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Fabrication and SNOM characterization of plasmon optical elements

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A new approach of fabricating plasmon optical devices is presented. Instead of using metallic structures realized by electron beam lithography and a subsequent lift-off process, structured dielectric coatings can be employed. The use of polymer films such as poly-methyl-metacrylate (PMMA) has some advantages in comparison to metallic structures: Structuring can be performed in a very simple and reproducible way by a one-step process. The realization of quasi two-dimensional optics is demonstrated on prisms and lenses with lateral dimensions of some tens of micrometers. For this purpose, plasmon excitation was realized by a modified Kretschmann-Raether configuration. A laser beam of 673nm wavelength is focused through a glass prism onto a silver-air interface. From this 15µm wide spot, a plasmon beam propagates 25µm before impingeing on the PMMA structure. Investigations were performed by Scanning Near-field optical Microscope (SNOM) in the collection mode. Due to the measured exponential decay perpendicular to the surface, an uncoated optical fiber was used to image the lateral plasmon field. The tip-sample distance was kept constant by a tuning fork feedback system.

With this setup the deflection of the plasmon beam caused by the structural elements was monitored (see Fig.1). To a first approximation, the Snellius law of refraction is fulfilled. An effective index of refraction for plasmons can be determined and is tuneable up to 1.40 by varying the thickness of the PMMA coating up to 140nm. Moreover, some plasmon-specific phenomena could be detected: An angle-dependent intensity modulation in the transmitted beam was observed as well as a beat pattern within the structural elements themselves. An explanation for these phenomena is given and the results of modeling are presented.

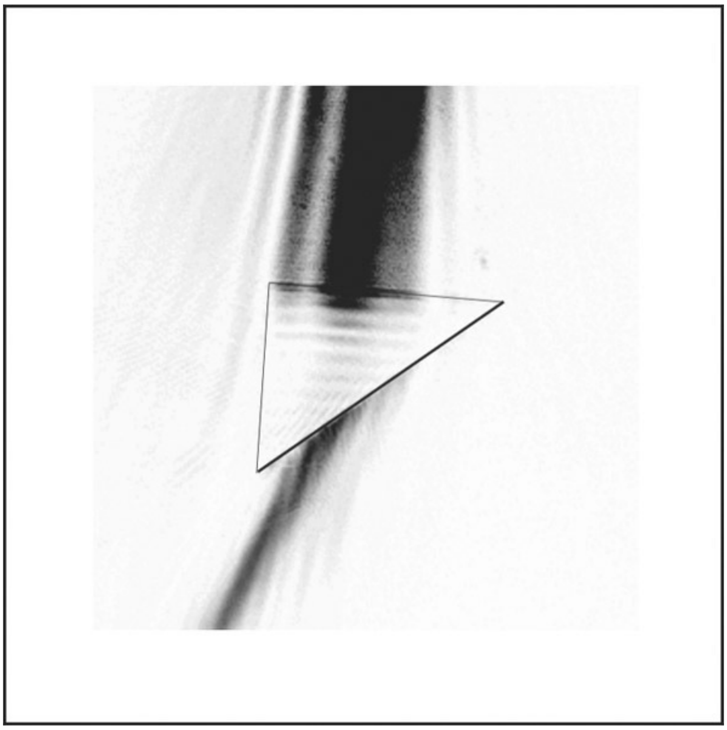

Fig. 1: Deflection of a plasmon beam at a PMMA prism with a prism angle of 40°. Propagation direction is from top to bottom. Image size is 40µm x 40µm.