Subject 1

Exploring the surface passivation of oxides on silicon by pulsed laser deposition

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In the effort of combining antireflective and passivating properties in one coating for the use on silicon solar cells, we are exploring the possibilities of introducing passivating qualities in oxide coatings by pulsed laser deposition. Pulsed Laser Deposition (PLD) is known for its flexibility in (independently) changing the deposition parameters, which offers one the possibility to deposit coatings in a broad range of deposition parameters. To unravel why coatings show surface passivation, effort is undertaken to determine the extent and content of the interface between the coating and silicon substrate.

Stoichiometric oxides (TiO_2, $SrTiO_3$, $BaTiO_3$) show no passivating qualities. The interface characteristics at the interface with silicon have to be altered. The first approach is to change the background gas in which deposition takes place. Introduction of positive oxide charge in the coatings by deposition in an oxygen deficient ambient, results in increased surface passivation. The introduction of water vapour in the vacuum chamber results in a further increase in surface passivation. These coatings show a steady rise in measured effective lifetime under laser irradiation in the Modulated Free Carrier Absorption (MFCA) set-up. However, the best result is obtained by deposition of reduced TiO_{2-x} with the substrate (at room temperature) placed in the plasma parallel to the main propagation direction of the ablated material.

We will make clear that the interface properties, probed by XPS and TEM measurements, play the key-role in passivation of the silicon surface. The importance of the oxide content at the interface is shown by using different cleaning methods of the silicon substrates. $SrTiO_{3-x}$ coatings show a higher passivating quality on non-etched silicon in comparison with HF etched substrates. Changing the interface species present by ablation of different oxide materials (SrO, $SrSiO_4$, $SrTiO_3$, TiO_2) have learned us more about the necessary chemistry at the silicon surface to achieve passivation.