Wireless potential of India's telecommunications

SEMICONDUCTOR INDIA

Summer 2008 | www.semiconductor-india.com

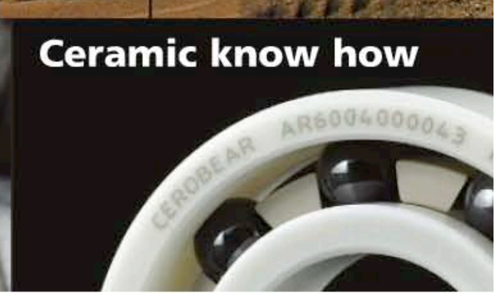
- Understanding realities
- The rising middle class
- ISA's international connections
- University research
- Maskless lithography
- Hope versus reality

Shining towards a new direction

Design start ups

Hybrid business

Ceramic know how



Flexible. Maskless. Answer to all problems?

Conventional photolithography normally requires a physical mask. The disadvantage of such systems could be the materials required. This article looks at flexible maskless photolithography for electronic devices by rapid prototyping. By ***Prabhat K. Dwivedi*** *and* ***Ashutosh Sharma*** *of DST unit on Nanosciences, Department of Chemical Engineering,* ***Indian Institute of Technology*** *and* ***Jay Sasserath*** *and* ***David Fries*** *of* ***Intelligent Micro Patterning*** *discuss how maskless lithography can provide solutions*

A MASKLESS photolithography system will be described that provides the capability for rapid prototyping of micro sized structures for microfludics, optoelectronics, electronic and photonic applications on different substrates using various kinds of photoresists. The system is useful for research purposes in terms of simple, cost effective and fast processing.

Maskless lithography system

The SF-100 ELITE is a simple, easy to use micro patterning system. Through its unique patented design, the system allows user to fabricate micro devices quickly, easily and cost effectively.

Smart Filter Technology provides the means for easy and efficient optical processing utilizing the SF-100. This technique utilises reflective micro opto electro mechanical (MOEM) elements to spatially modulate light such that light can be controlled on the several micron sized regime, simultaneously over a 16mm x11mm field of view. These individual exposures can be stitched together to form a single, large area pattern. Each SF-100 system includes a Smart Filter subassembly that incorporates all of the hardware and control software needed to produce these images in real time.

Figure 1 shows a schematic of the SF-100 ELITE. Designs are drawn using conventional engineering design or drawing programs. These designs are then transferred to the SF-100 host computer for use on the system. The SF100 computer is a standard personal computer that provides dual video output, one to the computer monitor and the other to the Smart Filter subassembly. The Smart Filter then modulates the appropriate MOEM elements, which are used to produce the pattern.

A mercury arc lamp is the source of optical energy for the SF-100. Since g-line (435 nm), h-line (405 nm), and i-line (365 nm) energies are transmitted to the substrate surface, many standard optical materials are compatible with the SF-100. Light energy passes from the lamp to the Smart Filter subassembly through a variety of optical components needed to provide collimated and uniform energy over the entire exposure

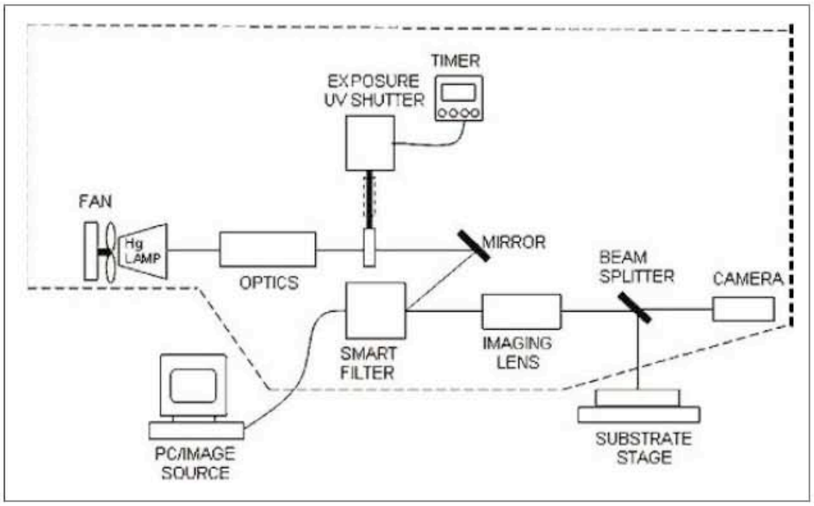


Figure 1-A schematic representation of an SF-100 ELITE Maskless Lithography System

