Directed Self-Assembled Porous Anodic Alumina by NanoImprinting Lithography

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Alumina nanopore arrays [1] are promising nanostructured templates for numerous applications such as information storage and solar energy harvesting [2]. It is produced by an electrochemical oxidation of aluminum in acid solutions. By varying experimental parameters as the acid electrolyte or the applied voltage, geometrical characteristics of the porous membrane can be modified (diameter and depth of pores, distance between nearest neighbor) [3]. In conventional methods, such as simple or double anodization, the hexagonal order is uneven over a large distance.

We present an innovative route including Thermal NanoImprint Lithography (TNIL) prior to aluminum anodization, to prepare flawless hexagonal arrays on surfaces as large as 4 cm². Figure 1 shows an image of the arrays characterized by Scanning Electron Microscopy (SEM). Interpore lengths vary between 100 and 250 nm and pore sizes from 30 to 150 nm.

In addition, original structures with generation of guided pores have been developed. Indeed, we can force the growth of a pore between three imprinted pores by adapting the anodization voltage, as seen on Figure 2. Shapes of the pores can be modified by varying the electrolyte: Figure 3 illustrates the differences.

These alumina nanopore arrays are used as templates for the self organized epitaxial silicon nanowires growth in a chemical vapor deposition reactor. Hexagonal nanowire arrays grown perpendicularly to <100> silicon substrates have been successfully produced.

References:
[1] H. Masuda et al, *Science* **268,** 1466 (1995).
[2] D. Buttard et al, *Phys. Stat. Sol. C.* **8,** 812 (2011).
[3] D. Buttard et al, *Phys. Stat. Sol. A*, **3,** 19 (2009).

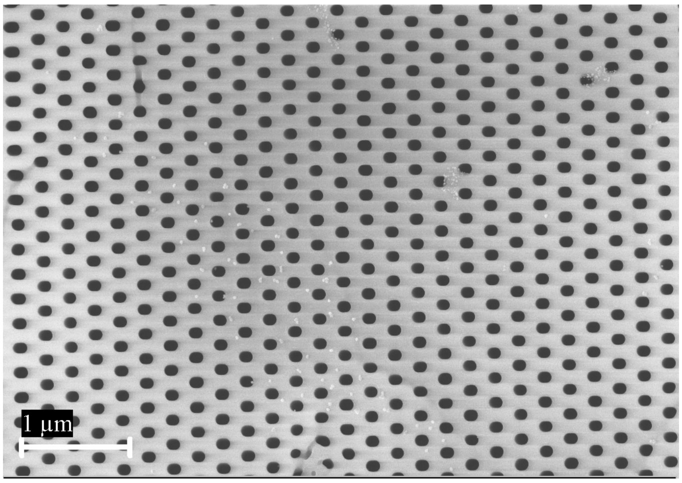

Figure 1: SEM images of alumina: aluminum was first TNIL patterned (mould lattice: 250nm); direct anodization under 100V gives a $4cm^2$ flawless pore arrays.

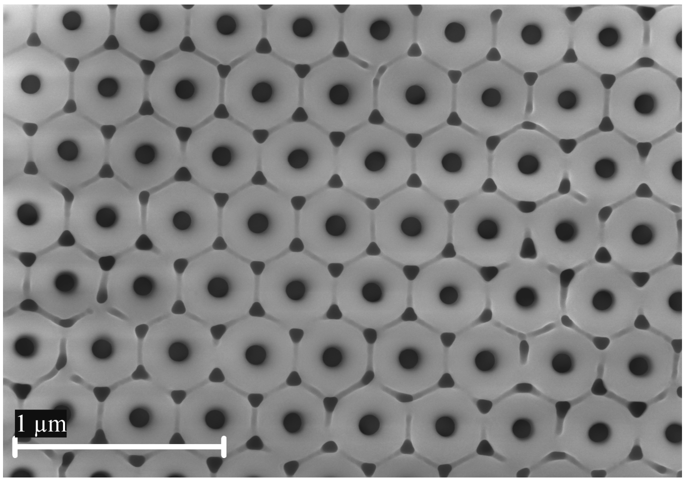

Figure 2: SEM images of alumina: anodization at 100V of TNIL patterned aluminum (lattice mould: 368nm), generation of guided pores between three imprinted pores

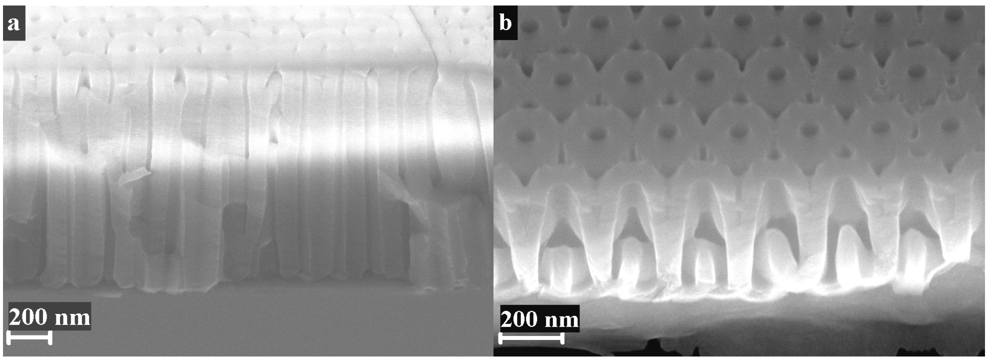

Figure 3: SEM images of alumina cross sections: a. anodization at 60V, in oxalic acid. The guided pores exist from the top to the bottom of the alumina layer (1500nm). b. anodization at 60V, in phosphoric acid. After a thickness of about 150nm, a rearrangement occurs and the guided pores disappear.