METALLIC NANODOT ARRAYS FABRICATED BY STENCIL LITHOGRAPHY ON SiO_2 AND POLYMER SUBSTRATES

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This work presents the fabrication of gold nanodots (NDs) on SiO_2 and polymer substrates using stencil lithography. Metallic NDs have acquired a lot of interest due to their application for biosensing and photovoltaics exploiting their localized surface plasmon (LSP) resonance behavior [1]. As shown in Figure 1.a), stencil lithography is a shadow mask technique that does not require any resist, energy radiation, baking or solvents [2]. It also offers the potential for cost-effective nanofabrication since the stencils can be reused several times [3]. Polymer materials also are interesting because they have lower cost and allow the fabrication of flexible devices. The fabrication of nanostructures on polymer substrates is of particular interest because conventional nanopatterning technologies such as electron beam lithography, focused ion beam or deep-UV lithography are not always compatible with polymer substrates.

The stencils used in this work are based on 100 nm thick low-stress silicon nitride membranes with arrays of 50 to 200 nm size nanoholes with different spacings. The silicon nitride membranes are supported on 6x6 mm^2 silicon chips. The nanoholes in the membranes are defined by electron beam lithography. The Au NDs were deposited on silicon oxide, polyimide, parylene and SU-8 substrates. The polymer substrates consist of 2 µm thick films deposited on conventional silicon wafers. To deposit the NDs, the stencils are fixed on top of the substrates by adhesive tape. The substrates with the fixed stencils were introduced into an e-beam evaporator for the deposition of 5 nm of Ti as adhesion layer followed by 50 nm of Au. The deposition was performed at 10^{-6} mbar and 20°C. The Ti was deposited at 4 Å/s and the Au at 1 Å/s.

Arrays of Au NDs ~50 to ~200 nm in size with different spacings were deposited through stencils. The size of the arrays is 30x30 μm^2. Figure 1.b) shows a stencil with nanoholes and their corresponding Au NDs deposited on Si oxide (Fig 1.c), polyimide (Fig 1.d) and SU-8 (Fig 1.e) substrates. The NDs clearly correspond to the apertures on the stencil. Some scattered particles in between the NDs are observed on the silicon oxide substrate (Fig 1.c). This is a consequence of the blurring related to the stencil-substrate gap and the mobility of the atoms deposited on the substrate. Figure 2 shows arrays of ~50, ~100 and ~200 nm NDs deposited on a parylene substrate. Figure 3 shows an AFM image, the profile and a 3D view of 100 nm size NDs with a thickness of ~50 nm deposited on a SU-8 substrate.

Au nanodots were also deposited on glass substrates in order to study their LSP behavior. The LSP extinction spectra of 100 nm metallic NDs arrays with different spacings are shown in Figure 4. The plots show the resonant behavior of the LSP. The resonance wavelength is larger for the shorter spacing between the dots.

This contribution demonstrates the fabrication of metallic nanodots on silicon oxide and polymer substrates by stencil lithography. It shows that stencil lithography is an alternative technique for cost-effective fabrication of nanostructures on polymer materials. The localized surface plasmon spectra of the nanodots show the potential of these structures for biosensing and photovoltaics.

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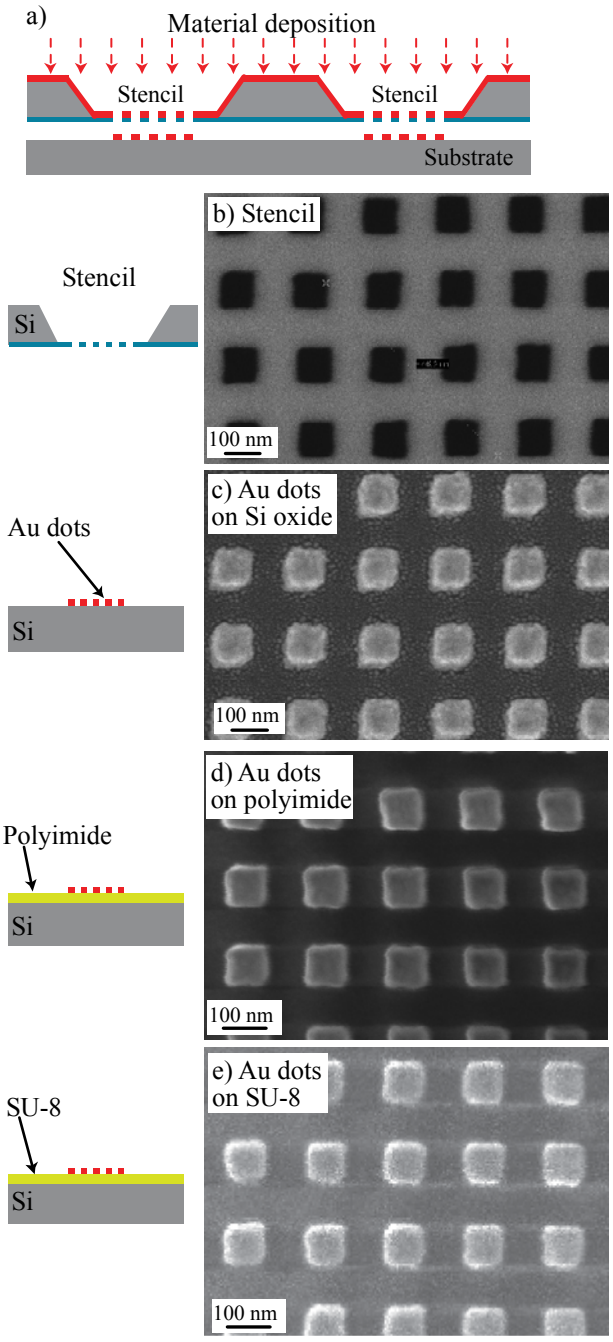

