# COMPLEX STUDIES OF GE NANOWIRE ARRAYS IN OXIDIZED ALUMINA MEMBRANES

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**Abstract.** Complex characterisation of Ge nanowire arrays grown in anodized aluminium oxide (AAO) membrane pores is introduced. Nanowire distribution in arrays and electroconductivity of individual nanowires were measured by conductive AFM. Macrocontacts were used to measure averaged conductivity of Ge nanowires, to obtain I(V) characteristics, and determine activation energy of nanowires. Dimensions of nanowire were determined after dissolving of AAO matrix.

**Introduction.** The ability to pack high densities of memory storage and processing circuitry into specific nanoscale arrays, and utilize the unique transport properties associated with these architectures, is expected to lead to new generation of computer processors with device sizes many times smaller and faster than current silicon based processors. Consequently, alternative non-lithographic methodologies for constructing the smallest mesoscopic features of an integrated circuit will soon be required. Encapsulation of nanowires within an ordered template offers the possibility of manipulating nanowires into useful configurations and allows their aspect ratios and, hence, their physical properties to be tailored. Nanowire synthesis within an anodic aluminium oxide film pores is one of the promising approaches.

**Experimental.** Ge nanowires were synthesized in AAO pores as described in [1, 2]. Ge filled AAO membrane surface was mechanicaly polished using diamond suspension with grain size 6 and 1 μm. After mechanical treatment samples were washed with ethanol in ultrasonic bath for 1-3 min. One surface was coated with a gold film of thickness of 100 nm by magnetron sputtering. For macro measurements second electrode of 2 mm in diameter was sputtered onto the opposite surface of the sample through a metall mask.
A home-built contact mode AFM was used for nanowire current mapping. Conductive Pt-coated ultrasharp silicon AFM tips (*Micromasch* CSC12/Pt/50), having a radius of curvature less than 35 nm, were used in experiments

**Results.** Mechanical polishing of the Ge filled membrane was used to the remove reaction products from the surface (fig 1a). 10-20 nm high features extending from the surface were found after polishing (fig 1b). The observed hilloks were identified as nanowires. The nanowire density was $9*10^8$ $cm^{-2}$. After surface etching with $H_3PO_4$ during 30 min [3] nanowires height increases to 70-100 nm. The contact resistance in macromeasurements decreases more than 2 times after chemical treatment of sample surface (fig. 2). I(V) characteristics of nanowire were linear showing good omic contact between the gold electrode and Ge nanowire.
Single nanowires were obtained dissolving of the AAO matrix in 6M NaOH [4]. Diameter and lenght of nanowires adsorbed onto glass from water solution was determined by AFM. The average diameter of the nanowires was about 150 nm..
Nanowire array electroconductivity was mapped by conductive AFM. Topography image of extended nanowires correlate very well with peaks on current map. Close to 100% of nanowires were found to be conductive. At 50V bias voltage the average current was 0.2 nA which corresponds to resistance 20 Ω*m. It is higher than bulk Ge resistance (0.48 Ω*m). Conductivity measured by macrocontacts was 20 times higher than obtained by conductive

AFM which can be explained by difference in applied voltages between electrodes (1 V and 50 V respectively). Activation energy of Ge nanowires was found to be of 0.54 eV which is in good agreement with Ge band gap (0.66 eV). Conductivity measurements of single nanowires obtained after matrix dissolution using conductive AFM and TEM-STM are in progress (fig. 3, [5]).

## REFERENCES


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## FIGURES

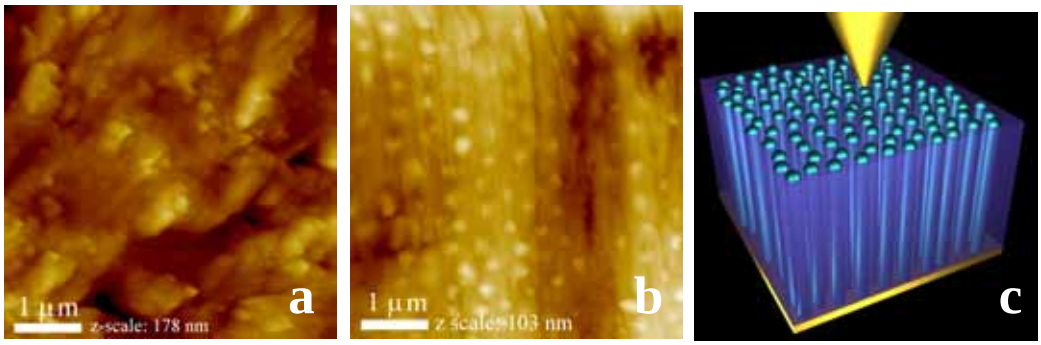


Figure 1. a - amorphous Ge on the surface of AAO; b - Ge filled AAO membrane after mechanical polishing; c - schematic view of Ge NW in AAO matrix and an C-AFM tip.

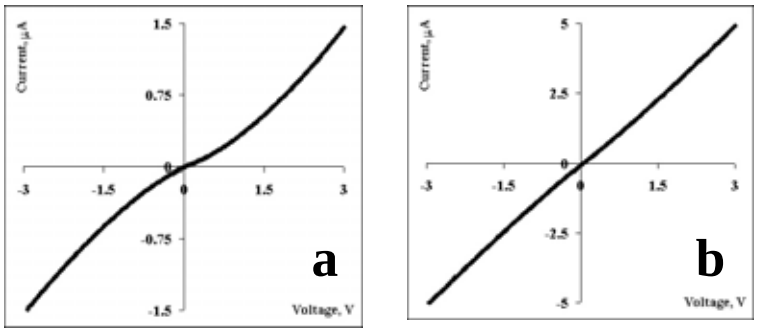


Figure 2. a - I(V) curve obtained on polished Ge filled AAO membrane; b - after additional chemical treatment.

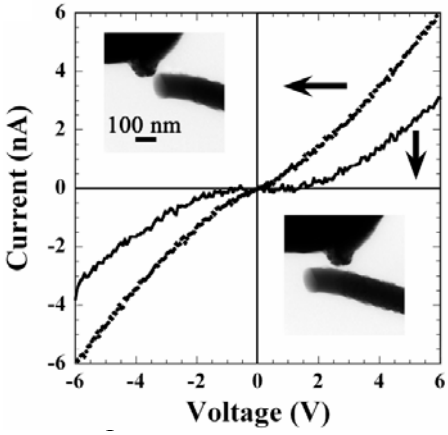




Figure 3. TEM-STM images and I(V) curves of Ge nanowire grown on Au tip in contact with another Au tip.