# PHYSICAL ANALYSIS AND MODELING OF PLASMA ETCHING MECHANISM FOR ULSI APPLICATION

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Due to the miniaturization and high integration of a semiconductor device, development cost increases. Therefore, many researchers challenge to develop the simulation technology for reducing the number of experimental trials and the development period. Device simulation with a physical model and process simulations, such as impurity diffusion, have been utilized for developing process and devices. However, the topography simulation used to predict the profile of plasma etching or deposition is not used for developing process. We developed practical RIE (Reactive Ion Etching) topography simulation which is integrating the plasma simulation with the surface reaction model. This topography simulation could reproduce RIE profile correctly, and it was shown that it is effective in developing and optimizing RIE process.

As shown in Fig.1, the plasma generated by applying RF power is used for RIE. An ion, an electron and a radical in a plasma are transported to the etched material surface by diffusion, and etching progresses according to a chemical reaction. Since this RIE process is complicated, it is difficult to design a model. RIE topography simulation was realized by integrating the plasma simulation with the surface reaction model.

The flow of plasma simulation is shown in Fig. 2. Poisson’s equation was solved in order to determine the electric-field distribution in a reaction chamber. The electron which received energy from the electric field collide with the gas molecule. By using the collision cross section data of the gas, the distribution and quantity of electrons, ions, and radicals are calculated. Next, the etching model of $SiO_2$ is shown in Fig.3. The radicals adsorb to the thin-film surface, and form a reactive layer and a polymer layer. The etching process advances by removal of the polymer layer and reactive layer by the radicals and the physical energy of the ion. Based on the ion energy, a formula for determining the rate of removal of the polymer or reactive layer was derived and incorporated in the model.

The RIE topography simulation result of the $SiO_2$ film is shown in Fig.4. It was found that it is in good agreement with a cross-sectional SEM image. By changing the flow rate of the gas, the bowing form and the phenomenon of stopping an etching process can be reproduced by simulation.

By integrating plasma simulation with the surface reaction model, the etching profile was reproduced. It is considered that this topography simulation is effective to develop and optimize RIE process.

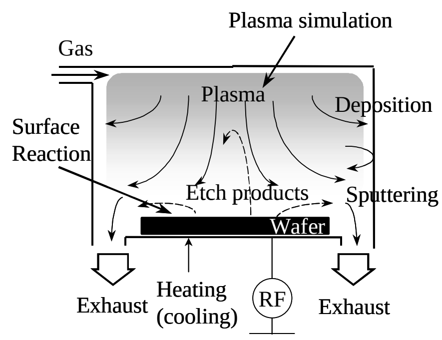


Fig.1 Outline of RIE process

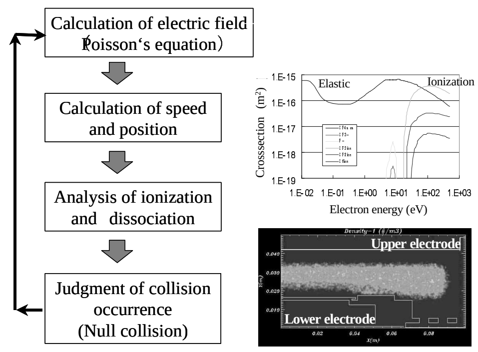


Fig.2 Flow of plasma simulation

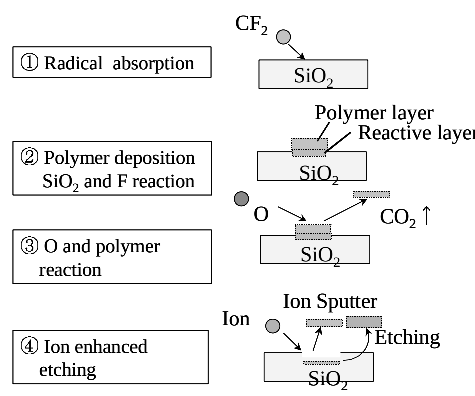


Fig.3 Surface reaction model

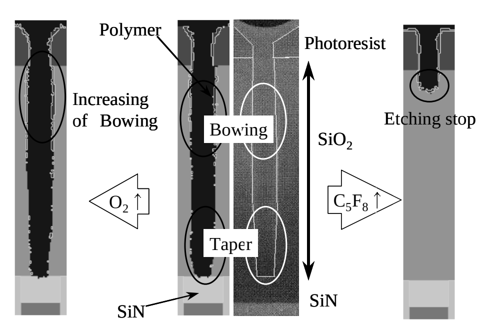


Fig.4 Result of RIE topography simulation