

Advanced high resolution interferometric phase shift technique for microlithography

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Abstract

A novel phase shifting technique that employs a special interferometer and a mask that consists of both transmitting areas and reflective areas will be described. This technique eliminates the need for conventional phase shifting materials.

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Summary

This paper reports simulation and experimental details of a novel phase shifting technique based on interferometry. Phase shifting is one of the most promising techniques [1] for future DRAM fabrication. In recent years, many phase shifting methods have been proposed to extend the resolution limit and the contrast of the image of patterns. These techniques, however, have several problems. The phase shifting elements on the mask need precise placement and exact thickness in order to achieve the desired

amount of phase shifting. Further adjustment becomes impossible once the masks are fabricated. As a result, the manufacturing cost of phase shifting masks is high, and yields are at present quite low. This has slowed the introduction of the phase shift technique into the production line.

Our new technique does not require any phase shifting elements incorporated into the mask, but rather is based upon a special interferometer. A conventional one-layered reticle is used as both a reflective mask and a transmission mask. The incoming laser beam is split into two by a beam splitter. These beams irradiate the mask from both the front and back side via two beam splitters. The reflected and transmitted beams are combined and projected onto the target wafer through a focusing lens. The optical paths of the beams are chosen so that the phase of the two beams is different by an odd multiple of π radians at the surface of the wafer by adjusting the position of the mask. This means that the electric fields of the reflected and transmitted beams have opposite signs and cancel each other at the pattern edges. This method can be particularly useful for short wavelengths, because it becomes increasingly difficult to find appropriate materials for the phase shifting elements.

The new phase shifting method was confirmed first with a He-Ne laser and then with an Ar⁺ laser and a CCD camera system to analyze the image. The focusing lens was a x20 microfocus objective lens that has a numerical aperture of 0.4. For 632.8 nm He-Ne laser light, a feature size of 0.47 μm , or 0.75λ , was achieved with an intensity contrast ratio of 50 %, and a feature size of 0.50 μm or 0.79λ , was achieved with 80 % contrast. For 457 nm Ar⁺ laser light, a feature size of 0.375 μm , or 0.82λ , was achieved with 55 % contrast, and a feature size of 0.425 μm or 0.93λ , was achieved with 80 % contrast. The experimental results match well with

the DEPICT-2 [2] simulation results. A spatial resolution of 0.2 μm should be feasible for 248 nm KrF laser illumination.

References

[1] M. D. Levenson. What is a Phase-Shifting Mask? SPIE Vol. 1496, 10th Annual Symposium on Microlithography, pp. 20-26, 1990.

[2] R. C. Pack and D. A. Bernard. DEPICT-2 Applications for VLSI Technology. Technical report, Technology Modeling Associates, Inc., Palo Alto, CA, 1990.

Figure Caption

Figure 1: Diagram of New Phase Shifting Method.

Figure 2: Interferometric Scheme of the New Phase Shifting Method.

