Poster

PHOTOCONDUCTIVE PROPERTIES OF GERMANIUM NANOWIRES INCORPORATED IN ANODIC ALUMINIUM OXIDE MEMBRANES

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Abstract. Photoconductive properties of Ge nanowire arrays with diameters of 50 and 100 nm respectively, grown in anodic aluminium oxide (AAO) membrane pores by a supercritical fluid deposition process were investigated. Photocurrent due to by laser light illumination was detected in Ge nanowire array. The photocurrent kinetics and a decrease of impedance at higher voltage frequencies indicates the existence of charge carrier traps in the GeNW-AAO system. Improvements in the Ge nanowire/metal electrode contact were also analyzed.

Introduction. Nowadays nanomaterials such as nanotubes, nanowires and nanoparticles are gradually being integrated into electronic and optoelectronic devices. One of the more serious problems of nanoobjects utilisation is the transition from prototype, which is based on just one nanoobject, to a device where thousands or billions of nanoobjects are integrated. Nanowire arrays inside AAO offer one of the most promising materials for the production of nanoscale devices because of the perfect pore orientations up to the macroscopic level and hence offer a possible architecture for device integration.
Since metal and semiconducting nanowires are expected to be of use as electronic and photonic guides; the problem of photon-to-electron conversion is an important one. We propose that arrays of semiconducting nanowires can be utilised as photon-to-electron converters with sub wavelength resolution. To test this hypothesis, photoconductive properties of Ge nanowires with diameters of 50 and 100 nm was investigated inside AAO membrane matrix.

Experimental. GeNW-AAO samples were prepared as described previously [1,2]. One surface of the AAO membrane was coated with an optically transparent ITO electrode. Off- axes DC magnetron sputtering was used for the sample coating for 20 min at a voltage of 30 V and current 50 mA. The target consisted of a 25 mm metallic alloy of $In_{91}Sn_9$. Sputtering was conducted in argon-oxygen atmosphere (20:1) at a pressure 4 Pa and substrate temperature of 250 °C. On the opposite surface a gold electrode of 2 mm diameter was sputtered for macro-contact measurements as with the other measurements.
The ITO coated surface was illuminated by a 100mW Melles Griot 510nm Ar laser (resulting light intensity 1400mW/cm^2) and the photocurrent was detected by a low-noise current amplifier SR570 (Stanford Research Systems) and HP 34401A multimeter. In impedance measurements, a sweep function frequency generator Hung Change 8205A was used.

Results. Photoconductivity of Ge nanowire arrays was tested by the macrocontact method (Figure 1) as described in [3]. The quality of the optically transparent coating was first tested and it was found that the ITO coated sample had approximately the same resistance as Au/Pd coated samples used in the conductivity measurements. A photocurrent of about 100% in magnitude was measured in the GeNW-AAO with respect to the dark current at a laser light intensity of $1400 mW/cm^2$, which increases up to 5 V as shown in Figure 2. A negligibly small ($2*10^5$ times smaller) photocurrent was detected at same parameters in empty AAO samples.

Impedance dependence on voltage frequency was measured to check the existence of charge carrier traps inside GeNW–AAO array. Impedance starts to decrease at frequency of 1Hz, that corresponds to time constant of 1s (Figure 3, curve 1), and is in good agreement with the photocurrent damping time constants of 0.1 to 6s. The measured impedance drop for an equivalent RC scheme with identical resistance (R) and capacity (C) values occur at 10^3 times higher frequencies (Figure 3, curve 2). This indicates that the capacity effect in GeNW–AAO sample is not responsible for the decrease in impedance. It was shown that removal of the AAO surface layer by chemical etching improves Ge nanowire / metal electrode contact and decreases the frequency effect as referred to in [3].

REFERENCES

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3. B.Polyakov, B.Daly, J.Holmes, D. Erts, Electroconductive properties of germanium nanowires incorporated in anodic aluminium oxide membranes. *In Preparation.*

FIGURES

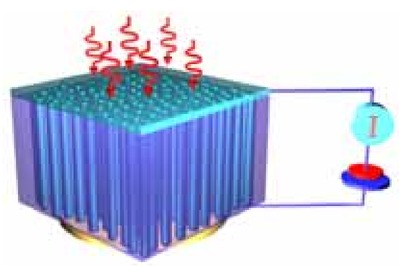

Figure 1. Scheme of photoconductivity measurement on Ge nanowire array.

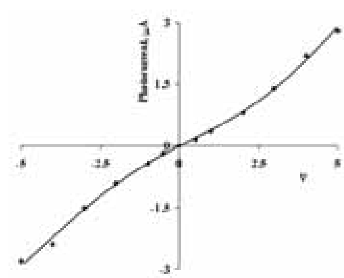

Figure 2. Photocurrent depending on voltage at laser intensity $1400 mW/cm^2$.

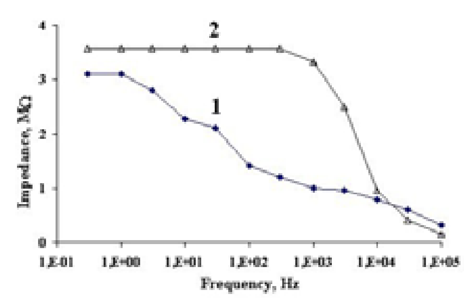

Figure 3. 1- impedance dependence on voltage frequency of Ge nanowire array, 2- equivalent RC scheme.