The influece of the internal structure in the resonant properties of poly-crystalline silicon microspheres

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Abstract

Silicon microspheres are promising technological platforms for developing applications in different fields of technology, such as metamaterials and opto-electronics [1,2]. The strength of this material resides in its capability of confining light thanks to its high refractive index, which yields the possibility of achiving high Q Mie resonances. Recently, a technological application consisting of a silicon spherical Mie resonator photodiode has been developed [3] ([Fig. 1 (a)]. Such photodiode can absorb infrared light efficiently at the band-gap edge of silicon, at wavelenghts above 1200 nm, thanks to the resonance phenomenon in the spherical microcavity. The richly peaked spectra of the photocurrent confirms this fact [Fig. 1 (b)]. However, such spectra could not be precisely fitted to Mie theory. We have found that the internal structure of the micropheres is the reason of this discrepancy. The HRTEM image of Fig. 1 (c) shows that poly-crystalline silicon microspheres contain in fact an onion-like distributed porous structure, surrounded by a non-porous shell. This makes that although high *Q* modes could in principle resonate at the non-porous shell, other modes whose electromagetic field distribution overlaps the porous structure, such as mode $b_{13,5}$ for instance [superimposed in Fig. 1 (c)], are expected to be killed. This fact was confirmed by optical scattering measurements performed at 90º. Based on these results, different crystallization procedures for avoiding the porous structure have been developed.

References

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Figures

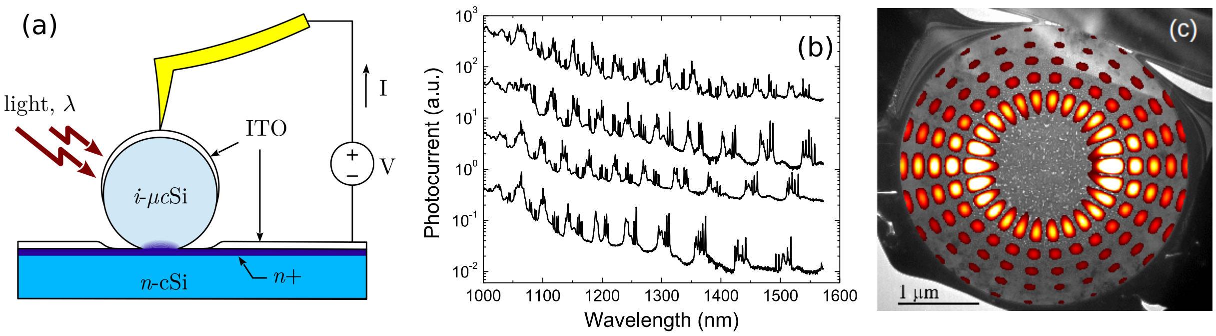

Fig. 1: (a) Scheme of a photodiode based on a silicon microsphere, (b) measured spectral response (short circuit current) of several devices corresponding to different sphere diameters. The sharp peaks correspond to Mie resonances, (c) HRTEM image of the internal surface of a poly-crystalline silicon microsphere showing the porous structure at the core. The electric field intensity distribution of mode $b_{13,5}$ has been superimposed.