Synthesis of conventional projection lithography for low k1 via interferometry

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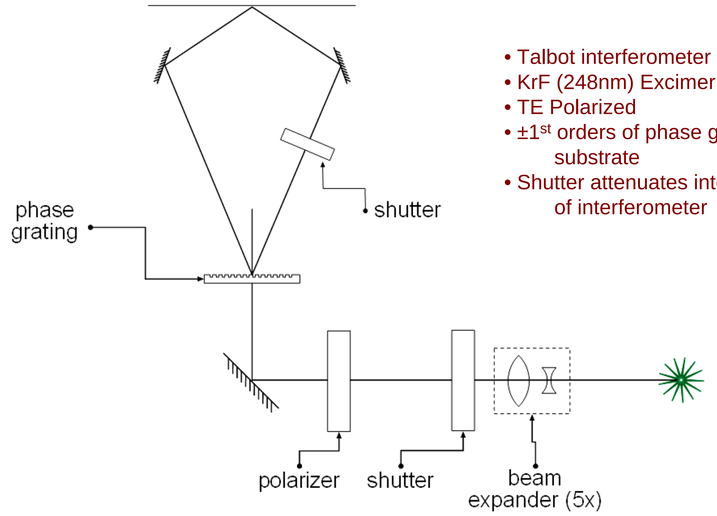
Abstract

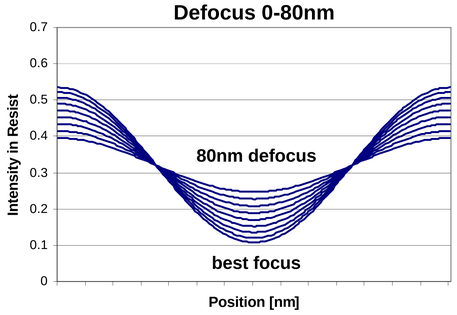
The aerial image attained from an optical projection lithography system is ultimately limited by the frequency information present in the pupil plane of the objective lens. Careful examination of this frequency distribution will allow the operation of such a system to be synthesized experimentally through the use of interferometric lithography. Synthesis is accomplished through single beam attenuation in a two-beam interference system, which is equivalent to adjusting the relative intensities of the primary diffraction orders in a projection system. Typical lithography conditions, such as defocus and partial coherence, can be synthesized inexpensively and efficiently using this technique. The metric of contrast is utilized to assess the level of correlation between various projection lithography configurations and interferometric lithography with single beam attenuation.

Experimental Setup

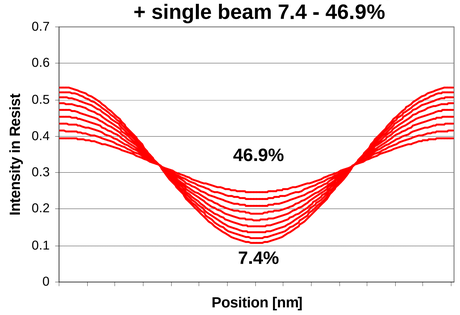


- Talbot interferometer
- KrF (248nm) Excimer laser source
- TE Polarized
- ±1st orders of phase grating interfered at substrate
- Shutter attenuates intensity of one arm of interferometer

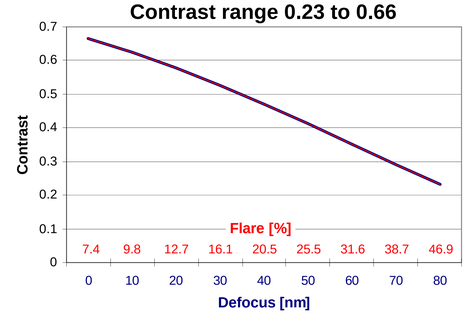
Partially coherent illumination (0.5)
Defocus 0-80nm



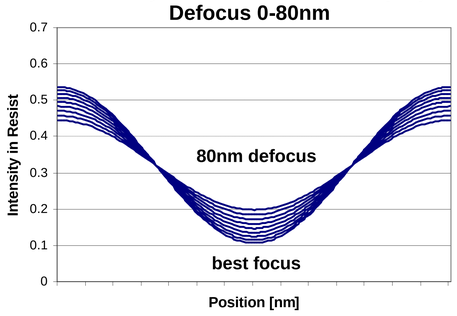
Interferometric Lithography
+ single beam 7.4 - 46.9%



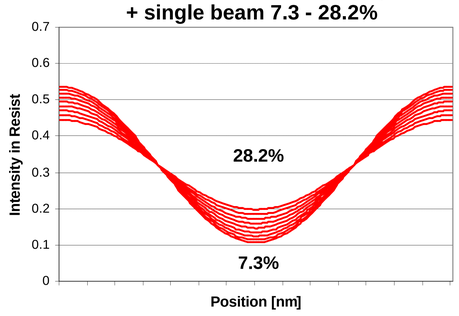
0.5 sigma projection v. IL
Contrast range 0.23 to 0.66



