Laser Array Based Interferometric Lithography

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Interferometric lithography has been demonstrated for making regular or simple patterns of nanostructures such as parallel lines and arrays of holes or posts[1,2]. In the conventional interferometric lithography technology, the interference pattern is generated by two mutually coherent laser beams and recorded in a thin film of photoresist. Complicated two-dimensional (arbitrary) patterns can be fabricated using mechanical control of photoresist or laser and multiple exposures[3]. The ultimate resolution in this technology is equal to half of the wavelength of the light source, which means the critical dimension of the line is limited by $\lambda/4$.

In this work, we propose a new interferometric lithography method using the interference pattern of a synchronized laser array. Fig. 1 shows the schematic of the proposed system. The basic idea of the method is (1) the interference from multiple lasers results in a very sharp and narrow fringes (lines) and thus makes it possible to fabricate the line width smaller than $\lambda/4$ and (2) a synchronized laser array provides a convenient means to add multiple lines by electrically controlling the optical phase of each laser and therefore realizes a dense high-resolution pattern.

Synchronization of a laser array can be achieved using an injection-locking method that locks all lasers to the same frequency of a master laser[4]. In the injection-locking scheme, it has been verified that adjusting the free-running wavelength of each laser can control the optical phase of each laser in the array.

Fig. 2 shows the numerical results of the interference from a 19 synchronized lasers assembled in a one-dimensional array with d=0.5 cm and L=2 cm. A Gaussian beam is assumed for each laser. The upper figure shows the intensity distribution on the photoresist, each curve corresponding to a certain phase difference value. The line width (calculated as the HMFW value of the peak intensity) is about $\lambda/5$. By using a multiple sequential exposure, a high resolution, dense, parallel line pattern can be produced. Details will be reported at the conference.

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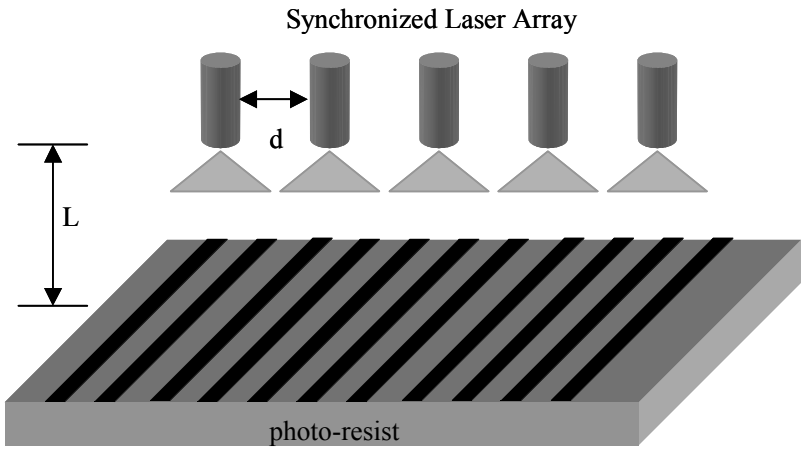

Fig. 1 Schematic of interferometric lithography using synchronized laser array.

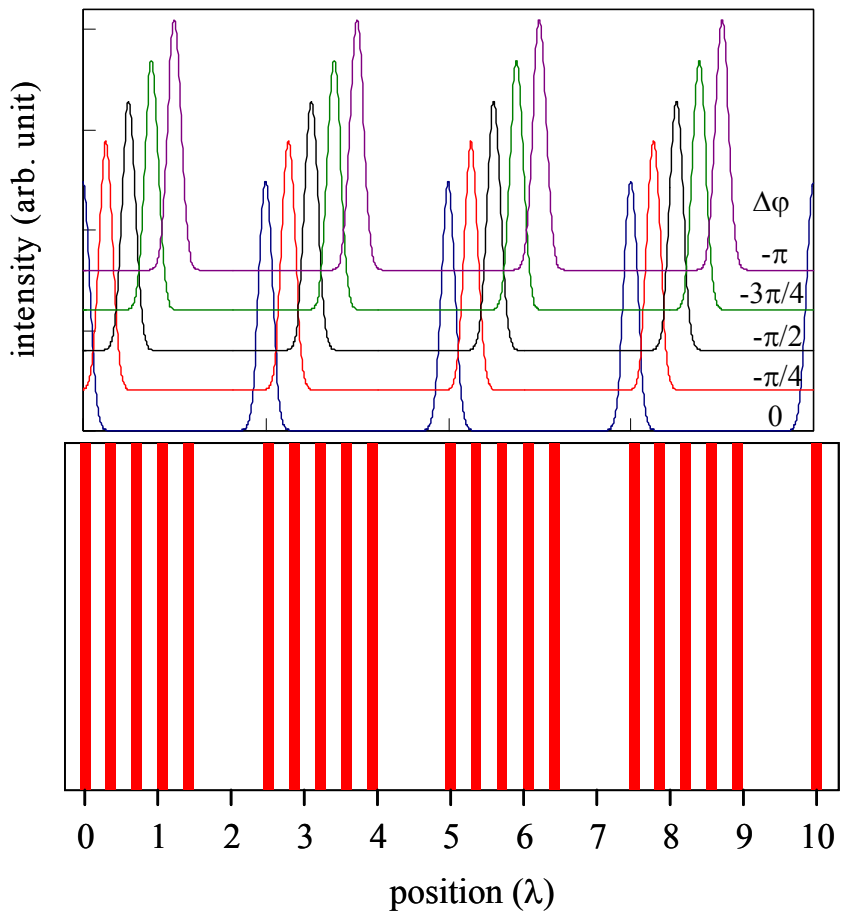

Fig. 2 Numerical results of interference pattern from a synchronized 19-laser array. Upper: intensity distribution on the photoresist; lower: pattern as a result of multiple sequential exposure.