GISAXS studies of low k dielectrics thin films for ultra large scaled integrated microelectronics

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The increase of the integration density and of the operation speed in ultra large scaled integrated microelectronics requires to reduce the dielectric constant for high frequency insulation between the copper connections of some tenth-of-micrometer thickness. The quality of the dielectric is defined by its dielectric constant k (> 1) relative to the unpolarized vacuum (k = 1). Bulk low k will never reach k lowed than 3 and the only way to achieve further k decrease is to introduce nanopores dielectric films compatible with required mechanical behaviour.

For deposited layers much thicker (~300nm) than the size of the scattering objects (<10nm), GISAXS analysis of the corrected data is the same as the one of SAXS in transmission. GISAXS allows to measure layers deposited on opaque buffers and, due to the grazing angle (above the critical angle, in order that the beam penetrates into the layer), increases the signal in $1/\sin(\alpha_i)$, α_i being the grazing angle, i.e. of ~300. The drawbacks are: i) the measure needs a synchrotron beam (in the present case the anomalous scattering/diffraction beamline, D2AM, at ESRF, ii) due to the shadow oof the sample for α_i in the range 0.1-0.5 degree at 8keV, we are unable to measure scattering object sizes large then ~10nm in the direction perpendicular to the layer. Comparative (or absolute) intensities can only be extracted if the beam monitoring do correspond to the beam impinging the sample: thanks to our 70mm long samples and our 0.1mm beam heigth, all the beam is intercepted by the sample and a correction of the intensities in $1/\sin(\alpha_i)$ give a superimposition of the SAXS patterns for different α_i. We compare the merits and the structure determined of different growth processes, porogen approach, self assembled and PECVD. All of them are baked in order to cure the amorphous $Si_wO_xC_yH_z$ "skeleton" (SiOCH). Depending on the process used, the pore morphologies are very different: they range from well-defined pores of 4-5 nm of diameter, with occasionally a strong anisotropy of the pattern, to sub nanometric ill-defined pores which may be described as density fluctuations. The sizes and volume fraction f_v can be compared to two other techniques: elipsometry-porosimetry and X-ray Reflectivity. Finally, it appears that the curing process is a key problem, which up to now has been difficult to characterize by GISAXS.

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