

AQM H-SiO_x/HSQ Developers

The wet etching of HSQ uses aqueous solutions of hydroxide containing salts, such as tetramethylammonium hydroxide (TMAH) and sodium hydroxide (NaOH). These aqueous solutions are known as developers.

TMAH or TMAOH

TMAH is a quaternary ammonium salt with the molecular formula $N(CH_3)_4^+ OH^-$. It is a solid commonly dissolved in ultrapure water to concentrations ranging from 1 to 25 %. TMAH dissolves unexposed and underdosed HSQ at 20 to 95 °C. Temperatures greater than 95 °C result in the thermal decomposition of TMAH and concentration change due to evaporation.

HSQ is commonly deposited on silicon substrates/wafers, which commonly have a (100) or (111) orientation. Both orientations undergo anisotropic etching in TMAH. The etching rate of silicon increases with temperature and changing TMAH concentrations. The roughness of a (100) silicon surface increases with decreasing TMAH concentration and longer etching time. The etch rate of (100) silicon ranges from ~0.3 to 1.4 $\mu\text{m}/\text{min}$, while the etch rate of (111) silicon is below 0.1 $\mu\text{m}/\text{min}$.

Substrates for long etches in TMAH include silicon nitride (negligible etch rate in TMAH) and silicon dioxide (etch rate of ~0.1 nm/minute).

“Salty” Developer

The developer commonly referred to as “Salty” developer, discovered by Yang and Berggren¹, contains NaOH and table salt (NaCl). Development of HSQ in “Salty” developer results in a higher contrast (γ) but lower sensitivity (higher dose required) than TMAH. Several salt combinations and concentrations were examined, the optimal containing 1 wt% NaOH and 4 wt% NaCl, which offers an outstanding γ value (> 10) for high resolution and high-density patterning of structures with less than 10 nm pitch structures.²

Purchasing

AQM formulated TMAH can be customized to standard solutions of 1 to 25% concentrations and purchased in 1 L bottles. Salty developers can be customized to several salt concentrations.

References

1. Yang, J. K. W.; Berggren, K. K., Using high-contrast salty development of hydrogen silsesquioxane for sub-10-nm half-pitch lithography. *J. Vac. Sci. Technol. B.* **2007**, 25 (6), 2025-2029.
2. Nam, S.-W.; Rooks, M. J.; Yang, J. K. W.; Berggren, K. K.; Kim, H.-M.; Lee, M.-H.; Kim, K.-B.; Sim, J. H.; Yoon, D. Y., Contrast enhancement behavior of hydrogen silsesquioxane in a salty developer. *J. Vac. Sci. Technol. B.* **2009**, 27 (6), 2635-2639.