Different curing strategies to create isolated pores in ultra-low-k thin films

A. G. Attallah[1*], M.O. Liedke[1], N. Koehler[2], M. Butterling[1], E. Hirschmann[1,4], R. Ecke[3],
S. E. Schulz[2,3], R. Krause-Rehberg[3], and A. Wagner[1]

[1] Helmholtz-Zentrum Dresden-Rossendorf, Inst. of Radiation Physics, 01328 Dresden, Germany,
[2]Technische Universität Chemnitz, Center for Microtechnologies, D-09126 Chemnitz, Germany
[3]Fraunhofer ENAS, Technology-Campus 3, 09126 Chemnitz, Germany
[4]Martin-Luther-University Halle-Wittenberg, Department of Physics, D-06099 Halle, Germany

A slow annealing ramp (10 K/min.) during thermal curing of spin-on ultra-low-k (ULK) thin films generates enlargement of the pore size as a function of curing temperature. This phenomenon suggests porogen agglomeration during curing, which forms larger and linked pores extended up to the film surface as a consequence. Such a pore linking would likely increase the k value due to moisture or other impurities absorption and possibly could lower the mechanical stability. We propose to vary the curing ramping time up to the optimum curing temperature of 450 °C in order to immobilize porogen molecules and hinder their clustering, hence to prevent the creation of interconnected (open) pores. As a probe of porosity positron annihilation lifetime spectroscopy (MePS [1]) and Doppler broadening positron annihilation spectroscopy (AIDA [2]) have been utilized and results of different curing slow ramps (10-40K / min.) and for the so-called rapid curing (without any intentional ramp) will be shown. In Fig. 1 the annihilation line shape parameters S and W, and the 3γ/2γ ratio for the rapid and in-situ slow (10 K / min.) curing is presented. A smaller value of S and a wider plateau of W for positron energies below 6 keV for the rapid curing case suggest smaller pore size and different pore wall chemistry as well as more homogenous pore distribution, respectively. The latter is reflected in the 3γ/2γ ratio as the increased o-Ps escape probability for the rapid cured film.

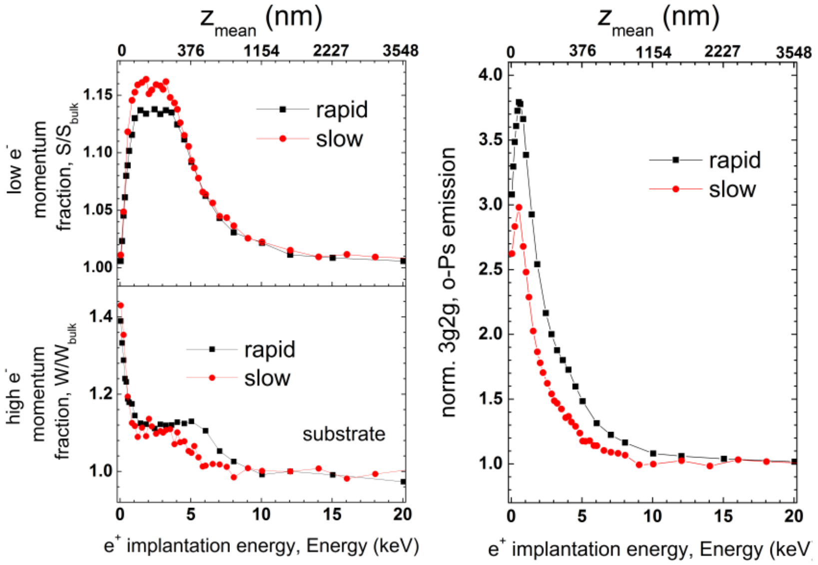

Figure 1 *Normalized S and W-parameters and* 3γ/2γ *for the rapid and slow cured ULK films.*

References

[1] A. Wagner, et al., *Journal of Physics: Conference Series* **791**, 012004 (2017).
[2] M. O. Liedke, et al., *Journal of Applied Physics* **117**, 163908 (2015).

[*]Corresponding author, Email: a.elsherif@hzdr.de