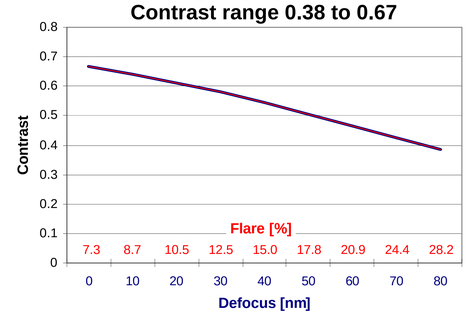
Partially coherent illumination (0.7)
Defocus 0-80nm



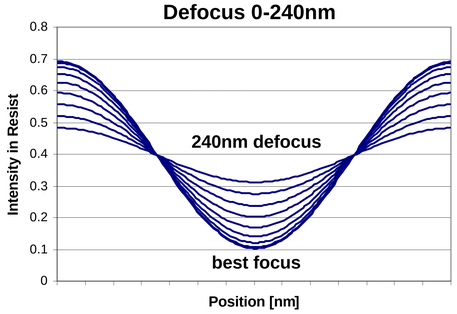
Interferometric Lithography
+ single beam 7.3 - 28.2%



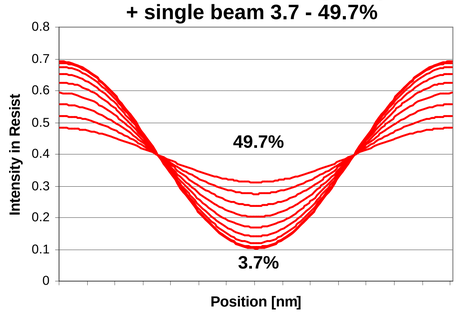
0.7 sigma projection v. IL
Contrast range 0.38 to 0.67



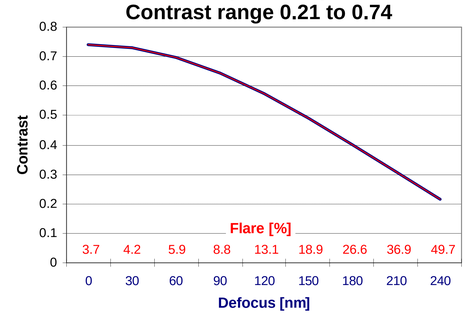
Annular illumination (0.85/0.55)
Defocus 0-240nm



Interferometric Lithography
+ single beam 3.7 - 49.7%

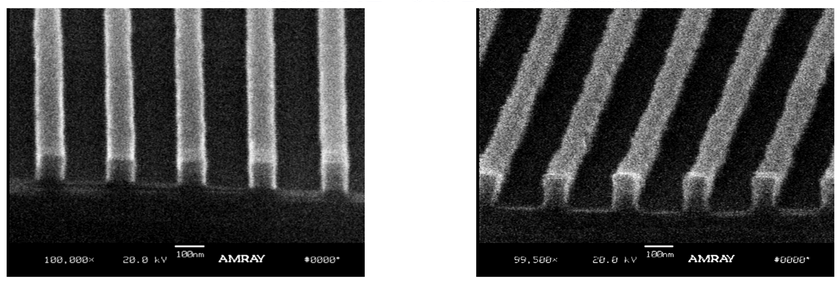


Annular (0.85/0.55) v. IL
Contrast range 0.21 to 0.74



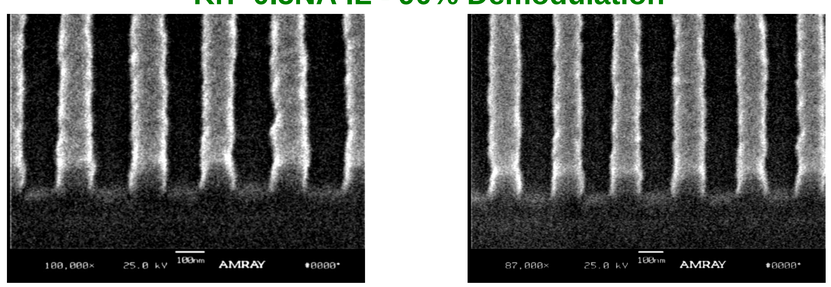
Results

KrF 0.5NA IL - 0% Demodulation



No single beam intensity added
- **straight sidewalls**
- **minor line edge roughness**
- **moderate thickness loss**

KrF 0.5NA IL - 90% Demodulation



90% of exposure is single beam
- **significant rounding at top of profiles**
- **increased level in line edge roughness**
- **high level of thickness loss**