

Dissolution optimization of highly etch-resistant, anthracene-based molecular resists

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The functionalization of anthracene and other polycarbocycles has been proposed by our group as a promising route towards the development of highly etch-resistant molecular resist materials for low LER sub 50 nm lithography [1]. Resist formulations based on such components have been tested with EUV interference lithography and promising LER performance has been demonstrated [2]. In addition simulation studies [3] have shown that indeed certain molecular architectures are expected to provide ultimately high resolution, low LER materials with distinct advantages if compared with linear polymers.

Nevertheless, molecular resists are not yet optimized with respect to both formulation and processing requirements and for this reason their performance is usually inferior to that of polymeric resists. Towards this end the understanding and optimization of molecular resists behaviour in critical processing steps such as development is of great importance.

In the present paper we report dissolution studies of chemically amplified resist materials based on functionalized anthracene molecular components for film thicknesses suitable for 32nm patterning. A fast dissolution rate monitor (DRM) based on White Light Reflectance Spectroscopy is employed in order to determine *in-situ* the resist film thickness loss during dissolution in standard TMAH 0.26N developers. First results are promising as it is shown in Figs. 1,2. Dark loss is negligible (fig. 1) for dissolution times (100sec) significantly longer than the lithographically useful ones. The PEB effect on the dissolution properties is shown in fig. 2 for various exposure doses.

The change in the dissolution rate of such molecular resist films could be also simulated along with their LER behavior using stochastic modeling of the lithographic process [4]. Fig. 3a,b shows the stochastic modeling approach for two resist materials (M21, M17) in 2D while in Figs. 3c,d, the possible conformations of M21, and M17 are illustrated. Lattices of such molecular entities are created taking into account excluded volume effects and assuming less than 5% free volume. Fig. 4 a,b shows a sample 2D development profile of a 200nm wide trench for these two materials and Fig. 4c, the corresponding thickness loss curve vs. dissolution cycles. The difference in the curves will be studied in terms of the molecular resist architecture and surface evolution and line-edge roughness data will be presented.

[1] D.Niakoula, P.Argitis, I.Raptis, E.Gogolides, V.P.Vidali, D.R.Gautam, E.A.Couladouros, W.Yueh, J. Roberts, R. Meagley, EUVL Symp. 2005, San Diego, USA. ; MNE 2005, Austria.

[2] C.Vannuffel, D.Djian, S.Tedesco, D.Niakoula, P.Argitis, et.al. Proc. SPIE 6519 651949(2007)

[3] A.Yamaguchi, H.Fukuda, T.Arai, J.Yamamoto, et.al J. Vac. Sci. Technolol. B23, 2711(2005)

[4] D.Drygiannakis, G.P.Patsis, I.Raptis, D.Niakoula, et.al Microelectron. Eng. 84 1062(2007)

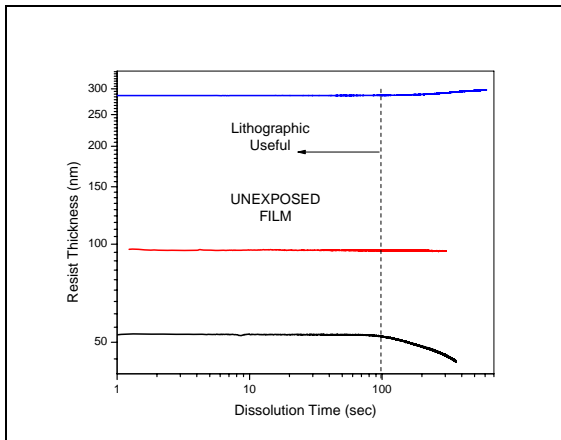


Fig. 1: Film thickness loss (dark loss) for a wide initial film thickness range.

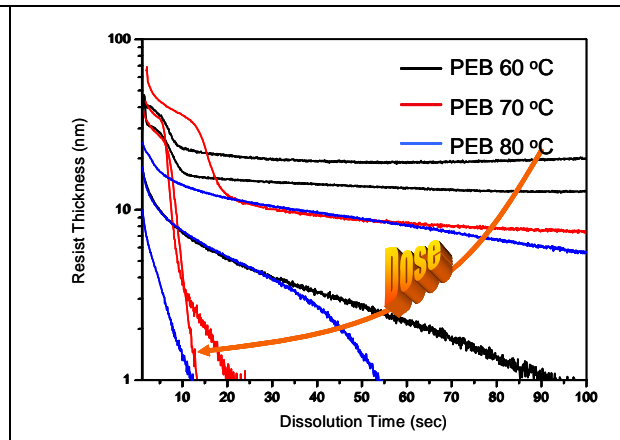


Fig. 2: Effect of PEB temperature on the dissolution of 100nm thick films for increasing exposure dose (as indicated by the arrow). The PEB time was kept constant at 60sec.

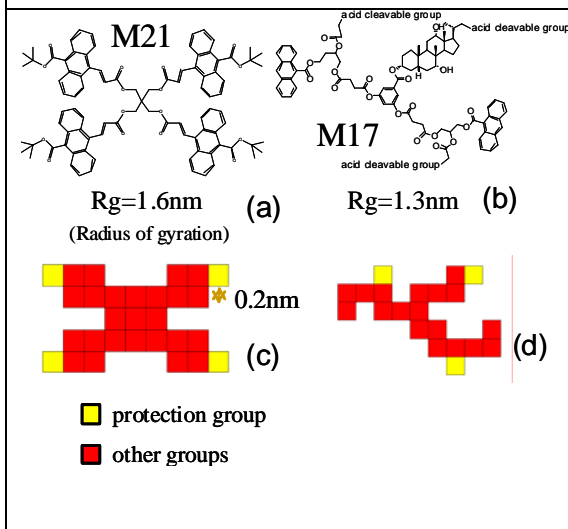


Fig. 3: Representations of the main components for two anthracene-based molecular resists used for the simulation.

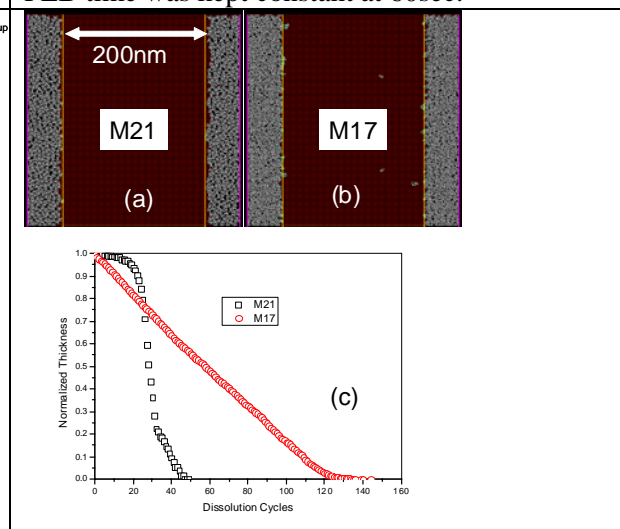


Fig. 4: a, b) Cross section of the simulated resist profiles for the two molecular resists studied c) Dynamic dissolution behavior for the two resists.