SnO$_2$ nanoparticles as catalyst precursors for plasma-assisted VLS growth with controlled surface density

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Radial-junction (RJ) solar cells based on silicon nanowires (SiNWs) are currently being investigated and improved by several research groups around the world.$^{1,3}$ Stable single RJ solar cells with efficiencies over 9% have already been demonstrated.$^2$ In addition, there is room for the improvement, by combining different materials in tandem RJ Si NW solar cell structures, e.g. hydrogenated amorphous silicon (a-Si:H) and microcrystalline silicon (μc-Si:H) (see Fig. 1-a).

The current process for the fabrication of RJ solar cells implies the use of a thin metal layer of evaporated tin (Sn) and its exposure to a hydrogen plasma to form Sn droplets. The density of metal droplets must be optimized to achieve sufficient light trapping with the optimal NW density being in the range of 10$^8$ cm$^{-2}$.

In order to control the nanowire density, we have started to investigate the use of commercially available tin dioxide (SnO$_2$) nanoparticles (NPs) separated from a nanopowder as colloidal dispersions and further deposited onto the substrate with a controlled density. Different particle size distributions have been achieved by centrifugation and dilution processes. SnO$_2$ NPs have been reduced to metallic Sn droplets by the hydrogen plasma treatment (see Fig. 1-b). Silicon nanowire growth was achieved by VLS process using reduced Sn as the catalyst. Further investigations exploring the plasma conditions in order to obtain microcrystalline silicon onto SiNWs core in a PECVD chamber with SiH$_4$/H$_2$ gas precursors are being studied. The μc-Si:H has been deposited on SiNW and studied by SEM observation (see Fig. 1-c) and HR-TEM (see Fig. 1-d) techniques. In addition, we explore and optimize the quality of the intrinsic μc-Si:H material deposited directly on SiNWs for the use in single junction μc-Si:H solar cells.$^5$

![Figure 1](image-url) Figure 1. (a) Illustrated schematic of tandem radial junction silicon nanowire solar cells; (b) Top view of SEM image of reduced Sn catalyst on silicon wafer; (c) SEM image of Si NW after μc-Si:H deposition; (d) HR-TEM image of core-shell structure of SiNW grown in <211> direction after μc-Si:H deposition.

Reference

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