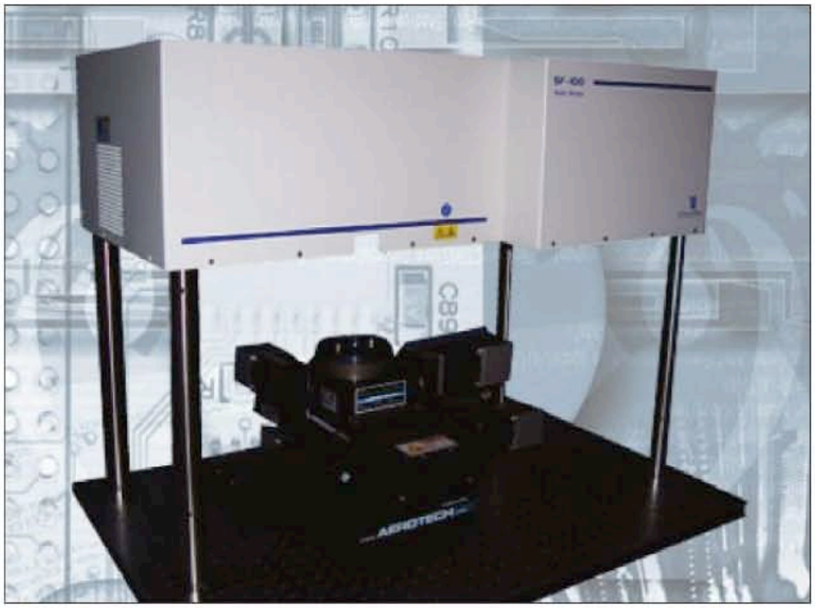


Figure 2-An SF-100 ELITE Maskless Lithography System

area. The light reflects off of the Smart Filter assembly to provide the optical pattern. After passing through additional optical components, the pattern is projected onto the substrate. The SF-100 includes an alignment fixture for mounting of the substrate. This allows the substrate to be moved in three dimensions, providing alignment in two, co-planar dimensions and the capability to produce three dimensional structures by aligning the substrate in a third dimension perpendicular to the two co-planar dimensions. An inline camera is used for feature registration and inspection of the exposed substrate pattern.

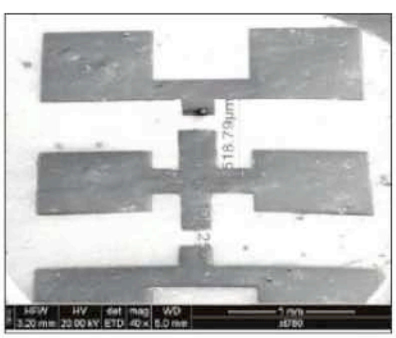
A UV filter shutter is included in the light path to provide for image to substrate alignment. This filter is normally located in the optical path allowing for viewing of the image on the substrate. By filtering all UV energy, the substrate can be aligned to the projected image without exposing the substrate. After the substrate has been placed in the appropriate position, the filter is removed from the light path through computer controlled actuation of the filter. All of the energy from the mercury arc lamp is then projected onto the substrate, facilitating exposure of the substrate. The length of time that the filter is removed from the light path is a user provided setting in the software.

Using this system, a number of different devices have been easily fabricated. The flexibility of the system allows the user to easily change over to different materials, substrates and masks. Examples of rapidly prototyped devices are given below.

Fabrication of electrodes for micro squid

Magnetic nano structures, self assembled or lithographically made, are of great technological importance for small scale devices like dense magnetic memory. However, the properties of material depend on individual feature, magnetic anisotropy of the material and the exact geometry of the features. Among the recent developed techniques for local magnetic measurements of bulk samples or to measure the magnetic response of a single magnetic nano particle, scanning squid microscopy is the most suitable in terms of spatial resolution and sensitivity. To develop such a technique one initially requires fabrication of special nano structures, namely two Josephson Junctions (JJ) in parallel. Large features of these junctions have been fabricated using the maskless lithography system whereas small features of nm size are incorporated using focused ion beam (FIB). Fabricating large features using FIB is not recommended as it takes a long time and energy.

We first design and fabricate the initial pattern using maskless lithography system of dimension of the order of 60 micron and then use the focused ion beam to get nano size features. The maskless lithography system helps us to get a sample ready for the nano-patterning very precisely and accurately. Examples of these devices are shown below in Figure 3.



