Nanofabrication of arch metal structures as gas/biosensors by grayscale electron beam lithography

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Local surface plasmonic resonators (LSPRs) have been substantially addressed as biosensors for environment protection, toxic material monitoring, medical diagnosis and healthcare, etc. So far, all the developed metallic nanostructures are typically in the format of dot arrays, gratings and pillars, etc. Due to anisotropic nature of these structures, for example, grating with sharp edge can cause low reflection due to light loss by random scattering, novel nanostructures with high degree of symmetry might be a good solution for achieving harvest of light in a broad angle of incidence. For this task, we have recently developed a novel structure, nano arch structure in metals as a new kind of biosensors, as schematically described in figure 1a. The so-called nano arch structure can be easily formed by coating a thin metallic film such as Au or Al on the top of semi-cylindrical lines of PMMA, replicated by grayscale electron beam lithography. By this way, the feature size such as the arch wall thickness can be readily achieved by controlling the film thickness, which is as accurate as 1 nm in our laboratory. It is anticipated that such a narrow edge in the arch structures should be able to generate strong surface enhanced Raman scattering (SERS) as high sensitivity biosensors.

Figure 1b presents the resist profile after EBL on a PMMA(100K)/PMMA(350K), which was carried out under the tension of 100KeV by JEOL 6300FS. On the top of nanoscale lines, thermal evaporation of metals such as aluminum or gold was carried out. Arch metal structures in different radius and periods have been achieved by such a straightforward method. Figure 2 shows the 20 nm thick gold arch metal structures with the radius from 40 nm to 80 nm and the pitch of 250 nm. 20 nm thick Al arch metal structure with radius from 70 nm to 100 nm and pitch of 400 nm is shown in figure 3 by comparison. The reflectance spectra from the 20 nm thick gold and 20 nm thick aluminum arch metal structures with various radii and periods are presented in figure 4. The local surface plasmonic resonance can be clearly observed. Angle resolved spectra are under the way for the study of isotropic property of the nano arch structures.

In summary, we have developed a novel nanostructure as arch architecture in metals with various radii, periods and thickness as biosensors. Optical measurements have also been done to prove this structure is like a resonance cavity and can be used as nano-channel in NEMS or biosensor for gas or liquid detection. Further work such as sensing behavior by both LSPRs and SERS are still under the way.

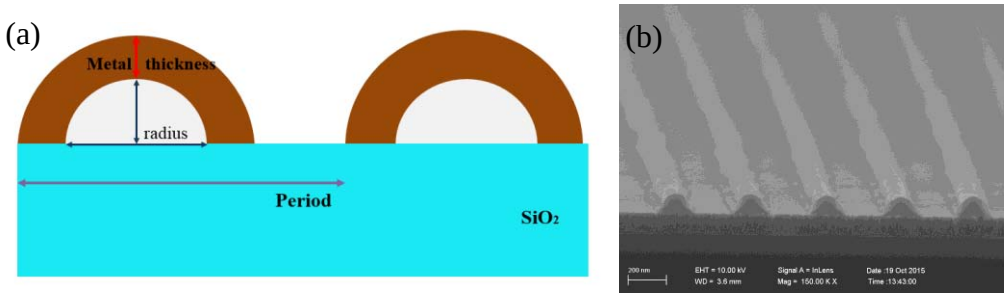

Figure 1(a) Schematic diagram of arch metal structure (b) SEM image of bilayer resist profile after developing process.

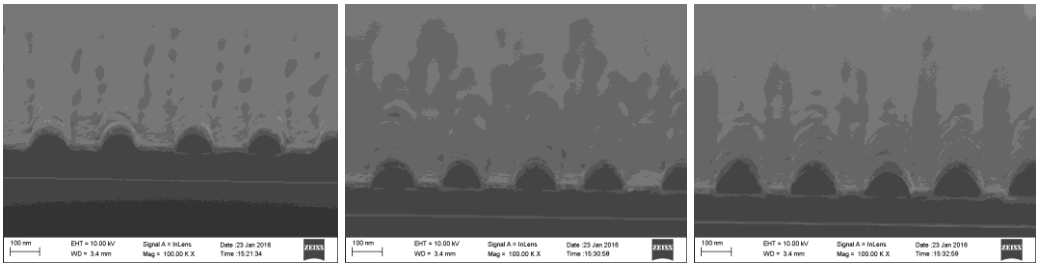

Figure 2. SEM images of 20 nm Au arch structure with radius from 50 nm, 60 nm to 80 nm and the period is 250 nm.

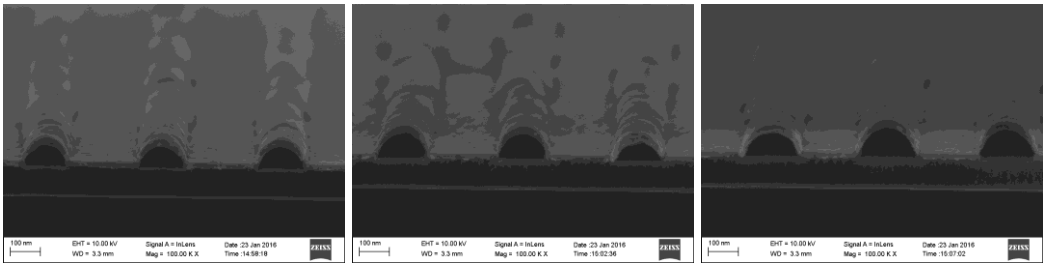

Figure 3. SEM images of 20 nm Al arch structure with radius from 70 nm, 80 nm to 100 nm and the period is 400 nm.

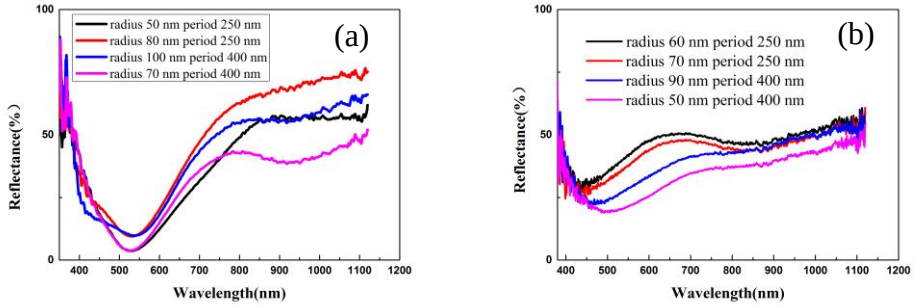

*Figure 4.*Optical measurement reflectance curves of this arch structures with different sizes and different metals.(a) 20 nm thick Au (b) 20 nm thick Al.