Figure 1. *a) Principle of stencil lithography. The stencil is fixed on top of a substrate. The material passing through the stencil is deposited on the substrate reproducing the pattern of the stencil apertures. b) SEM image of a stencil membrane with 100 nm nanoholes and 100 nm half-pitch. c,d,e) SEM images of Au nanodots deposited through the stencil shown in b). The dots are ~100 nm in size with 100 nm half-pitch and deposited on c) Si oxide, d) polyimide and e) SU-8 substrates.*

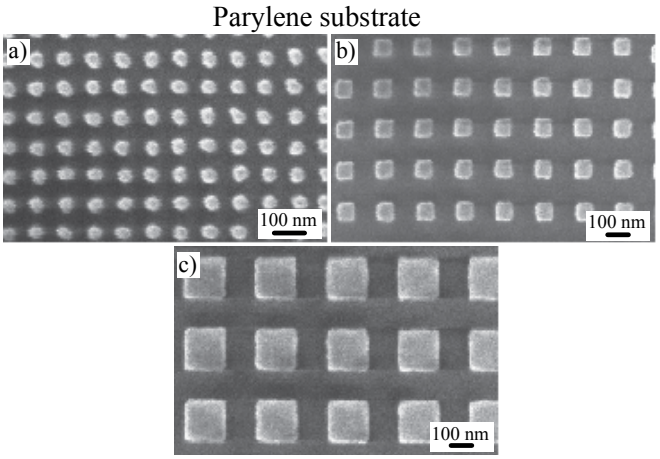

Figure 2. *a) ~50, b) ~100 and c) ~200 nm Au nanodots deposited on a parylene substrate.*

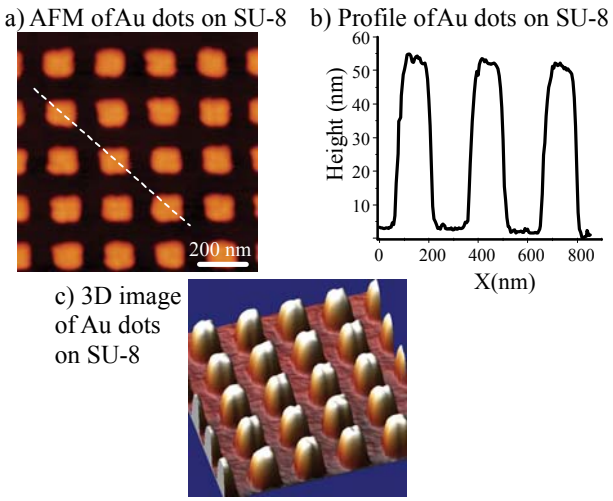

Figure 3. *a) AFM image of 100 nm size Au nanodots on a SU-8 substrate. b) Profile of the 50 nm thick Au nanodots extracted from image a). c) 3-D reconstruction of the dots shown in image a)*

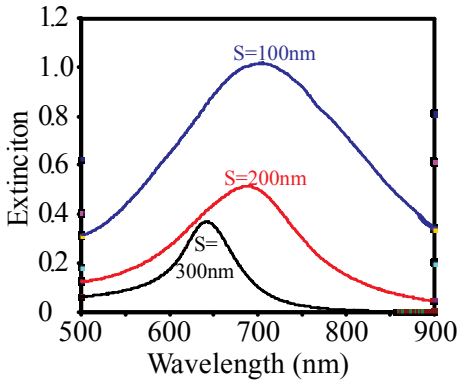

Figure 4. *Localized surface plasmon resonance extinction spectra of 100 nm Au nanodots deposited on a glass wafer. The dots have a half-pitch of 100, 200 and 300 nm. The spectra show a resonance behavior with a longer resonance wavelength for the shorter pitch.*