FABRICATION OF 3D SILICON NANOSTRUCTURES USING ION IMPLANTATION AND WET CHEMICAL ETCHING

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Control of the synthesis and manipulation of nano-objects, and their electronic and optical properties are key parameters for the development of functional devices. Several techniques are available to create nanostructures in a controlled fashion. Over the past ten years, the focused ion beam (FIB) technique has taken more and more place in the design and manipulation of nano-objects [1]. Indeed the FIB milling mode permits to remove layers from substrate allowing the imaging of a sample cross section with a high accuracy. FIB offers also the possibility for ion implantation and deposition of metal nanostructures [1]. Furthermore, the FIB enables to repair wires on a micrometer scale or making connections for electrical measurements (for example: carbon nanotubes characterization) [2].

Recently, a combination of FIB implantation and chemical wet etching was investigated for the preparation of micrometer scale nano pyramids array (NPA) approaching the 100 nm resolution [3]. The wet etchants used are strong bases (pH>12) such as KOH, TMAH or hydrazine (N_2H_4) known for their crystalline plan dependent etching.

In this paper, we report our experimental results on the synthesis of silicon 2D and 3D nanostructures of controlled shapes and sizes using focused ion beam implantation of Ga^+ ions into crystalline silicon followed by wet etching in TMAH. Ion implantation into silicon renders the implanted regions amorphous and relatively immune to chemical etchants. The difference in the dissolution rates of the implanted *vs* non implanted regions and silicon dissolution anisotropy in TMAH allows producing Si nanosctructures of various shapes and sizes in a controlled way (**Figure 1**).

FEI strata DB 235 dual (focused ion and electron) beam (FIB/SEM) system (acceleration voltage of 30 keV) was used in this study. The implanted doses were controlled by varying the current from 1pA to 300pA and exposure time from some seconds to some minutes. After ion implantation, the surface was exposed to 25% aqueous solution of TMAH at 80°C for few seconds.

The resulting nanostructures were characterized using SEM and TEM microscopies and energy dispersive X-ray (EDX) analysis. The obtained nanostructures are amorphous and EDX results showed the presence of ~ 5% of Ga^+ ions in the silicon nanostructures.

Crystallization of the nanostructures by thermal annealing is currently under investigation in our laboratory.

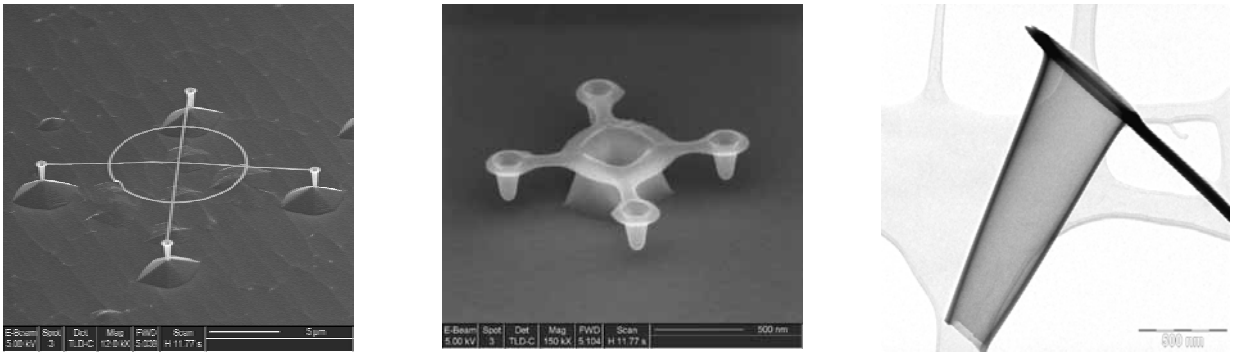

Figure 1: SEM images of 3D silicon nanostructures produced using focused ion beam and wet chemical etching in TMAH.

References

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