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Quantum confined nanocrystalline silicon TIANYUAN GUAN, CHITO KENDRICK, SAN THEINGI, LUIGI BAGOLINI, KORY RISKEY, LAUREN VITTI, GRANT KLAFEHN, CRAIG TAYLOR, MARK LUSK, BRAIN GORMAN, REUBEN COLLINS, Colorado Sch of Mines, JEREMY FIELDS, PAULS STRADINS, National Renewable Energy Laboratory — Quantum confined (QC) semiconductors have drawn much attention in photovoltaics due to their tunable optoelectronic properties and potential for efficiency improvements. Here, we report a study of nanocrystalline silicon (nc-Si:H), consisting of silicon nano-particles (SiNPs) embedded in hydrogenated amorphous silicon (a-Si:H) matrix. Films were grown by depositing the SiNPs and a-Si:H sequentially from separate plasma reactors in a common deposition chamber. Several characterizations were used to ensure the material had low defect density and that the SiNPs were highly crystalline and well within the QC regime. Optical properties of hybrid SiNP/a-Si:H films were explored using visible to near infrared photoluminescence (PL). At low temperature, PL revealed two primary emission features, one from conventional a-Si:H $\sim$ 1.3 eV and a second peak which can be attributed to recombination in SiNPs. The energy of this peak is higher than the bulk c-Si bandgap ($\sim$ 1.2 eV), and with decreasing SiNP size, it increases to $\sim$ 1.7 eV. This quantum confinement effect agrees with Density Functional Theory predictions. In addition, we also see that the PL peak for SiNPs surrounded by a-Si:H shifts to lower energy relative to the isolated SiNPs. This shift is also consistent with the modeling results which show that surrounding SiNPs with a-Si:H leads to a softening of the confinement barrier and a redshift in the optical gap.

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