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Highly Ordered, Single-domain Alumina Nanopore and Metallic Nanowire Arrays on Silicon for On-chip Integration of Semiconductor Devices

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Metallic nano-wires, rods, and dots can be used in a number of applications relevant to hyper-integration technology, including nanowire-interconnects (wires), on-chip magnetic storage devices (rods), on-chip Peltier cooling devices (wires and rods), and plasmonic wave guides (dots) [Ref. 1, 2]. In this paper, we will present a novel templating technique to produce metallic nanowires with controlled diameter and spacing on a silicon wafer.

Anodic porous alumina is an excellent example of self-ordered nano-structured material that is well-suited as templates for growing metallic nanowires for applications in magnetic, electronic and opto-electronic devices [Ref. 3, 4]. The pores form a hexagonally ordered structure with short-range order and vertical orientation. Pore size can be varied from 4nm-300nm by controlling the conditions during electrochemical oxidation of aluminum [Ref. 5, 6, 7]. Although, there has been a lot of work done to obtain porous alumina with well-defined pore diameters and distances, little has been done to integrate this process into wafer-level or to improve the poor long range ordering of pores [Ref. 8].

Highly ordered alumina nanopores with controlled symmetry have been grown by electrochemical etching of aluminum evaporated on nanoscale-corrugated silicon surfaces (Fig. 1, 2). The silicon surface was patterned using interference lithography and periodic inverted pyramid structure was obtained by chemical wet etching of silicon. Thin aluminum films were then evaporated and electrochemically etched to obtain nano-porous alumina. We will discuss the effect of anodization potential and electrolyte composition on the pore formation and ordering process. We will show examples of both ordering of pores at the lithographic length scale as well as at the sub-lithographic length scale. We will also present nanowire arrays grown by electrodeposition using ordered alumina templates and the effect of electrochemical conditions on the nanowire growth process. The effect of ordering will be shown by comparing the nanowire growth in ordered templates with commercially available ANOPORE^{TM} alumina templates with disordered pores (Fig. 3).

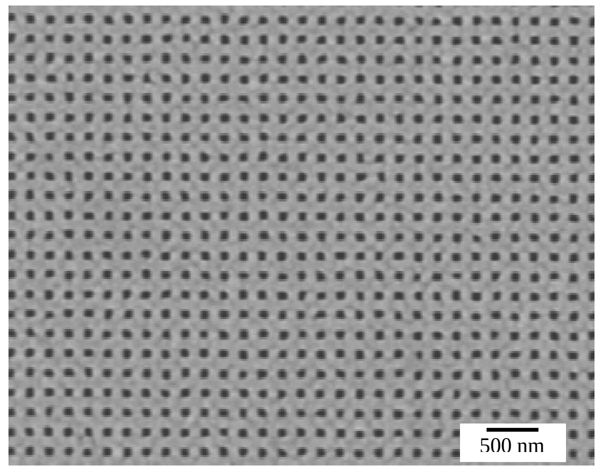

Fig. 1 Anodized alumina template on a Si wafer containing ordered nanopores. (Pore spacing = 200nm, Pore diameter =80nm)

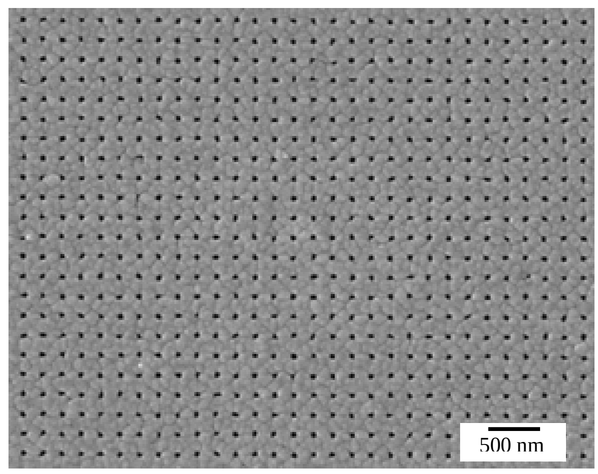

Fig. 2 Anodized alumina template on a Si wafer containing ordered nanopores. (Pore spacing = 200nm, Pore diameter =30nm)

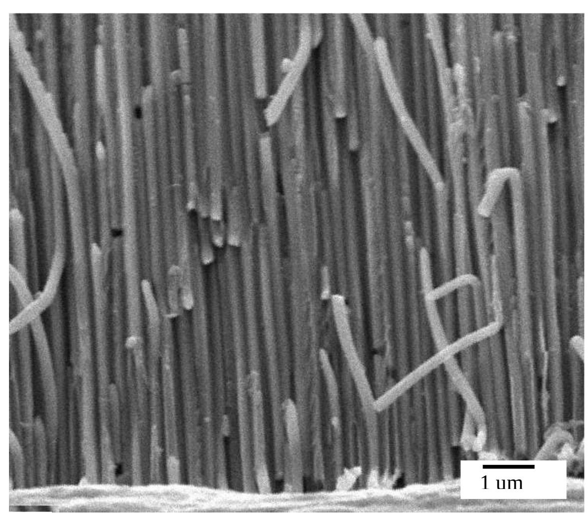

Fig. 3 Cross-section view of nano-porous alumina (ANOPORE^{TM}) filled with copper by electrodeposition (Pore diameter =200nm)

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