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Mechanism of Si and metal etching based on sticking reaction model

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Plasma etching technique has been wildly used in the fabrication of LSI device. With shrinking the device size, it is required to reduce CD shift and under-cutting as well as to improve uniformity in etching process. In development of etching apparatus and process, it has been necessary to understand the mechanism of the cause of CD shift. The CD shift and etching rate is determined by the reaction of incident species (ions, radicals), and surface materials. However, their mechanisms of the surface reactions are not explained quantitatively, although a portion of them was understood clearly. We proposed the mechanism taking a sticking reaction model on a wafer surface because the reaction is one of the key factors to determine the etching rate and CD shift. Because the surface reaction depends on the surface condition and temperature, the sticking coefficient S is formulated approximately as a function of them, $S = \alpha[1-\{1-(1-\theta)[1-(1-P_r)^{n/L}]\}^L]$, where α is the trapping coefficients, n and L is the vibration times and migration times until desorbing from the trapping state (physical adsorption), P_r is the chemical reaction probability from the state, and θ is the ratio of inactive site (coverage). n, L, P_r are functions of the surface temperature and potential energy barrier. In addition this equation can be expanded to chemical reactions. CD shift δCD is also formulated by assuming the taper angle determined by the balance of deposition and ion etching, $\delta CD = 2h \cot \cos^{-1}(R_d/Y\Gamma_{ion})$, where h is the film thickness, R_d is the deposition rate, $Y\Gamma_{ion}$ is the sputtering rate of deposited film. By using these two equations, we have studied the mechanism of CD shift in Al etching and undercutting in Si etching. It was confirmed that temperature dependence of them are explained. In addition, by comparing the CD shift equation with another one based on the statistical analysis, it was found that RIE-lag was a factor of CD shift in gate etching.