Self-organizing growth of freestanding silicon nanodots for photovoltaic applications

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Commonly, Si nanodots in a SiO_2 matrix for third generation photovoltaics are synthesized by means of spinodal decomposition of substoichiometric SiO_x ($0 < x < 2$). In this contribution we present an alternative approach based on the self-organizing formation of freestanding Si spheres with dimensions of nanometer scale. Under ultra-high vacuum conditions, such spheres form atop a SiO_2 surface at temperatures from 600°C, either during deposition or during annealing of an amorphous Si film deposited at room temperature. This dewetting process is thermodynamically driven by the surface tension between crystalline Si and SiO_2. Hence, crystallization is an inherent aspect of dot formation. The distribution of dot diameter yields a standard deviation of ~ 30% around an average value that can be controlled by the amount of deposited material. A constant areal fraction links the areal dot density to the average dot size. In order to obtain a stack of Si nanodots, the spheres are oxidized and the Si deposition step is repeated. Transmission electron microscopy investigations reveal monocrystalline spherical nanodots for diameters below 10 nm, while larger dots tend to hemispherical shape and poly-crystalline phase. An overall crystalline fraction of 77 % is found by Raman spectroscopy. First attempts of boron and antimony doping resulted in a slight increase of crystallization temperature. While Sb was detected by electron energy loss spectroscopy, it cannot unambiguously clarified whether it is found inside the Si dots or in the oxide shell. With regards to superstrate cell configurations, Si dot synthesis on ZnO/glass was successfully tested.