TEMPLATED CLUSTER ASSEMBLED NANOWIRES

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Templated self assembly of nanoparticles offers one way to reduce the dimensions of electronic circuit elements below lithographically defined feature sizes. In the method reported here, metallic clusters are assembled in V-grooves to produce wires with nano-scale widths. The V-grooves are formed in silicon substrates using KOH solution and the substrates are subsequently thermally passivated with silicon dioxide. The wires can be formed between existing electrical contacts on the substrate and their I(V) characteristics measured during and immediately after the fabrication process.

Using an inert gas aggregation source [1] and thermal evaporation, Sb clusters with average diameter 40nm were produced and assembled on passivated V-grooved substrates. Sb was selected for this investigation as evaporation occurs at temperatures achievable in the thermal aggregation source. Using Sb clusters, it should also be possible to study quantum confinement effects in wires with relatively large widths.

Initial Sb cluster assembly experiments were performed using non-contacted passivated V-grooved substrates and with inert gas (Ar) flow-rates into the source of between 10 and 180sccm. The Ar flow-rate controls the cluster velocity. The cluster deposition rate was measured using a quartz crystal film thickness monitor and the total amount of clusters deposited on the substrates was controlled by the duration of the deposition. Enhanced momentum-driven cluster movement on the walls of the V-grooves was seen at flow-rates exceeding 100sccm and in this flow regime wires with widths of less than 500nm were readily produced (Fig. 1). Collection of large numbers of clusters on the reverse side of an aperture plate indicated that reflection of the clusters from the V-grooved substrates was occurring. The essentially cluster free plateaus seen in Fig. 1 support this assertion and this selective cluster assembly leads to cluster wires without parasitic conduction occurring on the flat substrate areas.

Following characterization of cluster assembly on non-contacted V-grooves, contacted substrates were produced using optical lithography. On these samples 2μm wide V-grooves have been defined between contacts separated by 50μm. Electrical feedthroughs on the cluster deposition chamber allowed simultaneous electrical measurement on eight contact pairs on a 10x10mm substrate. The sample was mounted on a cryostat cold finger to allow low-temperature conductivity measurements across any of the eight contact pairs. Fig. 2 shows a pair of cluster-assembled wires and their resistance versus temperature plot from 5K to 300K.

References:

[1] W. A. deHeer, Review of Modern Physics, **65** (1993) 611.

Figures:

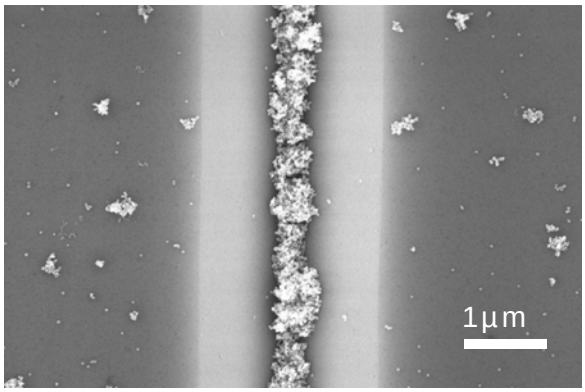
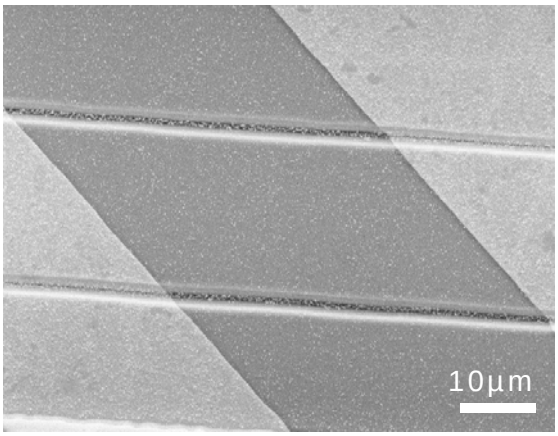
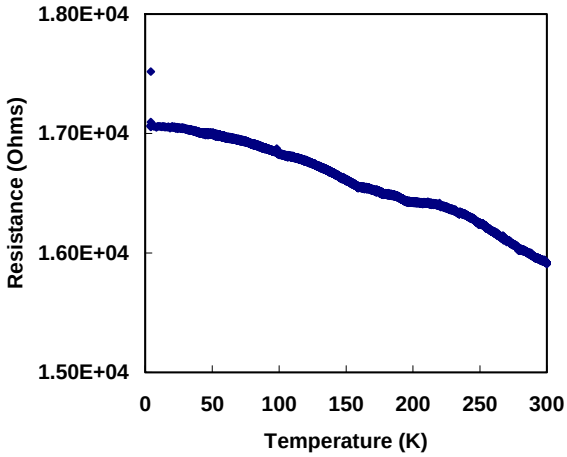


Figure 1. Sb cluster assembled wire in a 2µm wide silicon dioxide coated silicon V-groove.





(a) (b)

Figure 2. (a) Field-Emission SEM image of two contacted Sb cluster-assembled wires and (b) their resistance versus temperature characteristic.