Innovative point-contacting technique for thin-film silicon solar cells

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The passivated emitter and rear cell (PERC) cell has remained one of the most efficient monocrystalline-silicon photovoltaic cell designs in the lab and in production through the use of point contacts. The rear surface recombination is reduced, through rear surface passivation and micron-sized local point contacts [1]. An innovative rear contacting structure for CIGS thin-film cells was also achieved, where the rear surface recombination was reduced, by combining a rear surface passivation and nanosized local point contacts [2].
However, point contacts are very difficult to achieve on thin-film silicon solar cells, because forming the openings with a nanometer scale would be very expensive if done with existing techniques. We explore if an alternative technique could make such an application feasible.

The innovative technique presented is nano-scale contacting by using nanoparticles (NPs) of polystyrene as a mask. The challenge is to provide effective point contacts, usually done by expensive lithography or laser processing, but by using this far less expensive method. 50nm and 100nm diameter NP’s are dispersed onto a crystalline silicon test substrate, using undiluted and deionized-water-diluted solutions. After spin coating, substrate is annealed at 50°C, lower than the glass transition temperature of polystyrene (~100°C).
Room-temperature deposition of different thicknesses of high density plasma SiO_2 by MD-ECR is done, using SiH_4 and O_2. After removing the NP’s by dissolving them in toluene, the samples are characterized by using SEM, and by doing a Local resistance mapping by CP-AFM.

Before dilution with deionized water, closely packed particle films were obtained with the 50nm NP’s, unsuitable for our application. After dilution, homogenously distributed individual NP's were obtained, with only a few observed agglomerations. For the 50nm NP’s, particle densities of about ~40-100/µm^2 were obtained, which would give an average distance to a contact of ~50-100 nm. Fewer observed agglomerations and homogenously distributed individual NP's with an interparticle distance of 0,5-1µm, were obtained by using 100nm NP’s, which is far for silicon thin film application. An ultrasound bath of toluene was applied on the sample after deposition of different thicknesses of room-temperature SiO_2. The 50nm NP’s were partially removed, whereas the 100m NP’s were totally removed after deposition of 10nm SiO_2. Local resistance mapping, by CP-AFM, was applied on the latter, by applying a bias of + 2 V. Some nanocontacts were not electrically detected, due to the presence of native oxide in the nanoholes. After etching (4 s in 1% HF) on this same sample, most of the nanocontacts were revealed for high and positive applied bias; this effect can result from breaking the native oxide or tunnelling.

The study has shown that a disperse layer of NPs suitable to achieve point contacting at a nanoscale can be achieved. The 100nm NP’s are easier to remove than the 50nm NP’s. The HF (1%) treatment is beneficial to electrically reveal most of the nanocontacts. The next step that will be studied is the evaluation and improvement of the contact resistance, and the subsequent deposition of a nano-scale metallic point contact layer. The same process will also be repeated by using Si_3N_4 instead of SiO_2, and with different NP distributions. Finally, the same process will be transferred on silicon thin film.

References:

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