Photon-Electron-Phonon Interaction in Alloyed Amorphous Silicon

Using the observed temperature dependence of a-Si: H absorption spectrum and the second-order transition rate, phonon-coupled enhanced photon absorption is predicted for a-Si-X alloy. Phonons participated in the absorption process by oscillating the ground state electrons and create phonon coupled states. These states produce higher effective electron overlap between the ground and the excited state. We find that the electronic density of states is minimally altered by group IV elements while the phonon spectrum shows peak energy shift due to Si-X and X-X bond oscillations. a-Si,Sn alloy shows promising phonon-coupled photon absorption enhancement near the band-edge.

Absorption Coefficient of a-Si: H

The absorption spectrum of a-Si: H shows significant temperature dependence and a direct band-gap like behavior. However, the actual band-to-band transition is indirect but phonons freely couple during the photon absorption process due to broken symmetry (no momentum selection rule exists). Single photon absorption (direct) is dominate at low temperatures but phonon-assisted photon absorption is also significant at high temperatures. When phonon participation is enhanced, the absorption coefficient will increase without any increase in temperature.

Electronic Structure of $a$-Si$_x$X$_{1-x}$

The electronic structure of $a$-Si$_x$X$_{1-x}$ shows significant dependence on the alloying element, indicating that the phonon spectrum is readily altered by composition.