Selective Laser Ablation in Resists and Block Copolymers for High Resolution Lithographic Patterning

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Previously, we demonstrated an all dry, selective laser ablation development in methyl acetoxy calixarene (MAC6) which produced high resolution, high aspect ratio features not achievable with wet development.[1,2] In this paper, we investigate selective ablation in block copolymer systems. This offers an alternative to block removal using plasma etching when selectivity cannot be achieved.

We use a 532 nm CW laser (spot size ~600 nm and power density 2-4 MW/cm^2) and scan over block copolymer patterns of polyhydroxystyrene-*b*-polystyrene (PHOST-PS) and poly2vinylpyridine-*b*-polystyrene (PHOST-P2VP). Optical absorption contrast promotes ablation of the higher absorbing regions over the overall non-absorbing regions (polystyrene). Unlike direct write laser ablation, the final pattern resolution is determined by the size of the chemical patterns and not the laser spot size. For instance, in electron beam lithography of MAC6, the 10-20 nm e-beam exposed regions ablate in the 600 nm spot size laser producing aspect ratios up to 4:1 in 15 nm half-pitch patterns whereas in the BCP systems, the block sizes determines the ablated pattern resolution. We study in detail the ablation characteristics of the BCP materials function of laser power using Raman spectroscopy. For the ablated materials, we identify a multi-photon ablation mechanism.

Figure 1 shows integrated fluorescence vs. time and power for pure PHOST, P2VP, PS and the calixarene system we studied previously. The onset of fluorescence corresponds to the onset of laser ablation. Plotting the fluorescence data vs. time data we find each process has a multi-photon contribution. This non-linearity in the onset of fluorescence in the power vs. time plots (transition from black to colored feature for constant power). Processes dependent on heat would be linear with power. Selectivity to PS is implied due to very long delays in ablation onset.

Figure 2 shows the selective ablation of PHOST over PS in an aligned block-copolymer of 46 nm pitch. The alignment material, SU-8 ablates as well. Studies of smaller pitch systems indicate incomplete segregation which hinders ablation.In the PVP-*b*-PS system we study systems at 21 nm pitch. PVP has longer ablation delays relative to PHOST so selectivity is more difficult to achieve. The mechanisms of laser ablation in the different systems will be discussed.

[1] Oteyza, D. G. d.; Perera, P. N.; Schmidt, M.; Falch, M.; Dhuey, S. D.; Harteneck, B. D.; Schwartzberg, A. M.; Schuck, P. J.; Cabrini, S.; Olynick, D. L., Sub-20 nm laser ablation for lithographic dry development. *Nanotechnology* **2012,** *23* (18), 185301.

[2] Perera, P. N., et al. (2012). Selective laser ablation of radiation exposed methyl acetoxy calix(6)arene. *J. Vac. Sci. Technol. B.* 2012, 30 (6), 06FI02-1

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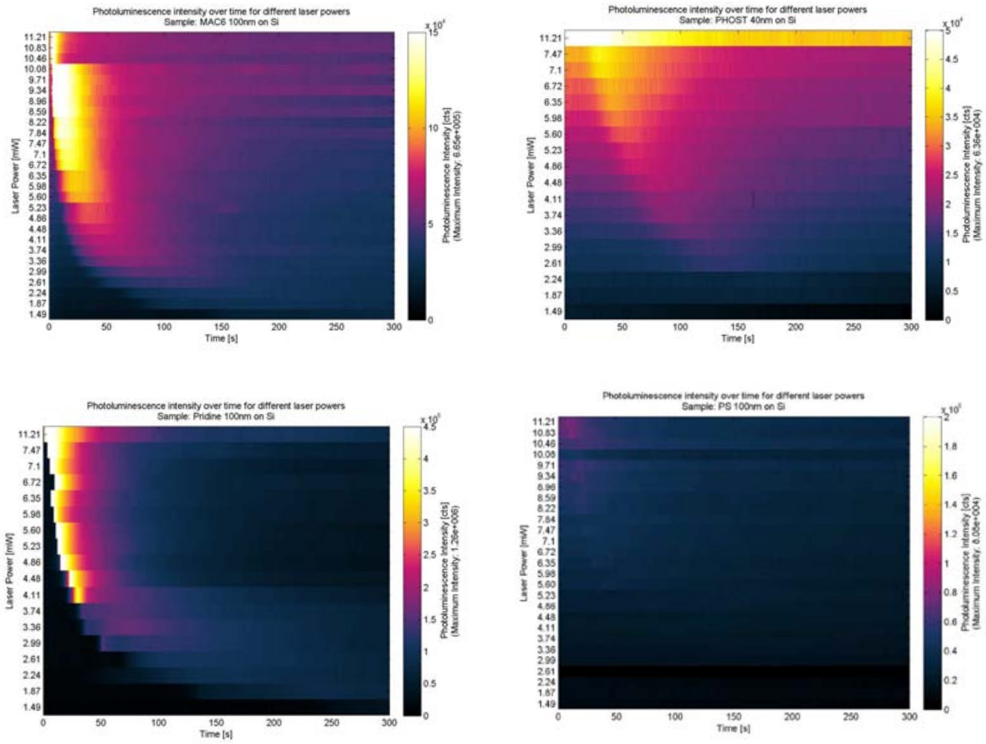

igure 1: Fluorescence **signal intensity as a function of power vs. time for 4 materials. The**

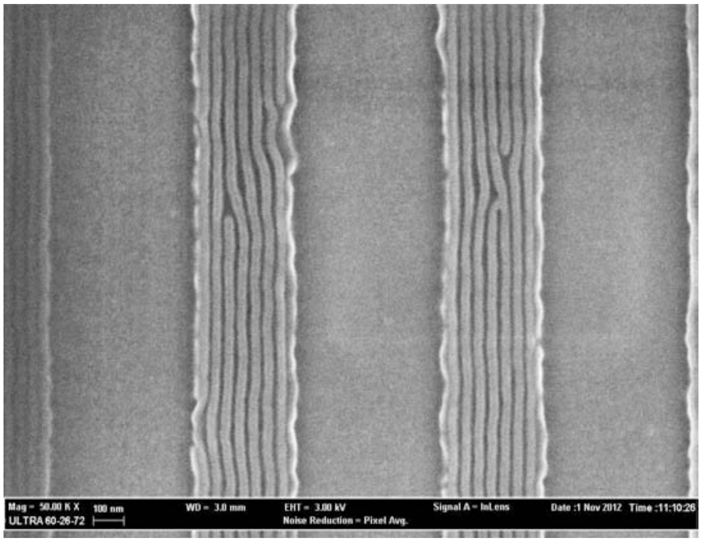

Figure 2. SEM image showing PS patterns after ablation of PHOST and SU-8 guiding polymer.