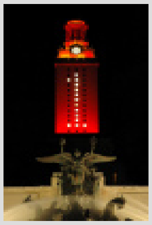
EXHIBIT

DSS-2006



Willson Research Group

The University of Texas at Austin

Immersion Lithography

Introduction

Semiconductor microlithography is the primary process for printing circuit patterns for microelectronic devices. In this process a substrate such as a silicon wafer is coated with a polymer film known as a photoresist. Portions of the film are then exposed to narrow band width UV radiation that is passed through a partially chrome-plated quartz mask and focused with a lens system. This exposure generates a solubility-switching reaction in the photoresist, rendering a portion of the film soluble in an aqueous base developer. When the exposed regions of the film are rendered soluble, the resulting relief is called a positive tone image. When the exposed regions become insoluble, the process is referred to as negative tone. The remaining resist acts as an etch mask while the pattern is transferred into the underlying substrate before being stripped.[1]

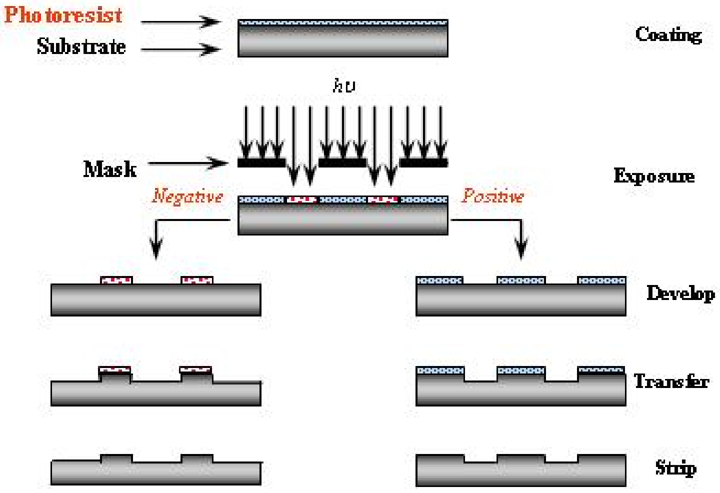


Figure 1

Background

The resolution (R) of the lithographic process is defined by the Rayleigh Equation,

$$R = k \frac{\lambda}{\;} = k \frac{\lambda}{\;}$$

where k_1 is known as the Rayleigh coefficient, λ is the vacuum wavelength of the exposing radiation, n is the index of refraction of the ambient medium through which the exposing radiation is focused,θ is the angular half aperture of the lens and NA stands for the numerical aperture of the lens. [2]

Improvements in lithographic patterning have led to the continual shrinking of device feature sizes and the resulting performance improvements and cost reductions seen in today's electronic devices. These improvements have historically been achieved through the development of new exposure sources with lower wavelengths. Accompanying incremental improvements in the lens system by the reduction of k_1 and the increase of NA through larger q's have also contributed.

Early exposure tools used 436 nm light from the g-line emission of a mercury arc lamp, followed by 365 nm light from its i-line emission. Krypton-fluorine (KrF) excimer lasers then replaced mercury arc lamps for leading edge lithography with 248 nm light, and the state of the art is now argon-fluorine (ArF) lasers producing light at 193 nm.

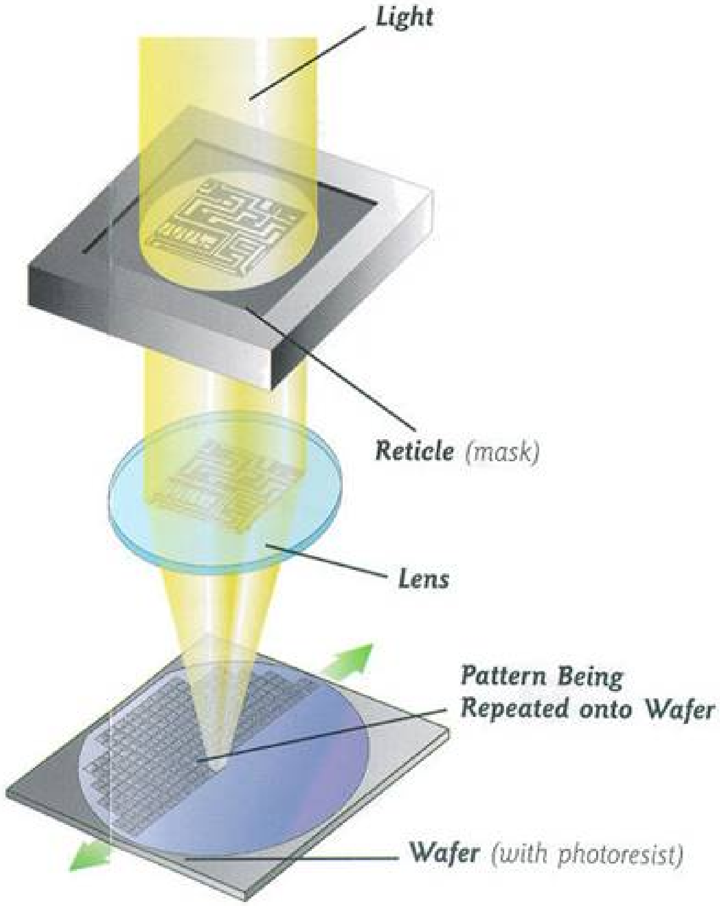


Illustration of exposure through mask and focusing by lens.

With each step down in wavelength, optical systems had to be redesigned and new materials have had to be developed.[3] To move below 193 nm, the development is complicated by the need for completely new materials for the lens systems as well as the photoresist platforms and the necessity for exposure to take place in vacuum. The rising costs of such development has led to the resurrection of a novel lithographic process first proposed in the 1980s called immersion lithography.[4][5][6][7] Immersion lithography with the 193 nm exposure wavelength is now considered the most likely candidate for printing features at 45nm and below.[8]

Continue to Immersion Lithography Theory

References

1. Thompson, L.F.; Willson, C.G.; Bowden, M.J. *Introduction to Microlithography*. American Chemical Society, Washington, DC. 1989.

2. M. Switkes, M. Rothschild, R. R. Kunz, S-Y. Baek, D. Cole, M. Yeung, *Microlithography World* **12(2)**, 4, 2003.

3. Stewart, M.D.; Patterson, K.; Somervell, M.H.; Willson, C.G. *J. Phys. Org. Chem.* 2000; **13**: 767-774.

4. A. Takanashi *et al.*, *US Patent No. 4480910*, 6 Nov. 1984

5. Lin, B. J. *Microelectron. Eng.***1987**, *6*, 31.

6. Kawata, J.; Carter, J. M.; Yen, A.; Smith, H. I. *Microelectron. Eng.* **1989**, *9*, 31.

7. H. Kawata, I. Matsumura, H. Yoshida, K. Murata, *Jpn. J. Appl. Phys.* **31**, 4174, 1992.

8. *International Technology Roadmap for Semiconductors*: http://public.itrs.net/

Version History

Original page created 02/23/06