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Line end shortening in CPL mask technology

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Abstract

Various types of line ends have been evaluated for either straight CPL mask or hybrid type builds. The authors will focus on image line end shortening and the impact of through dose and focus performance for very high NA ArF imaging. Simulations on test structures have been calculated along with in photoresist simulations to predict the impact on process window capability. Test structures have been designed and fabricated into a functional test for evaluation. Process evaluations have been completed and exposure-defocus window calculated.

Keywords: CPL; LES; Mask; Imaging

1. Introduction

Each generation of semiconductor device technology drives new and interesting resolution enhancement technologies (RETs). The race to smaller and smaller geometry's has forced device manufacturers to k1s approaching 0.40. The authors have been investigating the use of Chromeless phase-shifting masks (CPL) exposed with ArF, high numerical aperture (NA), and off-axis illumination (OAI). This has been shown to produce production worthy sub-100 nm resist patterns with acceptable overlapped process window across the feature pitch [1,2].

There have been a number of authors who have investigated CPL in the past but the technology has never received mainstream attention. This

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was due to constraints such as wet quartz etch during mask fabrication, limited approach to optical proximity correction (OPC), and exposure tool limitations such as on-axis illumination and too low NA. With novel binary halftone OPC and a capable modern mask making process, it has become possible to achieve global and local pattern optimization of the phase shifter for a given layout especially for patterning features with dimensions at sub-half-exposure wavelength.

2. Experimental

Simulations have been conducted with Prolith 8.03 from KLA-Tencor using imaging conditions with QUASAR™ illumination $\sigma = 0.85o–0.55i$, a numerical aperture of 0.85 and chromeless phase shifted mask designs with numerous variations. The mask was designed within the project team and built by Photronics. The processing experiments where conducted with an ASML TWINSCAN™ AT: 1200, QUASAR illumination, a numerical aperture of 0.85, $\sigma = 0.85o$, $\sigma = 0.55i$ and chromeless phase shifted mask. Wafer processing was conducted on a FSI Polaris 3500. The photoresist employed is TOK Tarf P5068 with a film thickness of 175 nm and Clariant Aquatar-6A Topcoat. All wafer metrology was conducted on a Hitachi 9300 SEM and process window analysis for simulated and experimental data was conducted with Prodata 1.4 from KLA-Tencor.

3. Results and discussion

3.1. Design layout

Fig. 1 is the layout of the three designs used in the study. The first design, "case 20" is the "No Cr" version which contains no chrome on any of the layout which is etched in the quartz to provide a 180° shift in phase. The actual etch depth is 112 nm. The second design, "case 28" contains chrome landing pads in several areas and is high-

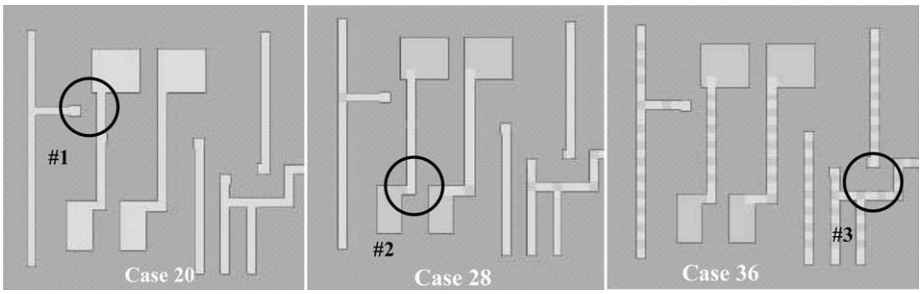

Fig. 1. Three design layouts used.

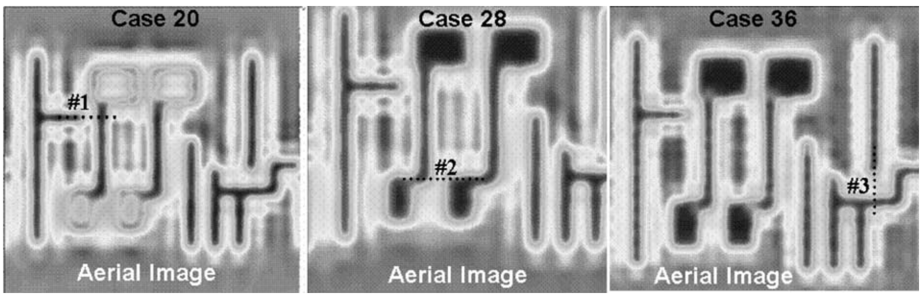

Fig. 2. Aerial image intensity.