Towards faster growth of hybrid films by spatial molecular layer deposition

Hardik Jain[1], Fieke van den Bruele[1], Paul Poodt[1]

Holst Center/TNO, High Tech Campus 31, 5656 AE Eindhoven, The Netherlands (hardik.jain@tno.nl)

Hybrid films are gaining importance due to their attractive ability of inheriting the properties of their organic and in-organic precursors in a single film. So far, most of the research on such films has been conducted on temporal ALD setups. We want to extend spatial Atomic Layer Deposition toolbox to Molecular Layer Deposition (MLD). In order to be able to make spatial-MLD possible at an industrial scale, we use an Alucone system of Trimethyl Aluminum (TMA) and p-Aminophenol (PAP) as a model to study the process kinetics of a spatial MLD process.

The hybrid films were grown at atmospheric pressure by a S-MLD rotary setup built at TNO, Eindhoven [1]. The effects of substrate temperature and p-Aminophenol's vapor pressure have been used to investigate the MLD process window for this Alucone system. The films' thicknesses and refractive indices were characterized ex-situ by Spectroscopic Ellipsometry.

At a low substrate temperature of 100 °C [fig.1], the process GPC grows linearly with exposure time and shows no signs of saturation thereby indicating multilayer physisorption. Further investigations at higher substrate temperatures and lower vapor pressures of PAP show a decrease in the contributions from physisorption and chemisorption and we finally report a saturating GPC of ~0.12 nm/cycle [fig.2] with little to no physisorption. We have modified a previously formulated Langmuir isotherm based mathematical model [2] with a linear term to account for physisorption and have used it to examine our results.

[1] P. Poodt, D.C. Cameron, E. Dickey, S.M. George, V. Kuznetsov, G.N. Parsons, F. Roozeboom, G. Sundaram, A. Vermeer, J. Vac. Sci. Technol. A. 30(1) (2012) 010802
[2] P. Poodt, J. van Lieshout, A. Illiberi, R. Knaapen, F. Roozeboom, A. van Asten, J. Vac. Sci. Technol. A. 31(1) (2013) 01A108
[3] F. Yang, J. Brede, H. Ablat, M. Abadia, L. Zhang, C. Rogero, S.D. Elliott, M. Knez, Adv. Mater. Interfaces 4(18) (2017) 1700237

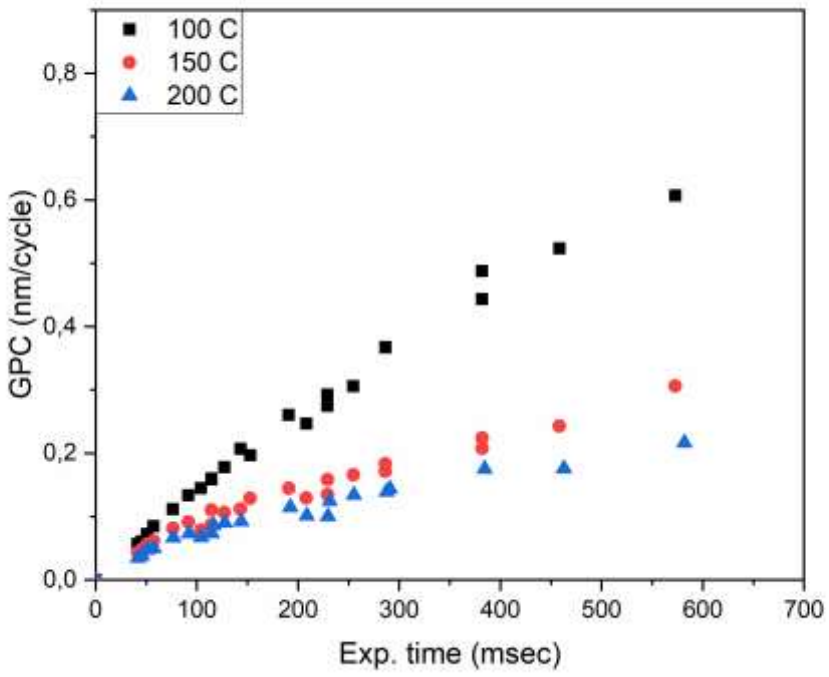

Figure 1. GPC Vs Exposure time curves at p-Aminophenol temperature of 100 °C. The linear behavior at substrate temperature of 100 °C indicates the presence of physisorption with no signs of saturation. The one at 200 °C shows traits of saturating behavior.

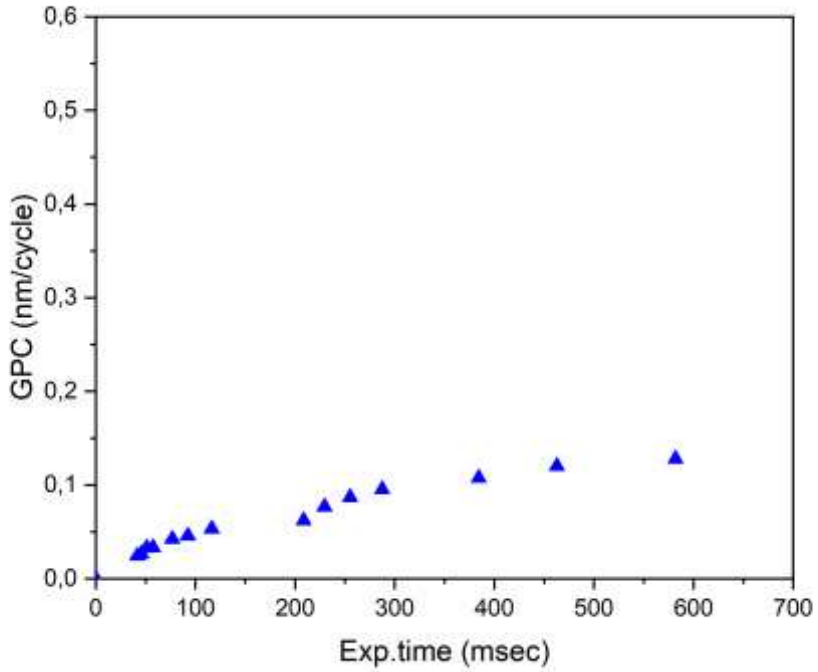

Figure 2. GPC Vs Exposure time curve at a p-Aminophenol temperature of 90 °C and substrate temperature of 200 °C. The curve appears to saturate at a value of ~0.12 nm/cycle.