5keV Ebeam lithography for 16nm half pitch resolution

C. Constancias, B. Dal'Zotto, C, Vannufel, L. Pain
CEA-LETI, MINATEC 17 rue des Martyrs F-38054 GRENOBLE cedex9
christophe.constancias@cea.fr

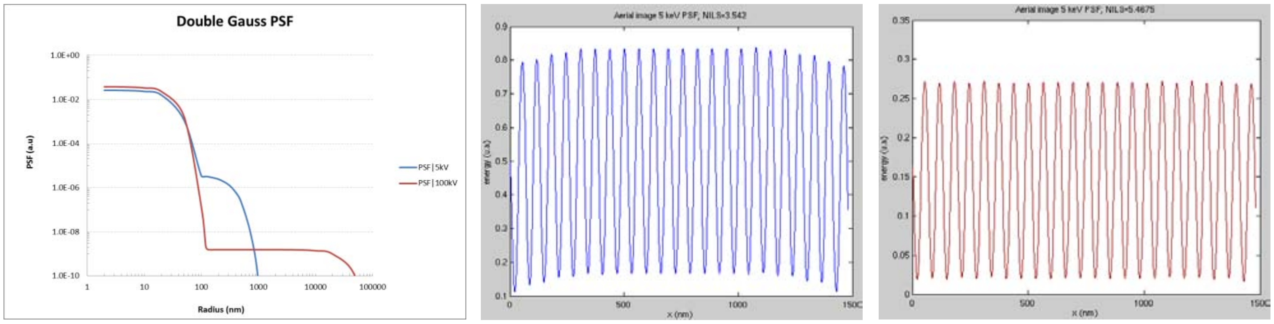
T. Kawamoto*, A. Miyake*
Canon Inc., 23-10 Kiyohara-Kogyodanchi, Utsunomiya city, 321-3298, Japan

The well-known Moore law leads to more and more pressure on lithography tool and processes. The wavelength reduction down to 13.5nm to overcome the diffraction limit, or electron beam (Ebeam) lithography are some of the key proposals for pushing the high density pattern resolution to a few nanometers. But the lithography activity needs tolerance and comfortable process window to get enough uniformity and high yield of production. Especially for high throughput Ebeam lithography at low voltage (5kV), the dose to size critical dimension has to be as small as possible: typically a few tenths of $\mu C/cm^2$, just above the 10% noise to signal ratio due to shot noise.

Today the MAPPER 5keV multibeam tool is designed to achieve 25nm spot size allowing 32nm half pitch patterns to be well resolved with ±10% process windows. 5keV acceleration voltage induces a radius of 300nm of backscattering electron (namely beta), which adds a dose proximity effect and a lower contrast of aerial image compared to 100keV acceleration voltage where beta is 30µm (Figure 1). In this paper we want to consider what should be Ebeam lithography at 5keV to make ultimate resolution, 16nm half pitch and below, available for the next semiconductor nodes?

In order to investigate how the Ebeam lithography process becomes sensitive to the dose control and possible blur, we made dedicated exposures at 100kV,(with a single Gaussian beam UHR VB6), adding artificial blur dose, emulating a contrast degradation into the resist. High density critical dimension (CD) from 32nm half pitch to 20nm half pitch have been exposed with positive chemical amplified resist. The process curves, CD measurement versus Dose, show that only the dose to size the target is impacted by the blur, while exposure latitude (EL), $EL=\Delta CD/\Delta Dose$, remains constant. This artificial blur well controlled at 100 keV with the VB6 allows to emulate the 5keV contrast in order to compare with the 32nm half pitch process curves achieved at 5keV and predict what should be the lithography process to reach 16nmhp well resolved at 5keV.

The research leading to these results has been performed in the frame of the industrial collaborative consortium IMAGINE driven by CEA-LETI.



A) B) C)

Figure 1 : A) Double gaussian PSF for 5kV and 100kV acceleration voltage, B) Aerial image for 5kV 32nm half pitch pattern, Normal Intensity Log Slope NILS=3.54, C) Aerial image for 100kV 32nm half pitch pattern NILS=5.47

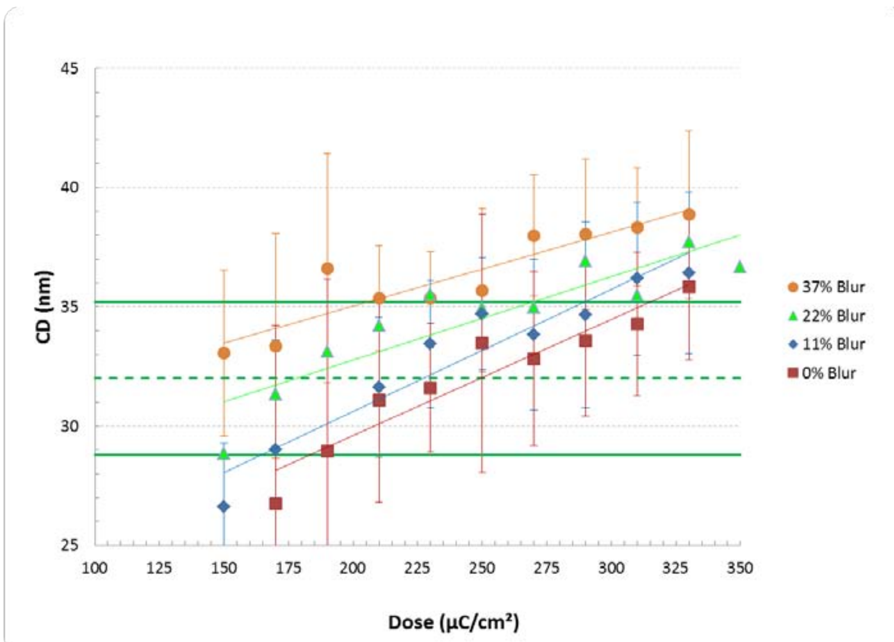


Figure 2: Critical Dimension (CD) versus exposure dose for 32nm half pitch pattern exposed at 100kV with different artificial blur doses.