

Influence of Additives on Etch Rates and Morphology at Silicon Substrates in HF-HNO₃-CH₃COOH Solutions

Masami Shibata, Kouta Fukasawa and Nagakazu Furuya
Department of Applied Chemistry,
University of Yamanashi
4-3 Takeda, Kofu, 400-8511 Japan

The HF-HNO₃-CH₃COOH etching systems¹ are the mostly widely used isotropic etchant for silicon². The etch rates in the etchants and the morphology of Si surface after etching depend on the composition of the etchant. In this work, the influence of the additives, KCl, KBr and KI, on the etch rates and the morphology of silicon substrates was investigated.

The substrates used were n-Si(111) wafers (resistivity 18-27 Ωcm). The solutions consisting of HF (50 wt%), HNO₃ (61 wt%), and CH₃COOH (98.8 wt%) = 80 : 5 : 15 containing various concentration of KCl, KBr and KI were prepared as an etchant. The etching of n-Si(111) substrates was performed for 1min at 298K. The n-Si(111) wafers were rinsed with ultra pure water, and dried with nitrogen gas. The thickness for the etching was calculated from the decrease of mass of the silicon substrate after the etching. The silicon surfaces after the etching were observed with FE-SEM, DFM, AES, and XPS.

Fig. 1 shows the correlation between the concentration of additives and the etch rates. The etch rates in the etchants containing 10^{-2}M KCl and 10^{-2}M KBr are as same as that without the additives. Silicon is hardly etched in the etchants containing 10^{-1}M KCl and 10^{-1}M KBr. On the other hand, the etch rate in the etchant containing 10^{-1}M KI is as same as that without the additives.

The value of roughness (Ra) measured with DFM (Tapping mode AFM) at Si substrate before etching is 0.39 nm. After etching in the etchant without the additives, the value of Ra is 45.8 nm at the surface. Fig. 2 shows the correlation between the concentration of additives and the values of Ra. The Si surface prepared in the etchants with $>10^{-4}$M KI, $>10^{-3}$M KBr and $>10^{-2}$M KCl is flatter than that without additives. The values of Ra after etching in the etchants containing 10^{-1}M KCl, KBr and KI are 3.42, 1.68 and 2.03 nm, respectively. Though the etch rate in the etchant containing 10^{-1}M KI is as same as that without additives, the surface prepared in the etchants with 10^{-1}M KI, is flatter than that without additives.

References

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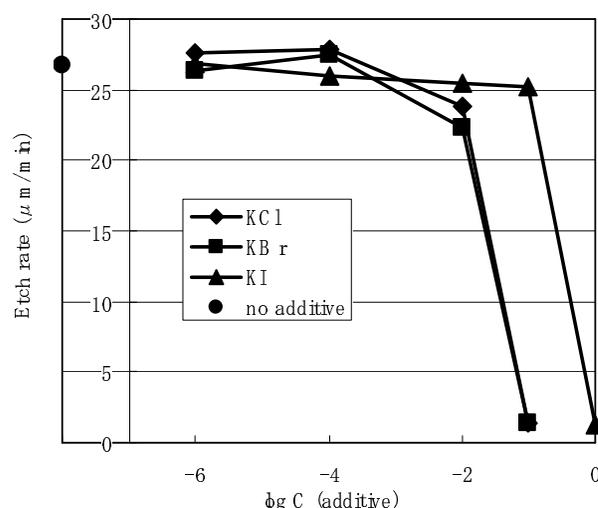


Fig. 1

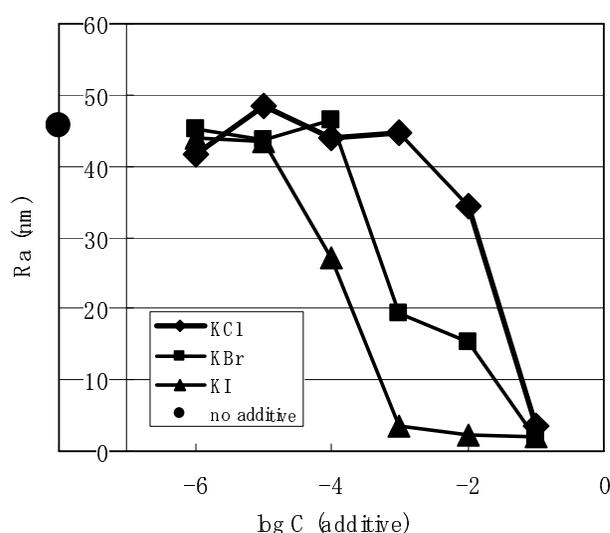


Fig. 2