TBAH-based Developer Solutions in Extreme Ultra Violet Lithography

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At present, extreme ultraviolet (EUV) resist sensitivity and resolution limits continue to be improved but line width roughness (LWR) and pattern collapse remains as issues.[1] As a possible solution, the use of alternative developer solutions has been reported.[2] Here, the feasibility of tetrabutylammonium hydroxide (TBAH) developer was demonstrated. A 20% LWR improvement was obtained with the TBAH developer solution compared with the standard tetramethylammonium hydroxide (TMAH) developer solution. It is also noteworthy that the application of the TBAH developer significantly reduces pattern collapse for half pitch (hp) 25nm patterns and below.[3]

In this paper, recent work on TBAH-based developer solutions with the application of additives is presented. Figure 1 shows the TBAH-based developer solutions with polyoxyethylene alkyl ether (C_nE_m) surface active agent, or surfactant, utilized as additive in these initial experiments. Figure 2 shows the hp 35nm and hp 32nm imaging results utilizing these TBAH-based developers. EUV lithographic exposures were made using the small field exposure tool (SFET) with annular (σ_{outer} 0.7/σ_{inner} 0.3) illumination conditions. Figure 3 shows the LWR analysis results. A significant improvement (15%) in LWR was obtained using the TBAH+C_nE_m (HLB: 15.3) developer solution (LWR: 8.1nm at hp 32nm) in comparison with the TBAH developer without surfactant (LWR: 9.6nm at hp 32nm). These initial results show the effectiveness of surfactants applied with the TBAH developer solution for reducing LWR.

In the conference, the effect of various additives on the TBAH-based developer process, through detailed analysis of dissolution characteristics, will be presented.

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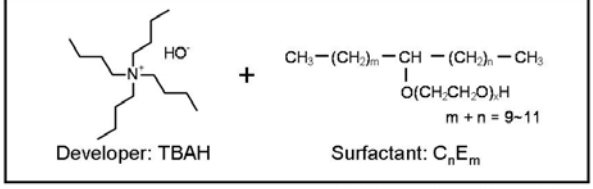
[1] S. Sivakumar, *presented at* the International EUVL Symposium (2009).

[2] T. Itani and J.J. Santillan, J. Vac. Sci. Technol. B27 (6), (2009) 2986-2989.

[3] K. Matsunaga, et al, *presented at* the International EUVL Symposium (2009).

	Developer + Surfactant	HLB
1	0.26N TBAH + none	--
2	0.26N TBAH + 0.1% C_nE_m	14.5
3	0.26N TBAH + 0.1% C_nE_m	15.3



TBAH: Tetrabutylammonium hydroxide
CnEm: Polyoxyethylene alkyl ethers
HLB: Hydrophile-lipophile balance

Fig. 1. The TBAH-based developer solutions with C_nE_m surfactant utilized as additive.

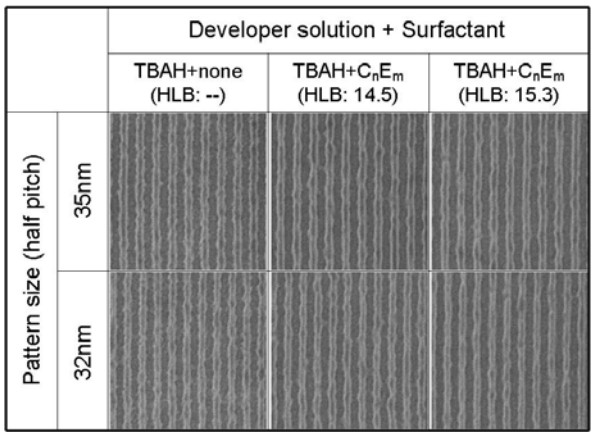


Fig. 2. The hp 35nm and hp 32nm imaging results utilizing the TBAH-based developers (lithographic exposures made using the SFET).

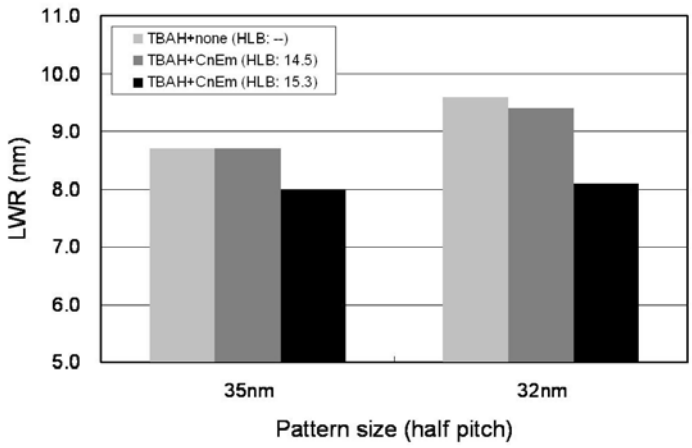


Fig. 3. The LWR analysis results utilizing the TBAH-based developers.