Novel calixarene-based UV-sensitive photoresist for evanescent near-field optical lithography

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A molecular glass photoresist based upon a calixarene-melamine structure has been developed. The resist is a chemically amplified, negative tone, photo-resist and consists of a modified calix[4]resorcinarene molecule, a hexakis(methoxy-methyl)melamine (HMMM) crosslinker and a commercially available Hg I-line sensitive photoacid generator (Irgacure PAG103). Propylene glycol methyl ether acetate (PGMEA) has been used as resist solvent, having both good solubility of resist constituents and an evaporation rate that yields good spin-characteristics.

Calixarene-based resists have been shown to have a very high resolution potential when used for electron-beam lithography [1]. Development of this resist was undertaken with the intended purpose of investigating the hypothesis that resolution limitations of commercially available UV-resists may have a detrimental impact upon evanescent near-field optical lithography results achieved up to this point [2,3].

Development of this resist has focused on three main issues: the ratio of calixarene to HMMM; PAG content; and spin-coating – thickness and conformity. The calixarene to HMMM ratio is crucial in regards to lithographical performance since it affects both the sensitivity and resolution of the resist. For resists with relatively high HMMM content resolution is compromised, while for resists with lower HMMM contents the clearance dose increases (see Figure 1(a)). Film thicknesses between 50 and 300 nm have been observed depending upon solid content (4-10 wt%) and spin-speed (1000-5000 RPM).

This photoresist has been demonstrated to achieve sub-micron resolution while retaining low line-edge roughness (LER). Resolution tests were performed using a Lloyd's Mirror interference lithography (IL) setup powered by a 325 nm He-Cd laser. Using this setup, half-pitch line gratings with periods in the order of 250 nm and low LER (3σ ≈ 19 nm) were achieved. Figure 1(b) shows a scanning electron micrograph of a half-pitch grating with a period of ~240 nm. This resist had a calixarene : HMMM ratio of 1:0.74 and a PAG : solid content ratio of 1:21.

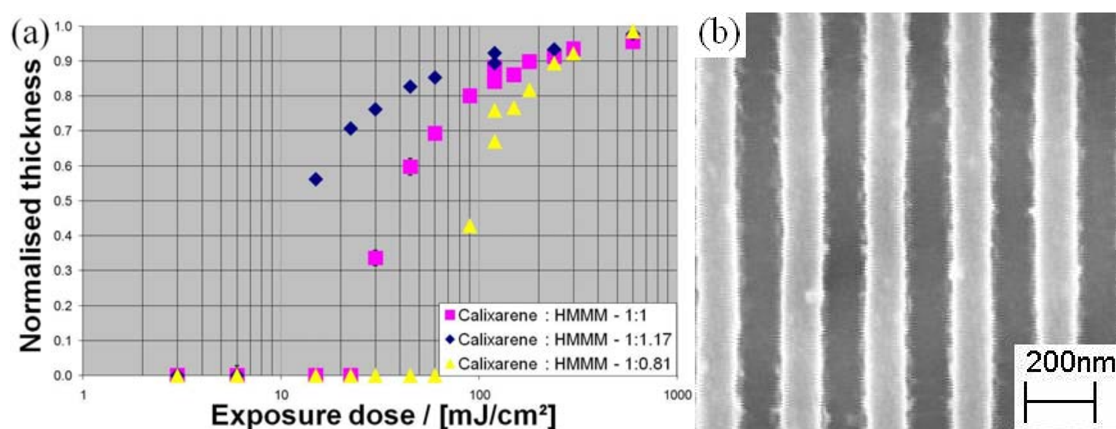

Figure 1: (a) Dose curves for three different photoresists with varying calixarene to HMMM ratios. (b) IL defined half-pitch grating with a pitch of ~240 nm in a calixarene resist. Calixarene : HMMM – 1:0.74, PAG : Solid content – 1:21, peak dose of 1.9 J/cm².

[1] Manako, S. et. Al, JVST B **18** 6, 3424-3247, 2000.
[2] M Schøler, RJ Blaikie, J. Opt. A, **11** 10, 105503, 2009.
[3] M Schøler, RJ Blaikie, Microelec. Eng., **87** 5-8, 887-889, 2009.