Plasmon confinement in V-groove waveguides fabricated by NanoImprint Lithography

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*Surface plasmon polaritons (*SPPs), are quasi two-dimensional electromagnetic waves propagating along a dielectric-metal interface. SPPs modes bounded to a subwavelenght structure are also called *channel plasmon polaritons* (CPPs). Recently, v-shape grooves made in noble metal film have demonstrated plasmon coupling in the bottom of the groove, allowing light guiding in subwavelength structures with low propagation losses [1]. The structures used for this demonstration were made in silver by Focused Ion Beam (FIB), resulting in a sharp v-groove, but showing rough sidewalls. FIB is suitable for single groove fabrication, but not for large volume applications, (i.e., biosensors).

In this work we present a process for the fabrication of the v-grooves in metal, based on **NanoImprint Lithography (NIL)** [2]. The process allows parallel fabrication of integrated devices: the v-groove and two deep channels, where the optical fibers are placed for optical characterization. The process is described in Figure 1: (a) the stamp (4 inch) is designed and fabricated in silicon; the grooves have been made by anisotropic wet etching of silicon (KOH), resulting in v-grooves with and angle of 70º and smooth sidewalls. Each stamp contains grooves with different lengths (from 100 μm to 500 μm), and different widths (5 μm to 12 μm). (b), the stamp is imprinted in PMMA. (c), a 200 nm thick film of **gold** is evaporated on the PMMA structures. (d) a UV sensitive polymer (Ormocomp®,) is cast onto the gold, and cured with UV light, so it can be the support for the thin gold film. (e) The PMMA sheet is dissolved, in acetone, whereby the smooth grooves in the silicon stamps are replicated in the gold film, as shown finally in (f). Figure 2, (a) and (b), show two examples of the devices based in v-grooves, fabricated in gold on the transparent substrate.

Figure 3 shows results of SNOM characterization, using an interferometric photon scanning tunneling microscope (PSTM). The light was launched with an incident angle of 45º at the beginning of the groove. Figure 3 (a) is a topographical image of the groove, (b) is the light intensity in that area. Comparison between (a) and (b) leads to the conclusion that there is an intensity enhancement in the bottom and in the top corners of the groove. This result agrees with simulations presented by Bozhevonlyi et al. in [3], where the field distribution inside the groove has been simulated for different geometries, showing that for wider grooves, the coupling happens also in the corners.

Phase mapping [4] allows measuring the wavelength of the SPPs and CPPs that propagate in the structures. The wavelength inside the groove (CPP) has been measured to be different to the one propagating on the gold surface outside the groove (SPP). Further more, changing the incident wavelength, the dispersion curve can be represented for SPPs and CPPs in this sample, and be compared to the one at air. Both dispersion curves are non-linear, as expected, and the slope for SPPs and CPPs curves are different, leading to the conclusion that plasmon confinement is possible in v-grooves made with this method.

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Figures:

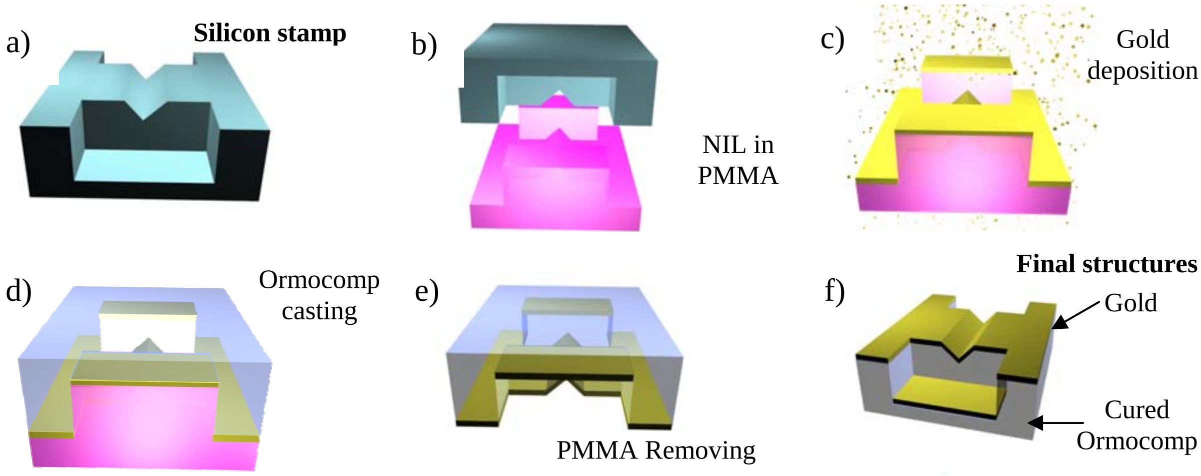

Figure 1. Scheme of the fabrication process: (a) silicon stamp, containing the v-grooves. (b) NanoImprint process, to transfer the features to PMMA. (c) a 200 nm thick film of gold is deposited on the PMMA structures. (d) casting of a UV curable polymer (Ormocomp, by micro resist technology) on the structures, and UV curing. (d) PMMA is dissolved in acetone. (f) scheme of the final structures, showing the same geometry of the initial stamp, but made in gold on top of Ormocomp.

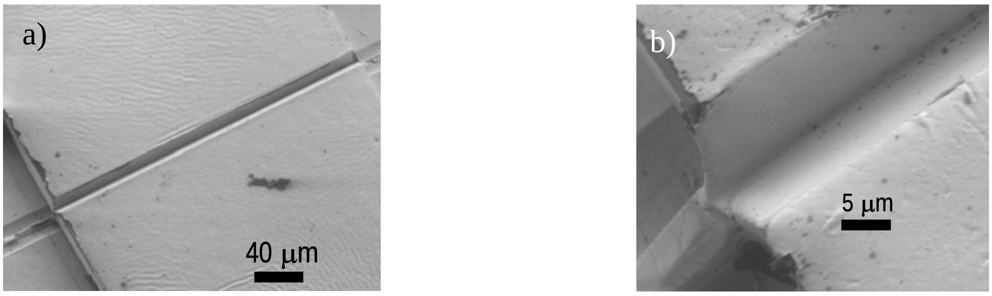

Figure 2. SEM images of the **structures fabricated in gold** (figure 1 f). (a), the groove and the deep channels. (b) a detail of the v-groove, showing the smoothness of the sidewalls.

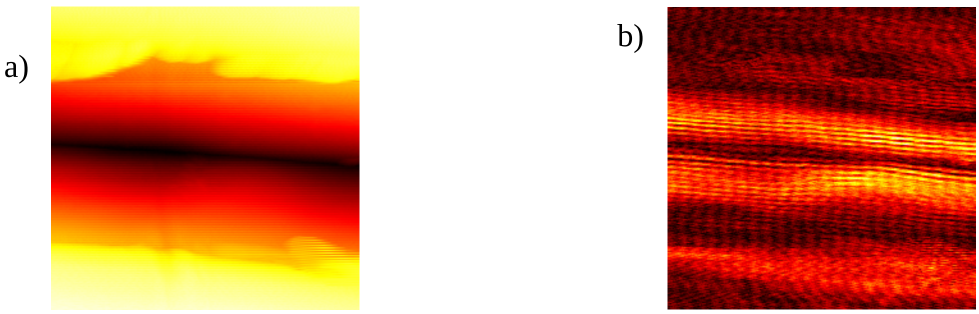

Figure 3. Results of SNOM characterization. (a) shows to the topography of the v-groove; (b) represents the field intensity. Light is shown to be confined mainly in the bottom of the groove, and also in the edges.