Writing Nano-imprint Templates by Shaped E-beam Lithography

Dirk Beyer, Peter Hudek, Olaf Fortagne, Timothy Groves, Juergen Gramss
Leica Microsystems Lithography GmbH, Goeschwitzer Str. 25, D-07745 Jena, Germany
dirk.beyer@leica-microsystems.com
www.semiconation.com

Imprint lithography is nowadays discussed as a promising technique to reduce the costs and at the same time to increase the throughput of contemporary lithography techniques. It is a micro-molding 1X lithographic process, in which the topography of a template patterns the resist on the wafer. In this context the template fabrication process has a lot of similarities to existing e – beam direct writing approaches and can benefit from any progress, which is achieved in both fields of application: e-beam direct writing and mask writing.

The aim of this work is to present initial results on templates written with a commercially available shaped-beam mask-writer and to describe the necessary exposure optimization technique for approaching the required resolution. Recent works using high-resolution Leica VB6 e-beam tools operating at 100kV[1] demonstrated the excellent resolution capabilities of Gaussian beam systems going well beyond the currently required minimum feature size for the 65nm node. If imprint lithography is to be considered as a practical method for the manufacturing of high density ICs, a faster electron beam mask-writer with a high placement accuracy will be essential for the template production. Therefore, the Leica SB350 50keV[2] shaped-beam system was used in our study. Our main focus was directed on large-area 1X templates, which are applicable in Step & Flash Imprint Lithography (S-FIL)[3]. This technique seems to be not limited in its ability to provide precise overlay results. The UV-transparent S-FIL template allows not only the UV-curing of the resist, but also the optical alignment of the wafer and template. As a result, S-FIL appears to be the most suitable imprint technique to fulfill the stringent requirements of silicon IC fabrication[4].

The 1X process exactly replicates the imprint templates making complex OPC structures unnecessary. Our templates were fabricated using the conventional optical phase-shift mask technology with a 15nm thick Cr layer[5] and a thinner layer (180nm) of spin coated ZEP7000 e-beam resist on top. Electron beam lithography using probes of a few nanometer spot – or , as in our case, shape size - has in principle the capability to resolve the required feature size. Practically the resolution is limited by the edge slope of the shape itself**,** by parasitic electron scattering and process blur effects. Based on the inherent high resolution capabilities of the Leica SB350 e-beam tool we developed an efficient and very precise correction method[6] using the software package PROXECCO from PDF Solutions. This procedure allows us to resolve sub 50nm dimensions, which is unique for 50kV shaped beam systems. Taking also a non–linear process into account, well-resolved trenches measuring 33nm and contacts as small as 44nm could be obtained[6,7].

RERERENCES

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FIGURES

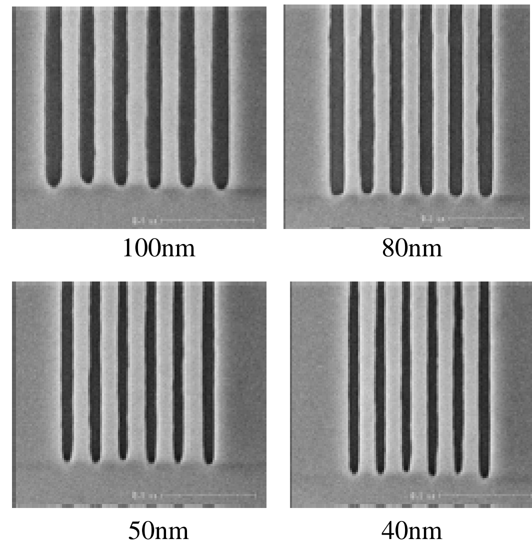

Fig. 1. Final template semi-dense features after etch (line spacing was kept constant at 100nm), with PEC applied, no exposure bias is used.

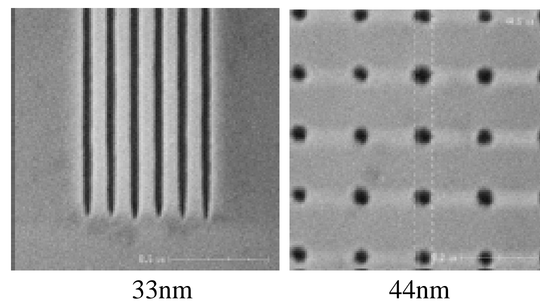

Fig. 2. Minimally resolved final features on the template, 33nm trenches and 44nm contacts.