In Situ Purification and Characterization of Direct-Write Nanostructures Fabricated using Electron Beam Induced Deposition

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One of the emerging techniques useful for the rapid prototyping of nanodevices is electron beam induced deposition (EBID) due to its ability to direct-write complex 3D structures with a resolution on the order of 10s of nanometers. EBID builds structures in a layer-by-layer process analogous to that of additive manufacturing by employing a focused electron beam to facilitate a dissociation reaction of a precursor in a localized area on a substrate housed within a scanning electron microscope (SEM). EBID is therefore highly flexible and different materials systems can be explored depending on the precursor employed.

One drawback of EBID is a lack of material purity for most as-deposited materials. This poster presents a detailed study of the purification of EBID deposits using *in situ* pulsed laser heating. The morphology of 3D deposits is studied in detail both with and without laser treatment and morphological changes are correlated with changes in resistivity. This morphology change is shown in the STEM micrographs in **Figure 1**. Part **a** depicts an EBID deposit without laser treatment and parts **b** through **d** show deposits with laser treatment. Notably, significant purity is achieved on suspended nanowires yielding improvements in resistivity of more than 2 orders of magnitude while retaining a high degree of shape fidelity.

Additionally, nanomechanical tests were performed on various geometries including: nano-pillars, nano-cantilevers, and nano-trusses fabricated using EBID. These tests were performed using an *in situ* nanoindentation system made by Nanomechanics, Inc. (shown in **Figure 2**) which allows load-displacement curves to be directly measured while simultaneously imaging within a SEM. Compressive strengths of up to 2.2 GPa are reported for individual pillars. The *in situ* nature of the nanomechanical tests enables real-time feedback providing information on elastic and plastic deformation as well as fracture. The nanostructures were also thinly and conformally coated with ceramic oxides using atomic layer deposition. The mechanical properties were compared for structures both with and without coating.

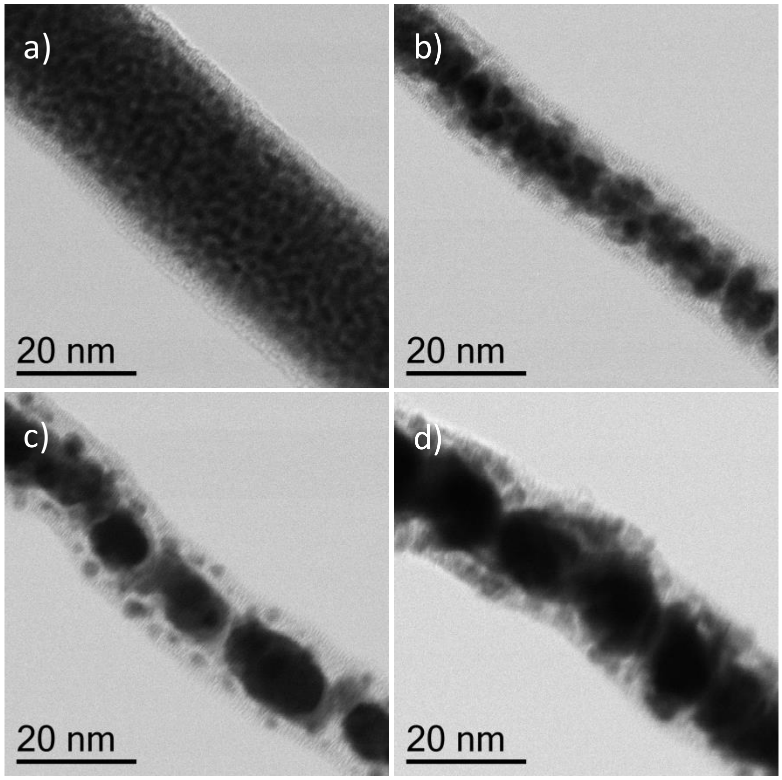

Figure 1: Bright Field Scanning Transmission Electron Microscope images of pillars grown using EBID: a) an as-deposited EBID segment b) – d) Laser treated segments using different growth conditions

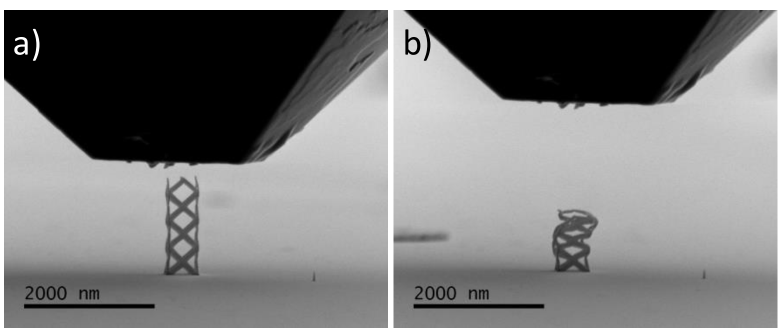

Figure 2: Scanning Electron Microscope images of nanocompression testing: a) before compression; b) after compression.