Slow light in photonic crystals for photovoltaics

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Thanks to the development of nanophotonics, new concepts have recently been proposed to control light trapping and absorption efficiency in photovoltaic (PV) solar cells. These approaches may be based on the surface plasmons, diffraction on a patterned surface, or light coupling into photonic crystal (PC) Bloch modes. Absorption control is all the more important in the case of PV cells based on very thin absorbing layers: for cost issues but also considering the limited carrier diffusion length in such materials, their thickness should be kept as low as possible, which is generally achieved at the expense of the conversion efficiency.

In this communication, we will report on the increase of the absorption efficiency in very thin layers of absorbing materials, periodically patterned as planar PCs. This enables to couple the incident light into the absorbing medium, and to control the photon “lifetime”, in particular through the use of surface addressable slow light resonances.

We will illustrate the interest of this generic concept with an absorbing medium of hydrogenated amorphous silicon (a-Si:H). Pattering such layers may be achieved using low cost technologies like laser holography or nanoimprint. We will show both theoretically and experimentally that this way of photon trapping may be used to control the absorption over a very wide spectral range. The absorption efficiency may be increased by 50% in the whole 300-750nm range, just by drilling a 1D or 2D photonic lattice within the layer. Additionally, due to the intrinsic nature slow light modes, the absorption efficiency is relatively independent to the angle of incidence. We will also show how such an absorbing PC can be integrated in a typical thin film solar cell structure, including transparent and metallic electrode; these additional layers enable a further control of light trapping and of the photon lifetime in the absorbing layer.