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FIB/SEM Fabrication of Nanostructures for Plasmonic Sensors and Waveguides

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Focused ion beam (FIB) and scanning electron microscopy (SEM) fabrication has been demonstrated as a useful tool for the development of active optical components such as sensors and waveguides. The detection mechanism in these fiber optic sensors is based on shifts in localized surface plasmon resonances (LSPRs) of metallic nanostructures and surface plasmon resonances (SPR) associated with nanoholes in optically thick metallic films, that occur when the refractive index of the medium surrounding the metallic nanostructures and nanoholes is changed[1-4]. These sensors can be employed for the detection of chemical agents in air as well as liquid media surrounding the sensors.

Employing FIB and SEM has allowed formation of nanostructures such that the plasmon resonances associated with the nanostructures could be engineered and precisely controlled by controlling the nanostructure size and shape. Here, we demonstrate direct deposition of conductive nanostructures created using electron beam induced deposition (EBID) from a precursor, dimethyl Au(III) acetylacetonate, in a predefined reaction region. The nanostructures were created using a FEI Nova 600 SEM/FIB operate at 5kV which produced a beam current of ~0.4nA[5].

Morphological characterization and material properties of nanostructures created by EBID were documented using a combination of FESEM, conductive AFM, STM and quantitative X-ray analysis. Fig. 1 shows multi-length scale secondary electron micrographs of the EBID deposited plasmonic nanostructures. Resulting nanostructure arrays contained features with diameters in the 70-40nm range and gaps between the features which measured from 30-20nm. Quantitative EDS of EBID deposited features, measuring 4µm x 4µm x 700nm found an average chemical composition of ~57 wt% Au, ~33 wt% C and ~10 wt% O. Conductive AFM data, shown in Fig. 2, confirmed the 4µm EBID structures contained conductive domains. Dark field optical microscopy, to test the plasmonic response of these EBID nanostructures, showed a similar optical response from nanostructures created by FIB milling of an evaporated Au thin film. The direct fabrication of nanostructures by EBID shows promise as a simpler fabrication technique when creating plasmonic sensors and waveguides.

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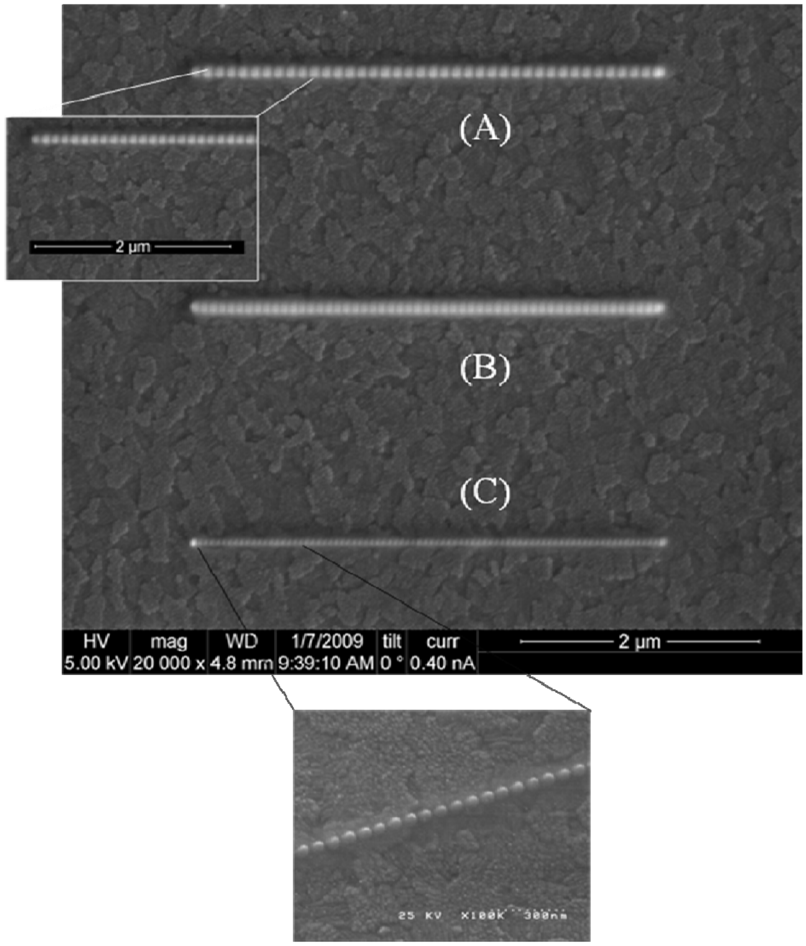

