100 KeV and 50 KeV Electron Beam Nanolithography processes comparison

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Many applications of nanofabrication techniques now require the production of sub-10 nm structures [1]. In this way, nanolithography processes comparison using 100 KeV and 50 KeV electron beam exposure are reported. Results are obtained using LEICA gaussian beam equipments, respectively the 100 KeV VB6 ultra high resolution (UHR) and the 50 KeV VB6 high resolution (HR) models. Comparison are made with organic (Sumitomo NEB22A2) and inorganic resist (HSQ - [2]), both on isolated line for sub 20 nm NMOSFET device application, and dense array of periodic dots for density storage application. We show that resolution for HSQ & Sumitomo NEB22A2 process can be pushed respectively around 10 nm & 40 nm for isolated feature and 20 nm (1:1) & 50 nm (1:3) for periodic dots – figure1.
For the same nanolithography processes, differences in performance at 100 KeV and 50 KeV are due to several factor like the interaction of the beam with the resist and substrate or the beam spot size. Fitting equation 1 with experimental exposure dose enables to obtain a gaussian latent image parameter (σ_{li}) depending on process and equipment - figure 2.

$$f(\sigma_{li}, r) = A(D, \sigma_{li}) \sum_{nf=\frac{Lx}{\Delta x}, mf=\frac{Ly}{\Delta y}} \exp\left(\frac{-(r - n\Delta x - m\Delta y)^2}{2\sigma_{li}^{\,2}}\right)$$

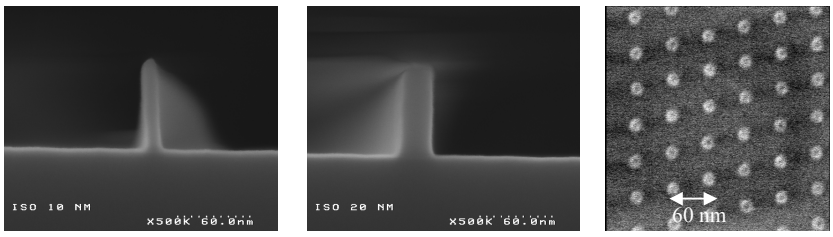
where D is the exposure dose, Δx and Δy the exposure grid in X and Y and Lx, Ly the gate size.
Thus limitation in resolution could be analysed via simulation of latent image energy distribution in resist – figure 3. This parameter, which ranges from 5 nm to 20 nm depending on conditions, enable to better understand nanolithography limitations.
These results open new paths for the realisation of ultimate gate length or high density storage media.

References:

[1] C.Vieu and al, Applied Surface Science 164 (2000) 111-117
[2] H.Namatsu and al., J. Vac. Sci. Technol. B16(1), Jan/Feb 1998

figure 1:

[a] sub-15 nm feature – HSQ @100 KeV
[b] 20 nm feature – HSQ @50 KeV
[c] 20 nm dots (1:3)



[a] [b] [c]

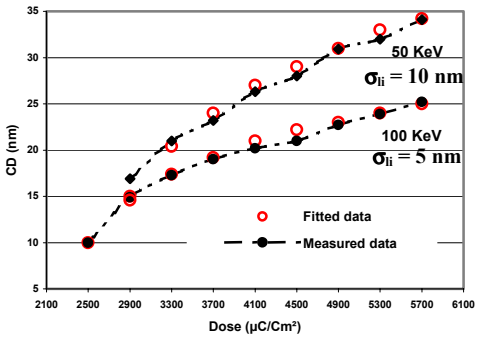


figure 2: determination of gaussian latent image parameter HSQ process at 100 KeV and 50 KeV

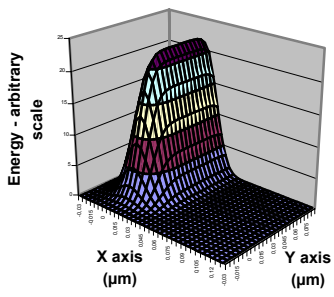


figure 3: Modélisation of 20 nm line, σ_{li}=10 nm, 50 KeV