Nanostructuring of Porous Silicon by Electron Beam Lithography.

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Porous silicon is a promising material for many interesting applications, such as photonic structures and sensing devices, due to its tunable refractive index[1] and its huge specific surface[2], respectively.
An important goal in porous silicon technology is the achievement of the lateral definition of the material, which cannot be obtained by conventional photolithigraphic techniques, because of its incompatibility to alkaline developers.
In the present paper, we propose to use electron beam lithography in order to obtain high-resolution patterns on porous silicon samples.

First attempts have been performed spinning conventional PMMA resist onto porous silicon substrates, writing patterns by electron beam, and developing in acetone.
We have verified that this technique is fully compatible with the material, i.e. no damaging of porous silicon occurs. Moreover, we demonstrate that the material, due to its porosity, acts as a low atomic number substrate, reducing proximity effect[3] and thus allowing the achievement of a very high resolution. Fig.1 shows a comparison between same patterns written at the same dose on two porous silicon substrates with different thickness (70 nm and 850 nm). It can be obseved that on the thicker sample the separation line is wider, i.e. the proximity effect is reduced by the presence of a larger porous beneath. In fig.2 we report an array of nanodots obtained on a porous silicon sample 500 nm thick.

Another approach to structuring of porous silicon was to perform direct electron beam exposure, without any PMMA resist film.
By means of FTIR microscopy we have observed that electron beam induces hydrogen desorption from porous silicon surface, and ,after exposure to ambient air, a local oxidation occurs. Fig.3 shows a typical FTIR map.
Thus we have developed the samples in HF solution, observing that electron beam written patterns are selectively etched. Furthermore, profilometric measurements show that the depth of etched regions increases with the electron dose.

In summary, we have demonstrated that standard electron beam lithography can be succesfully applied to porous silicon, which seems to be a promising substrate for this technique. Moreover, we have found an innovative resistless technique, that could be used to micromachine porous silicon in a very easy way, opening new perspectives in device realization.

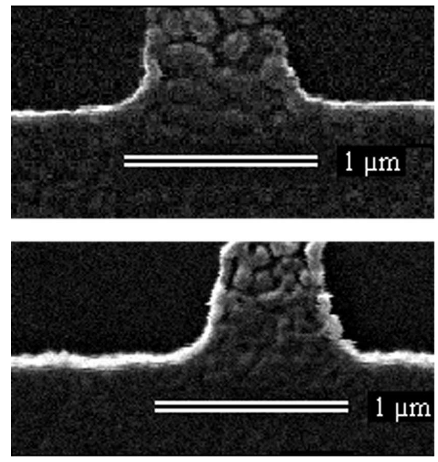

Fig.1. The separation line between square patterns exposed at the same dose value on porous silicon layers 70 nm thick(bottom) and 850 nm thick (top).

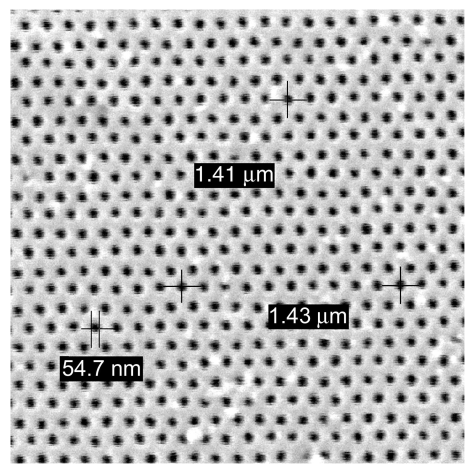

Fig.2. Array of nanodots written by electron beam lithography on PMMA deposited on porous silicon.

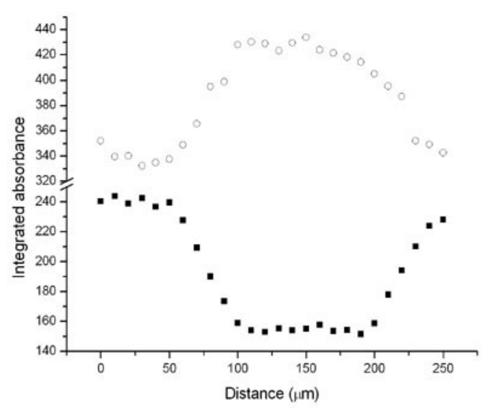

Fig.3. Results of micro-FTIR mapping are reported: in the irradiated zone of the sample, absorbance due to SiH_x complexes (squares) is reduced, while absorbance due to SiO_2 (open circles) increases.

REFERENCES
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3. See, e.g., M.A. McCord and M:J: Rooks, in *Handbook of Microlithography, Micromachining and Microfabrication*, P. Ray-Choudhury, Editor, p.157, SPIE, Washington (1997).