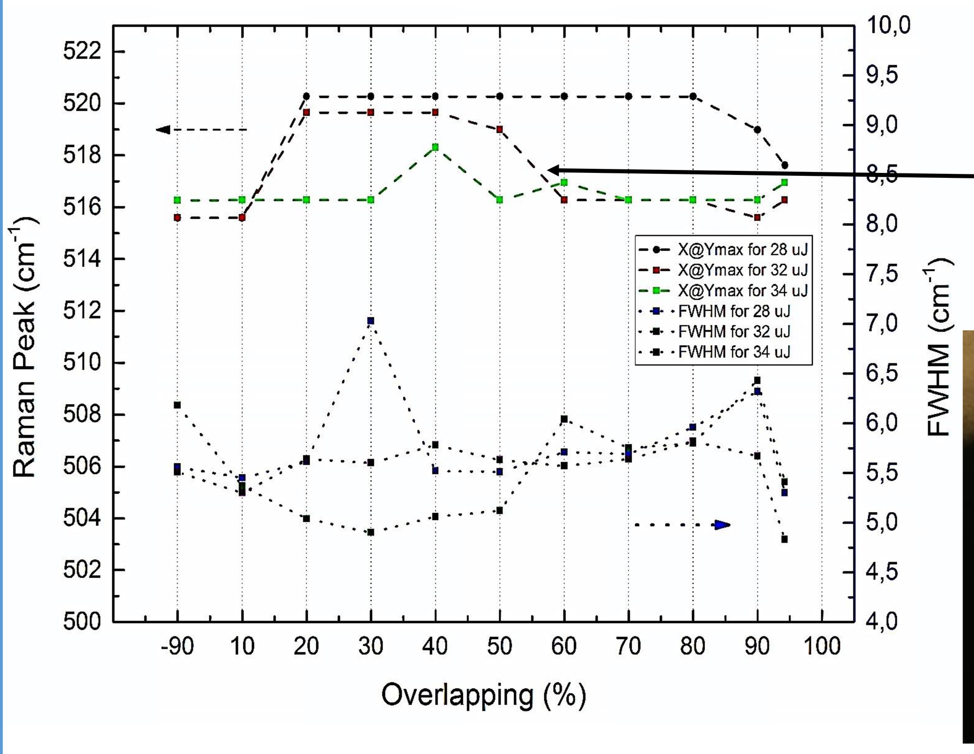
Specification of Samples
Thickness of a-Si : 650 nm
Thickness of Intermediate Layers: 30 nm

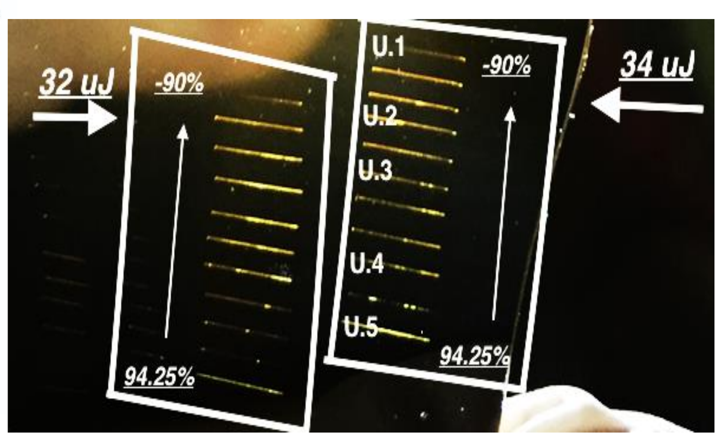






Results & Discussion





In literature, it is commonly reported that the laser crystallization processes are employed at elevated temperatures of substrates (up to 700°C), whereas in this work the laser crystallization process was conducted in **ambient conditions and temperature**. Here, pulsed operation of the laser allows an operator to control relevant process parameters such as incident energy and allowed duration for heat to flow, which enables better control of the crystallization process. The average irradiation power of pulsed laser is lower than a continuous wave laser that is typically used to achieve micrometer large crystal domains over substrate. Getting rid of preheated substrates decreases the fabrication cost, i.e., is expected to increase the manufacturing efficiency. In addition to these, processing of Si films with single pulse without overlapping allow us to study the laser crystallization method in detail. To conclude, the percentage of pulse overlap affects the defect formation on the Si thin films. By determining the overlap percentage for specific variables such as thickness of a-Si layer, pulse energy, etc., and choosing suitable intermediate layers, crystallinity can be increased. Our further studies (not shown here) lead us to conclude that growth of micrometers large crystal domains on thin Si films is possible with nanosecond pulsed IR lasers.

Acknowledgment
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