Photopatternable Inorganic Hardmask

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We present here a directly photopatternable inorganic hardmask for 193 nm lithography. This resist is based on the solution-deposited dielectric HafSOx [1], which has previously been reported to be a high-performance, high-sensitivity electron beam resist [2]. HafSOx resists exhibit a number of desirable characteristics for use in electron beam lithography such as high resolution and low LER (Figure 1). HafSOx resists have the added advantages of exceptional etch resistance, (demonstrated by an etch selectivity over Si > 160 under a RIE process using SF_6 plasma), and high sensitivity, where doses as low as 8 $\mu C/cm^2$ (30 keV) have been realized.

In light of these promising electron-beam results, we have extended our investigation of HafSOx resists as hardmasks directly patterned by 193-nm lithography. By tuning its composition, we have achieved a remarkably high index of 2.0 at 193 nm, thereby providing additional process latitude relative to conventional photoresists. The result is a high contrast, negative tone resist that operates in an optimal thickness range of 20 to 40 nm. Initial 193-nm exposures using interference lithography have yielded 60-nm lines and spaces (Figure 2). The platform's demonstrated resolution with e-beam exposure strongly suggests its extendibility to 32 nm.

The HafSOx platform is also differentiated from other inorganic resists on the basis of its amorphous nature and chemical inertness, allowing it to function directly as a hard mask with high-fidelity pattern transfer. We have further demonstrated the ability to build multilayer films by simply depositing subsequent coats on annealed HafSOx base layers without forming interfaces between coats. This capability enables the use of HafSOx resists in double patterning techniques such as litho-freeze, litho-etch processes, where a second resist layer is deposited on a developed resist underlayer.

[1] J.T. Anderson, C.L. Munsee, C.M. Hung, T.M. Phung, G.S. Herman, D.C. Johnson, J.F. Wager and D.A. Keszler, Adv. Funct. Mater, 17 (2007) 2117-2124

[2] J. Stowers and D.A. Keszler, Microelectronic Engineering, 86 (2009) 730-733

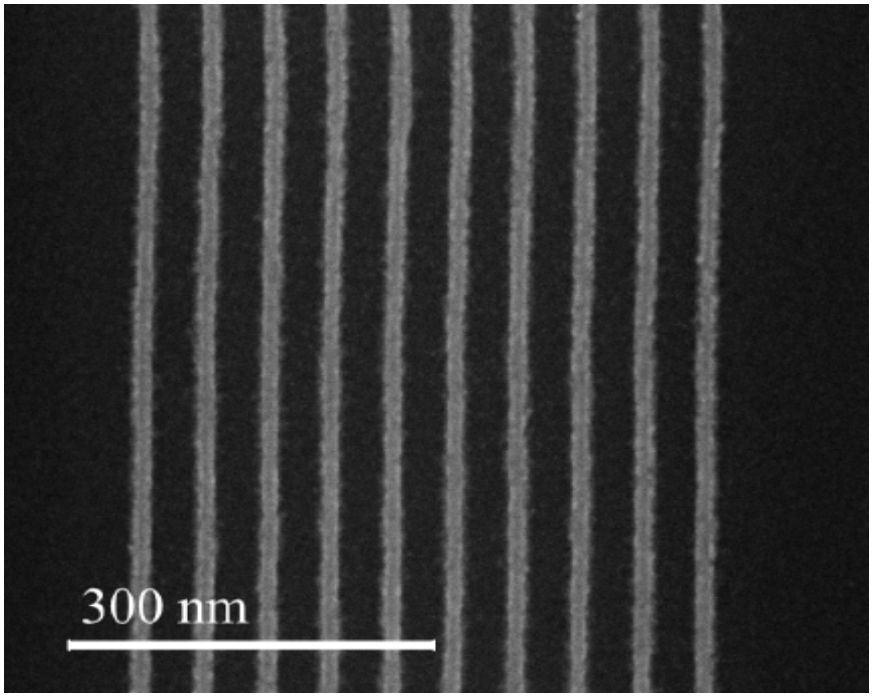

Figure 1: SEM image of 15 nm lines on a 50 nm pitch by electron beam lithography, LWR = 3.4 nm

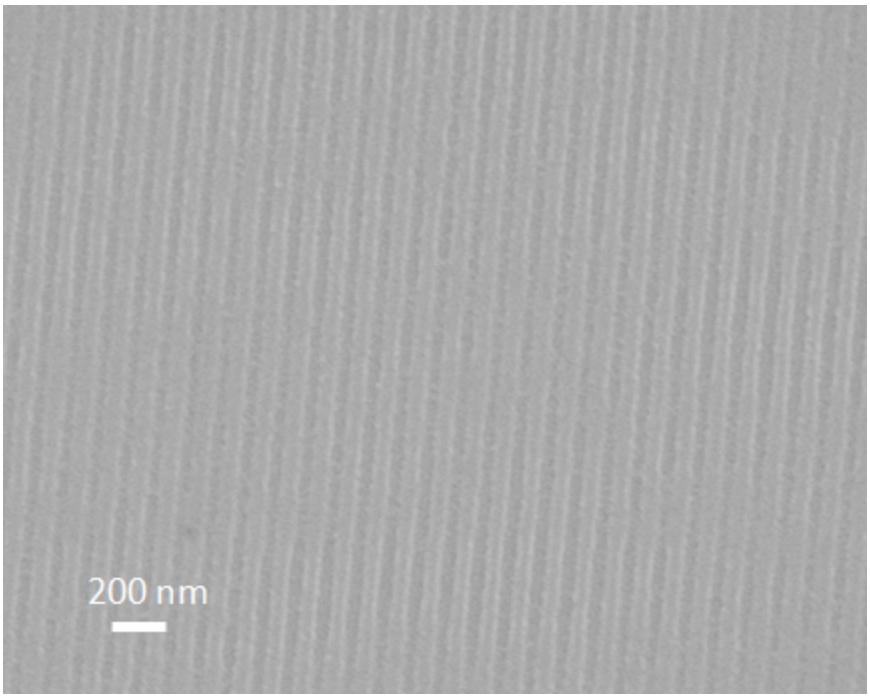

Figure 2: SEM image of 60 nm half-pitch features at a dose of 21 mJ/cm^2.