Disordered macroporous silicon as optical filter in the medium infrared region

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The ability to modify the properties (electromagnetic, optical, thermal and so on) of a material tailoring them for target applications is a powerful tool for the maximization of the performances of ultimate devices. Micro- [1] and even more efficiently nano-technology [2] have certainly boosted the development of that field. Porous silicon is a prototypical example: whereas crystalline silicon is not photoluminescent, porous silicon shows tunable visible photoluminescence, strictly related to the structural parameters of thickness, porosity, pore shape and size (from few nanometers to microns), and to the chemical termination of the inner surface [3].

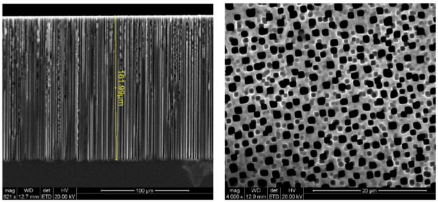

Figure 1: Cross (left) and top (right) view SEM images of disordered macroporous layer, sample 1.

Due to the huge impact on the world of optoelectronics, the optical response of porous silicon in the region from visible to near infrared radiation has been thoroughly studied [3,4]. Since in the mid-infrared (mid-IR, 2.5–25 µm) its optical behavior does not differ from that of crystalline silicon, but the surface-to-volume ratio can be increased up to 3 orders of magnitude, for a long time porous silicon has been used as an easy tool for the vibrational analysis of organic monolayer grafted onto the Si surface [3]. More recently, ordered arrays of macropores [5,6] have shown the ability to block the transmission of specific wavelength ranges in the mid-IR, working as filters.

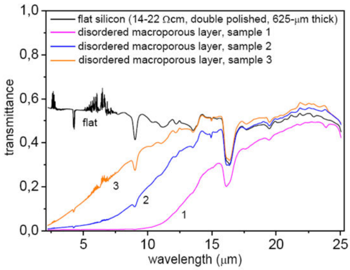

Figure 2: IR transmittance spectra before and after the formation of a layer of disordered macropores. The layer thickness and the porosity range are: sample 1, 162µm and 25-45; sample 2, 64µm and 19-36; sample 3, 20 µm and 13-30. In all cases the reference is the spectrum of the empty chamber.

Here we report preliminary results about the lowering of the transmittance in the 2–10 µm region when the IR beam crosses a disordered macroporous layer (Fig. 1) along the pore direction. The pores are obtained via electrochemical etching in a solution of HF in dimethylformamide [6] without any photolithographic pre-patterning of the surface. Fig. 2 shows that the filtering efficiency varies with both the thickness and the percentage of void space in bulk silicon (porosity), being the two characteristics strictly coupled in disordered macroporous layers.

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