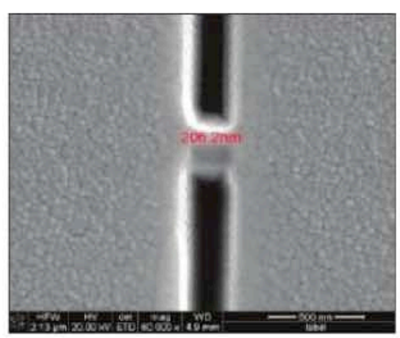
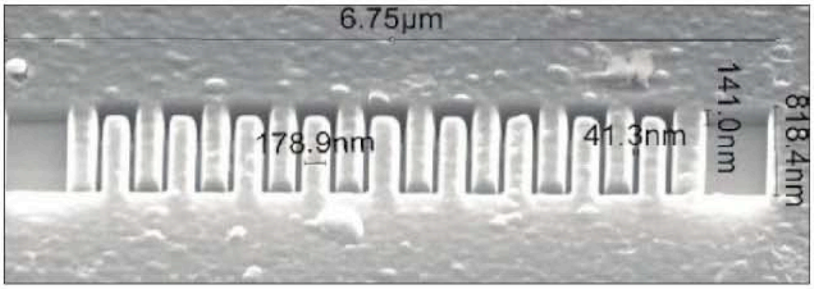


Figure 3-Examples of MicroSquid Devices Fabricated Using FIB and Maskless Photolithography

Fabrication of nano multigate organic TFT

Maskless lithography has been used to fabricate nano electrodes for organic thin film transistors. 15 and 30 micron strips have been created using maskless lithography system, as shown below in Figure 4. FIB is used to make Al nano electrodes within these channels. Fabricated channels are shown in Figure 5.



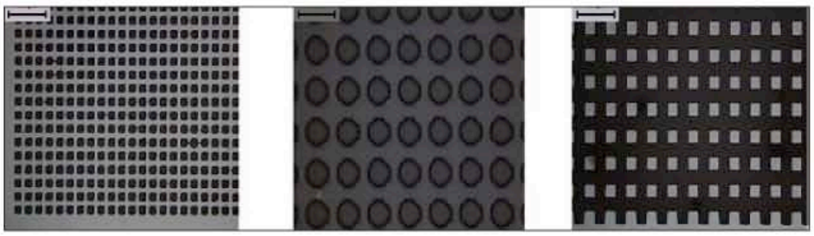


Figure 5-Nano electrode fabricated in 15 micrometer strip initially created by maskless lithography

Development of micro size patterned photoresist surfaces

The maskless photolithography system is being used for making patterns on different negative photoresists, such as SU 8. The minimum feature size that can be patterned by this system is approximately 5 micro metres on these surfaces.

These patterned photo resist surfaces can be used as a master stamp or as a mould for generating other patterned surfaces of different materials and surface structures.

Patterned carbon structures

Another application for our system is to pyrolyse the patterned surfaces of polymers to obtain patterned carbon structures. The maskless lithography system is used to pattern SU-8 negative photoresist in different shapes, such as pillars, channels, and cross channels. These structures are then pyrolysed to provide a carbon rich surface. Applications for these types of devices are wide spread and include microbatteries.

Buckling study of UV exposed patterns

Buckling phenomenon is also being studied by uniform exposure of UV radiation on selective areas of negative photoresist coated films on silicon. By controlling the stress and adhesion in negative photoresist patterned thin films by UV exposure, uniform buckles can be introduced.

By patterned exposure of UV, this phenomenon may also be of use in various applications like fabrication of micro channels for micro fluidics.

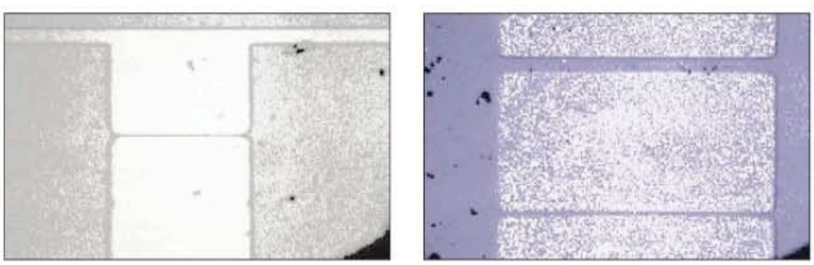


Figure 4-Organic TFT's fabricated using maskless lithography. The left photo shows a 15 um strip, where both 15 and 30 um strips are shown in the right photo.

Summary

Maskless lithography has been shown to be a vital technique in our lab for rapidly prototyping many state of the art electronic and microfluidic devices. Many examples have been shown, where the same system and basic techniques are applied for device fabrication.

These are only a small sampling of the work that has been performed on the system and we expect that the number of applications and uses for maskless photolithography will grow over time.

REFERENCES:

Acknowledgements: The authors acknowledge the financial support provided by the DST Unit on Nanosciences. Also, authors wish to thanks Prof. Y N Mahaptra and Dr. Anjan K Gupta for providing images.