DEVELOPMENT OF NANOIMPRINT LITHOGRAPHY TECHNIQUE: FABRICATION OF AN OPTICAL MICRO-ENCODER

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The capacity to, not just to pattern, but to replicate these patterns at the micro and nanoscale is of crucial importance for the development of micro and nanotechnologies. In recent years, many new lithography techniques for micro and nano-scale patterning have emerged [1]. Among these, nanoimprint lithography (NIL) has become one of the most promising and successful nano-patterning technique. NIL was first introduced by S.Y. Chou back in 1995 [2,3] and since then has attracted great interest of researches from all over the world, to the point that MIT's Technology Review has included NIL in the list of the 10 emerging technologies that are likely to change the world [4].

NIL principle is divided in two steps: imprinting and pattern transfer (Fig.1). A thin resist layer (deformable polymer) is deposited on a substrate (Fig.1a). A micro and/or nano-patterned mould is physically imprinted in the substrate at higher (Fig.1b) and demoulded at lower temperature than the polymer glass transition temperature T_g (Fig.1c). In the compressed area, a thin layer of polymer is always remaining, the so-called residual layer, which is removed by an anisotropic etching process (Fig.1d), typically reactive ion etching (RIE). After this "window opening", pattern transfer to the substrate is achieved by deposition of a thin metal layer (Fig.1e) and further lift-of process (Fig.1f).

With suitable stamp and resist, the resolution obtained by NIL can be below 10 nm as many experiments have indicated [5] and it only needs simple equipment and relatively easy processing. This is the main reason why NIL has emerged as one of the most promising low-cost and high throughput nanopatterning method.

Optical encoders have been used for decades as displacement measuring devices. In simple terms, an encoder consists of a scale and a scanning device that reads off the scale. Optical encoder scales are rigidly attached to a metrology frame and consist of grating or grid plates, and the read head senses displacement relative to the grating scale. Highest resolution (a small fraction of the grating period) is achieved with a variety of diffraction based schemes [6, 7]. The main advantages of optical encoders are the short and constant beam path lengths between gratings and sensors, reducing the effects of the atmosphere by orders of magnitude compared to lasers interferometers. The main drawbacks associated with encoders today is that commercially available encoder plates are limited in accuracy to worse than 100 nm (these encoders have line widths between 0.5 μm-10 μm). Since the encoder can only be as accurate as the grating scale, advance in this area crucially depends on the availability of encoder plates with sub nanometer accuracy [8]. Considering the disadvantages related to e-beam lithography, interference lithography [9] and UV-lithography, NIL appears as a promising technology to produce low cost high-accuracy encoders.

In this work an angular micro-encoder is fabricated by NIL as a first step to control NIL process towards the fabrication of a nano-encoder in the near future. The micro-encoder has been fabricated in silicon and pyrex glass substrates with further chromium layer lift-off. The linewidth achieved is of 3 µm which gives a good starting point for further investigations in nano-replication by NIL.

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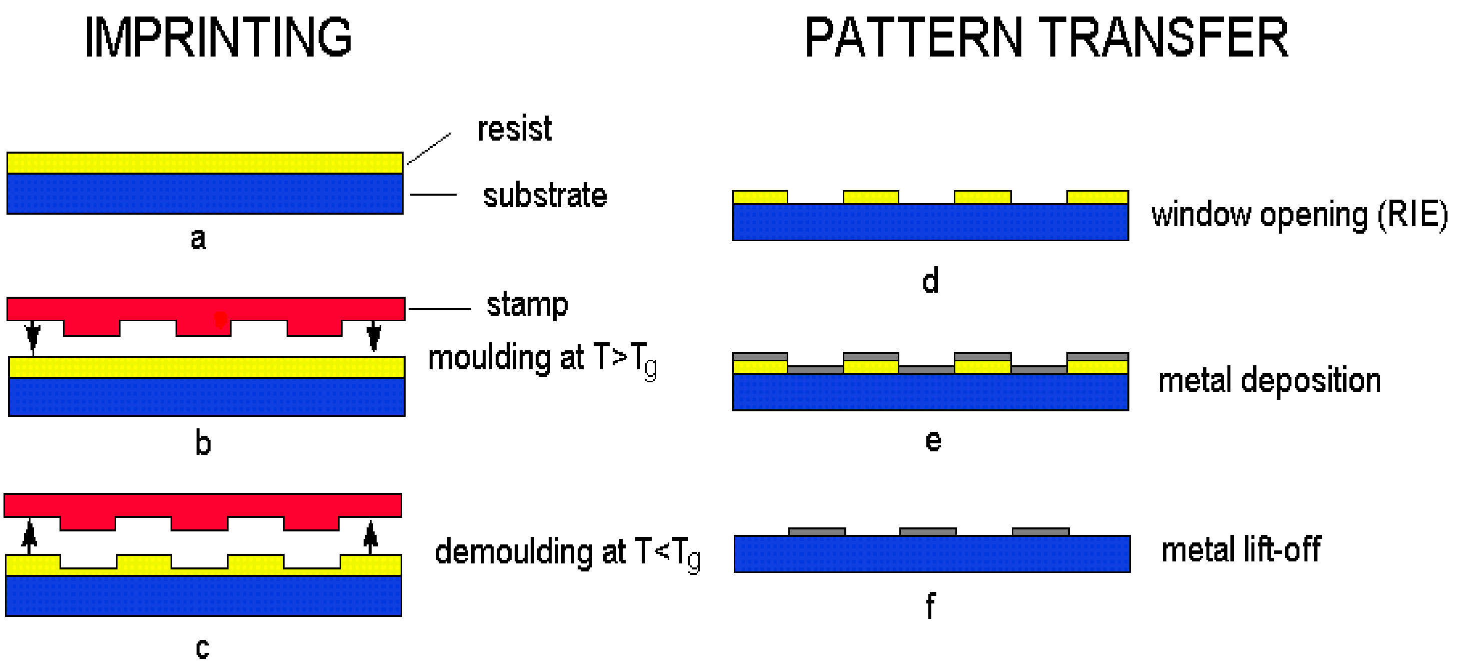

Fig.1: NIL process