Fig. 1. Electron beam induced deposition of gold nanopillars on ITO-coated glass slides for developing plasmonic waveguides: (A) ~ 70 nm pillars with ~ 30 nm spacing between the pillars, (B) ~ 70 nm pillars with ~ 20 nm spacing between the pillars, (C) 40 nm pillars with 20 nm spacing between the pillars.

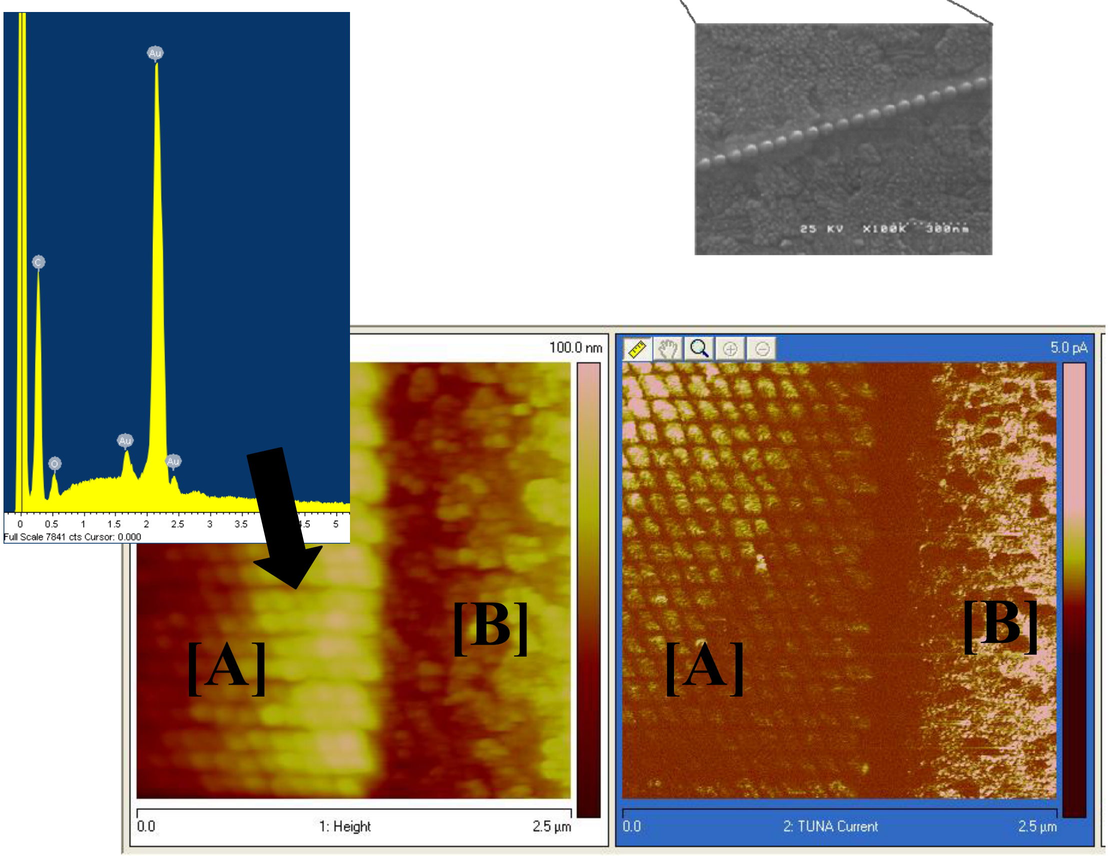

Fig. 2. Contact mode AFM height image (left) and conductive AFM data (right) of an EBID deposited structure [A] deposited on an ITO substrate [B]. The conductive AFM data shows an array of conductive domains in the EBID structure region. Differences in the conductivity signal intensity, between the EBID structure [A] and the ITO substrate [B], is clearly observed.

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