Magnetically Aligned Nanowires for Nanodevices

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Spatial manipulation of nanostructured materials such as nanowires and nanotubes is a critical step towards mass scale integration in high density devices. Furthermore, these devices will require facile techniques for establishing electrical contact between the nano-entities and their supporting substrates for applications in electronics, optoelectronics, sensors, spintronics and thermoelectric devices. Previous efforts include during and post growth electric field assisted alignment[1], magnetic entrapment[2], microfluidic alignment, manipulation of nanowires with capped magnetic ends[3], and template assisted self assembly of mesoscale structures[4]. These initiatives were critical steps towards incorporating nanoengineered materials in devices and will require subsequent methods to establish electrical contact for many practical applications. This step has been addressed by in situ growth and e-beam lithography. Although both of these methods work well, in situ growth is not appropriate for many systems and post alignment e-beam lithography is not easily scaled up for mass production. In this paper we demonstrate a simple, robust method for establishing electrical contact of a single magnetically aligned nanowire using solder plated ferromagnetic pads.

Segmented nanowires were fabricated by electrochemical template synthesis and suspended in isopropal alcohol. Although Ni/Au/Ni and Ni/Bi/Ni nanowires were used to demonstrate proof of concept the mid-section of the nanowire is interchangeable with a variety of materials including semiconductors, metals, alloys, conducting polymers, and magnetic materials.

The nanowires were aligned with an external magnetic field, used to control the directionality, in coordination with the magnetic interaction between the nanomagnets on the nanowire and ferromagnetic pads on the substrate. This magnetic assembly technique was shown to have potential for mass assembled and individually addressable nanowires with the use of different substrate architectures for 2D control.

The solder thin films were shown to establish electrical joints as indicated by the I-V responses.

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References:

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Figure 1. Fabrication of electrodeposited nanowires; a)commercially available templates are b)sputtered with a Cu seed layer, c-e)nanowires are electrodeposited, f)the seed layer is etched, the template is dissolved and the nanowires are suspended in solution.

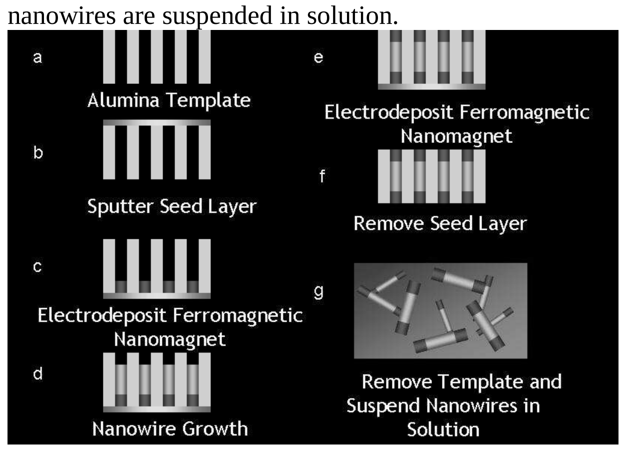

Figure 2. 1 microL of nanowire solution is dispensed on the substrate in a magnetic field, the nanowires align, the solution evaporates and the substrate is heated to establish good electrical contact

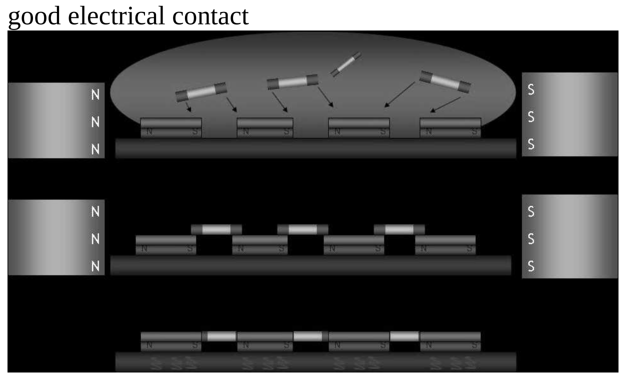

Figure 2. Dependence of average film stress of FeCoNi electrodeposits on operating temperature; same conditions as Fig. 1 except 0.02 M $NiCl_2$.

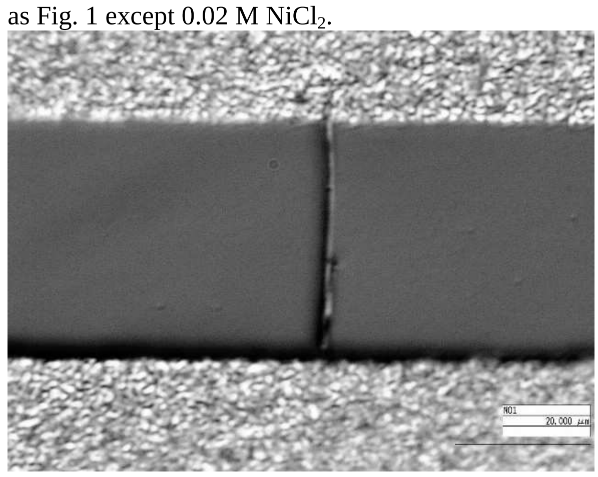

Figure 3. Magnetically aligned Ni/Au/Ni nanowire between two solder plated Ni pads.