Implementation and application of a „triple wavelength laser diode into a lithography setup

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In directly writing lithography systems, better control of the focal position of the “writing beam” can be gained by implementing a laser diode, emitting 3 different wavelengths (405nm, 650nm and 780nm). This facilitates the realization of higher resolution, improved reproducibility and better quality of the structures.

1 Fundamentals

Lithography on confocal basis (Fig.2) is one alternative possibility to expose photo resist surfaces within lithography processes using focussed laser beams (Fig.1).

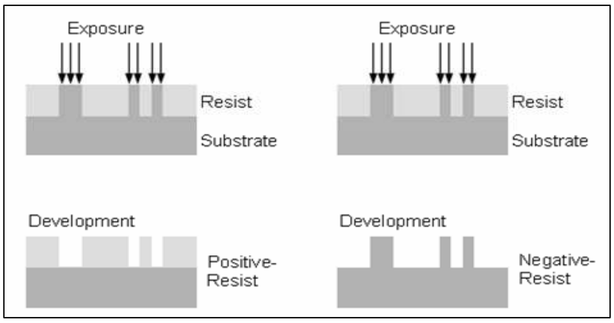

Fig. 1 *Principle of lithography process*

The reflected light from the resist-surface (focal plane) is used to control the distance or the focal position of the “writing beam”, respectively.

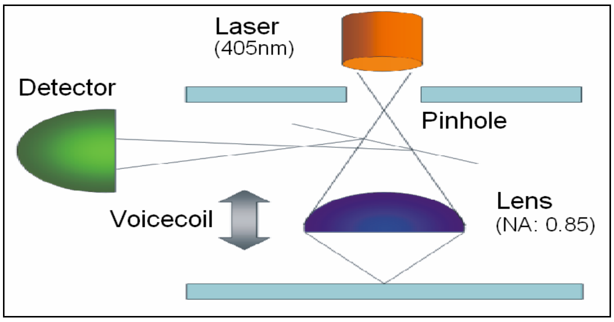

Fig. 2 *Scheme of a confocal system*

2 Implementation

The resist coated substrate, which has to be structured, is located below the focussing lens on an X-Y table. The X-Y table is controlled pointwise by Labview© according to the desired pattern (Fig.3).

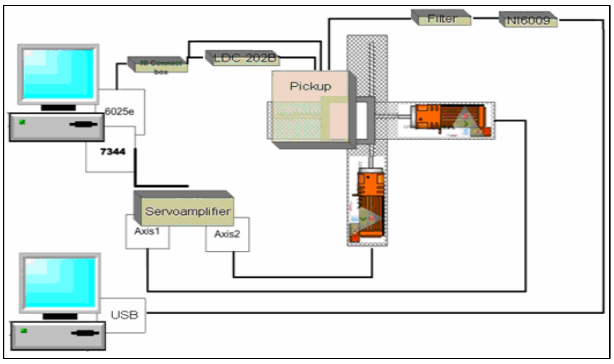

Fig. 3 *Laser lithography setup*

The laser diode used within the setup emits 3 wavelengths (3λLD; Fig.4), from which the 405nm is used to structure the photo resist. To control the focal position of the „writing beam“, the signal of the reflected light of the 650nm laser diode is sent to a computer via an USB Interface.

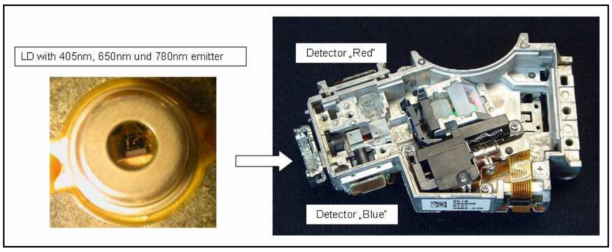

Fig. 4 *Optical unit with 3λ laser diode at the left (Pictures © Leslie Wright / Samuel Goldwasser)*

3 Application and results

A homogeneous, planar and error-free photo-resist layer (Fig.5) is highly important for proper structuring of technical surfaces.

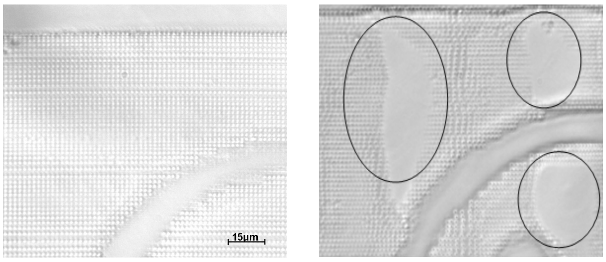

Fig. 5 *Structured photo-resist: left: error-free resist layer; right: faulty photo resist layer*

Errors within the photo resist layer caused by different resist heights are shown in Fig.5. These height differences result in constant distance changes between the resist surface and the focussing lens: Therefore a uniform exposure of the resist is not possible. Fig.6 shows the signal of the 650nm laser diode: A linear increasing unevenness of the resist layer causes a saw tooth signal.