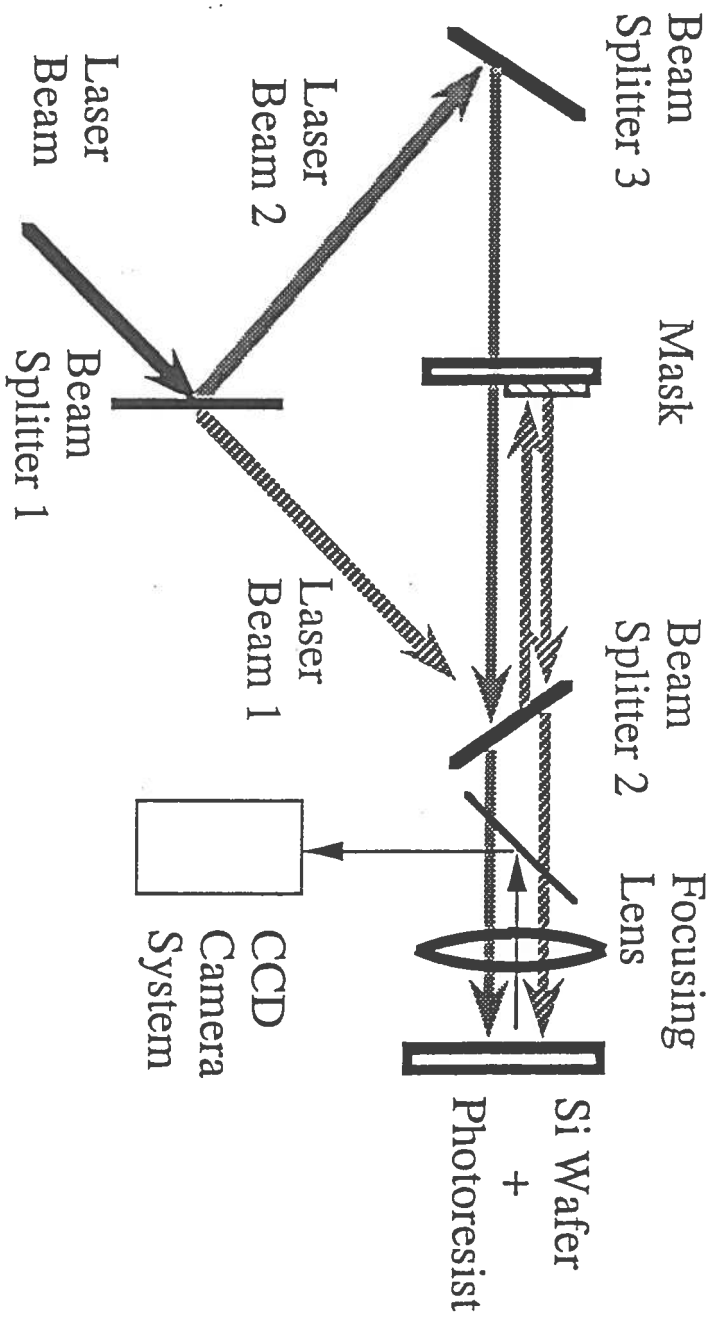


Fig. 1

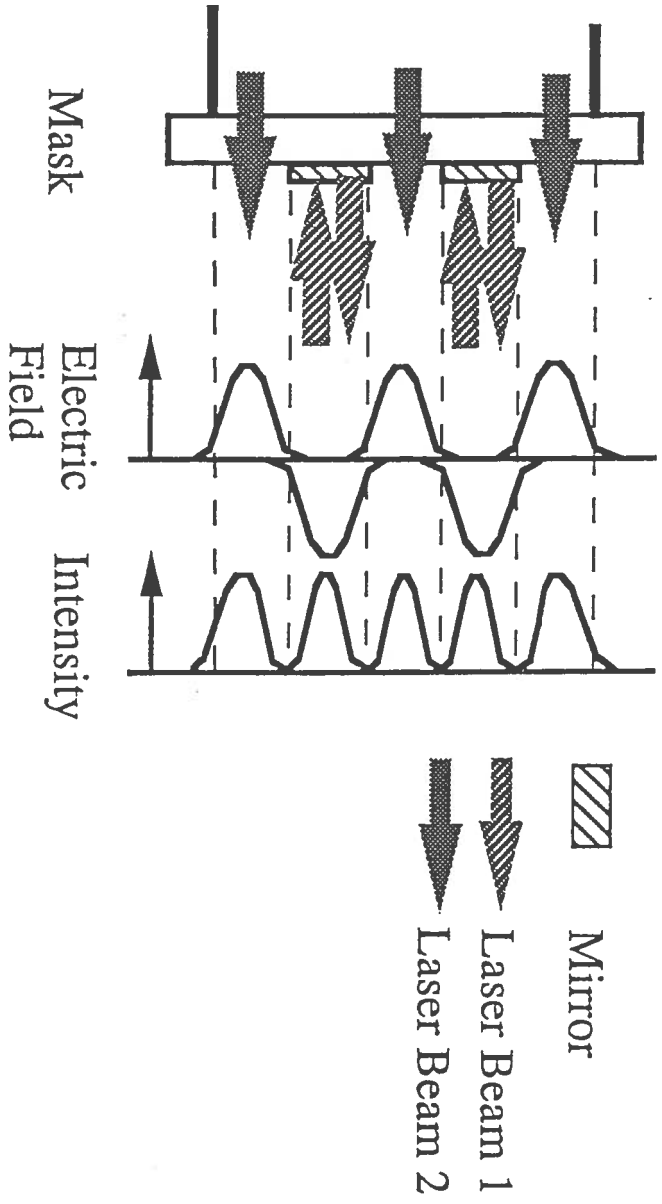


Fig. 2