EVANESCENT WAVE LITHOGRAPHY. A NEW TOOL IN NANOFABRICATION.

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Conventional optical lithography is based on UV-light sources and illuminating photoresists through masks. Currently, the author is working on the use of evanescent waves to perform lithography, and to the best of our knowledge not used before. Evanescent Wave Lithography has some key advantages and singular capabilities as we will try to demonstrate. In particular, it can reach lower resolution limits and simultaneously make continuous 3D surface profiles in an easier manner. The depth profile capability comes from the special property of exponential decay in the field amplitude of an evanescent wave, contrary to conventional photolithography where the resist is whole-thickness exposed. Only binary profiles are possible in a single step classic lithography basis. The lower achievable resolution limit (~50nm) comes from the well known fact that the effective wavelength in a propagating media is *n* times less than in vacuum propagation, being *n* the refractive index of the propagating media. To achieve evanescent wave regime we need total internal reflection at a resist-prism interface (Fig.1) and this needs of an incident medium with a higher refractive index than the resist, typically higher than 1.65, so for example, the effective wavelength when using vacuum i-line (365 nm) should be less than 220 nm. Therefore, by certain means we can achieve the resolution of VUV-EUV lithography but based on near-UV light-sources and conventional resists.

There are previous results that support our approach. Sainov [1]-[2] uses the evanescent wave to generate holographic gratings of Λ=156.7 nm with a laser emitting at 514.5 nm. Although our proposal keeps some similarities with the work of Sainov, it does not seem that the evanescent wave has been used before for nano-profile fabrication.

The techniques for nano-patterning the surfaces under design are based on ion-etching, electron-beam, etc… [3]; or based in other scanning technologies, like atomic force microscopy or scanning tunneling microscopy, which permit nano-patterning point by point with a nanometric probe by means of different physical mechanisms, for example, the anodization of differential oxidation of the surface. However, they are costly techniques in terms of time and inappropriate for extended areas. The evanescent wave promises a simple and rapid fabrication of several devices in large areas. Recently, A. Nesci y H. Tao *et al* [4]-[5] have measured the structure of the interferential evanescent wave encountered in the set-up of Fig.1. A similar set-up has been used by the author to register lithographically the interference of two laser beams and we obtained the satisfactory results of Fig.2, confirming the capability of the evanescent field to sculpt 3D profiles on the surface of a resin.

We will show that by using an interference scheme (interference lithography) it is possible to achieve periodic structures of Λ~100 nm by simple means and also reaching details of only 10 nm size (Fig.2) in field structure, not possible with conventional interference lithography. Some experimental and simulation results are shown in the figures. First intended devices to present at the meeting are an anti-reflection coating and a sub-wavelength grid polarizer, both based on nanoscale optical phenomena.

References:

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[3] Philippe Lalanne, Mike Hutley, http://gea.df.uba.ar/curso2002/lect3.pdf

[4] Hong Tao, et a, Chinese Physical letters vol.21, no. 5 (2004), 907-10

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Figures:

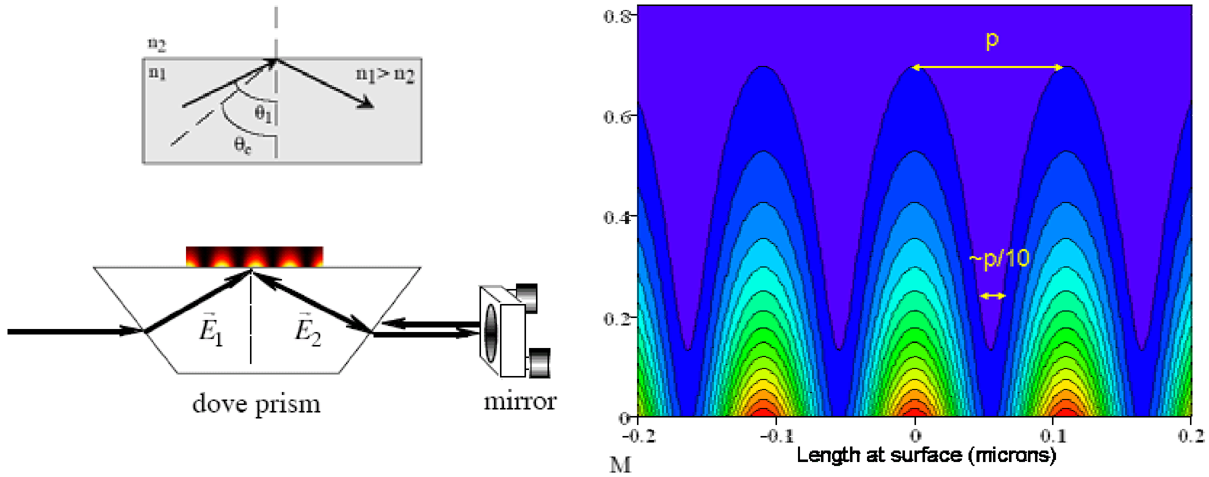

Fig. 1 Left-up: As is well known, to obtain a surface evanescent wave it is necessary that $n_1 > n_2$ (refractive indices) and $_1 >$ $_c$ (incidence angle above critical angle). Right: Field amplitude structure of the interference of two evanescent waves under a possible interference set-up (left). Amplitude of E_2 is 10% of E_1 (right). The evanescent field penetrates the resist close the interface in the Evanescent Wave Lithography technique.

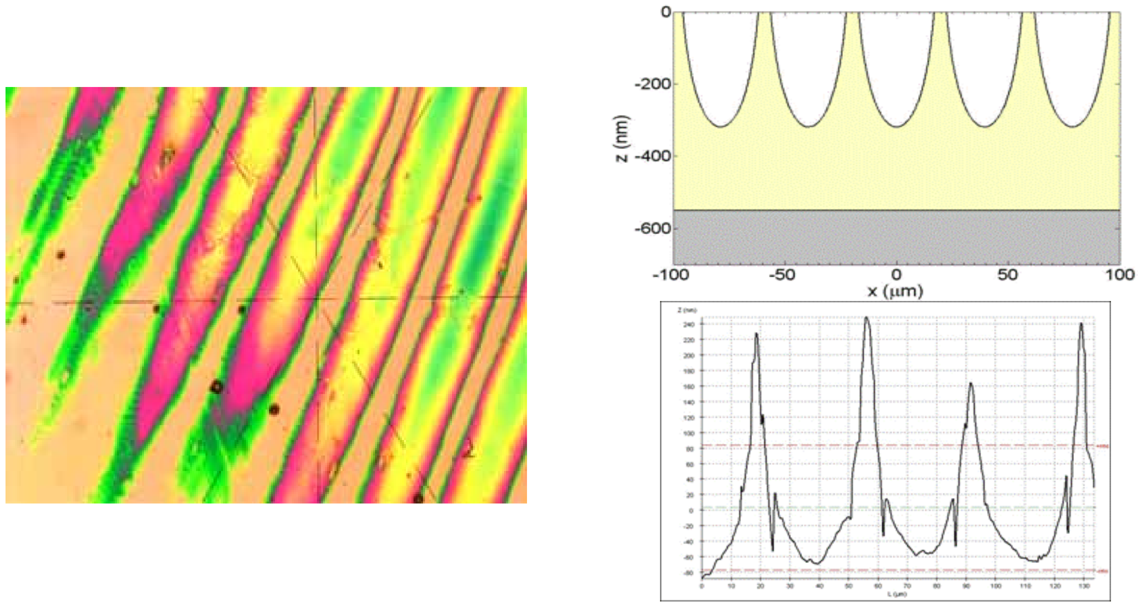

Fig. 2 Some experimental results from Evanescent Wave Lithography (EWL). Left: interference grating registered by EWL with a 405 nm laser split beam (35 m). The image is obtained with a conventional optical microscope in reflection mode and every colour corresponds to an interference fringe, i.e. to a certain thickness or penetration depth. The colour-depth map demonstrates the ability of the evanescent recording to generate 3D profiles on surfaces in one single step. Top-right: simulated registered profile by using a model of threshold exposing dose of a positive photoresist. Bottom-right: depth profile of an experimental sample obtained with a confocal profiler confirming our expectations.