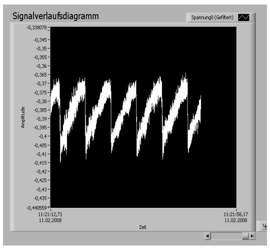

Fig. 6 *Signal response of the 650nm laser diode*

Intention of a control unit is to minimize this effect by adjusting the actuator (voice coil) based on the signal gained by the 650nm diode.

Fig.7 shows structured surfaces: A diffractive optical element (DOE) here: Dammangrating (used to split laser beams) at the left and a section of a computer generated hologram (CGH) at the right.

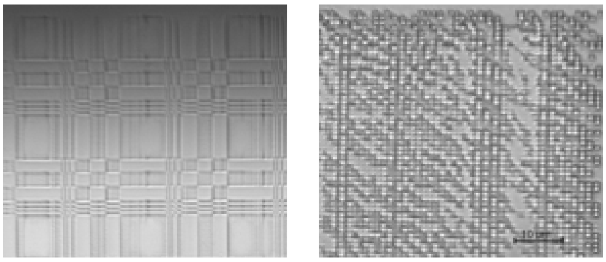

Fig. 7 *Structured photo resist: left: DOE (Dammangrating); right: CGH (used for projection purposes)*

Further development

Near field optical techniques are suitable to bypass the limitation of optical resolution caused by diffraction. By this, smaller structures can be realized. Solid immersion systems make use of the frustrated total internal reflection (FTIR) at a boundary layer. In solid immersion lens (SIL) systems, a hemispherical lens (or a more complex shaped "super hemispherical lens") is placed in front of the focussing lens of the confocal optical unit (see Fig.2) , so that the focal plane of the focussing lens coincides with the planar surface of the SI- lens (Fig.8).

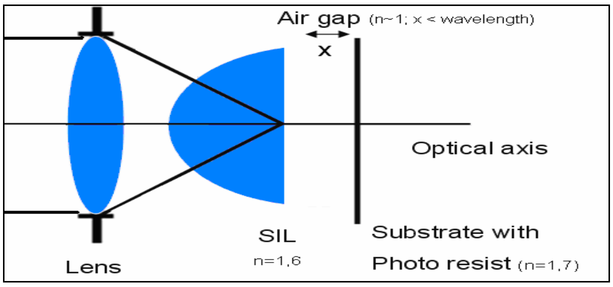

Fig. 8 *Functional scheme of structuring optics with solid immersion lens (SIL)*

If this lens-system is brought close to a surface (air gap/ boundary layer <λ), evanescent waves propagate beyond the boundary layer (Fig.9) [1]. This process is called FTIR and can be used to structure photo resist surfaces with high resolution or, by using information gained by the reflected light, to characterize surfaces and their topographies.

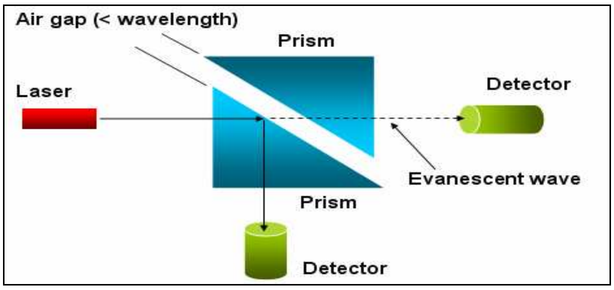

Fig. 9 *Principle of frustrated total internal reflection (FTIR)*

Fig.10 (left) shows an example of a laboratory SI-setup used for data storage realized by Philips N.V. The picture on the right displays a solid immersion lens made out of diamond produced by Element Six Ltd.

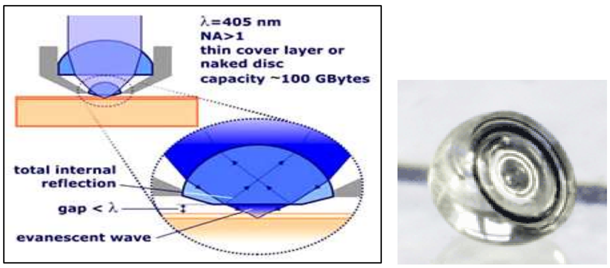

Fig. 10 *Left: SI-lenses for data storage (© Philips N.V); right: Example of SI-lens (© Element Six Ltd.)*

In our running experiments these lens systems are tested for Nano- and microstructuring.

Literature

[1] J.Tominaga, T.Nakano; Optical Near- field Recording (2005)