분과초청3

Plasma Etching Process based on Real-time Monitoring of Radical Density and Substrate Temperature

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Large scale integrated circuits (LSIs) has been improved by the shrinkage of the circuit dimensions. The smaller chip sizes and increase in circuit density require the miniaturization of the line-width and space between metal interconnections. Therefore, an extreme precise control of the critical dimension and pattern profile is necessary to fabricate next generation nano-electronics devices. The pattern profile control of plasma etching with an accuracy of sub-nanometer must be achieved. To realize the etching process which achieves the problem, understanding of the etching mechanism and precise control of the process based on the real-time monitoring of internal plasma parameters such as etching species density, surface temperature of substrate, etc. are very important. For instance, it is known that the etched profiles of organic low dielectric (low-k) films are sensitive to the substrate temperature and density ratio of H and N atoms in the H2/N2 plasma [1]. In this study, we introduced a feedback control of actual substrate temperature and radical density ratio monitored in real time. And then the dependence of etch rates and profiles of organic films have been evaluated based on the substrate temperatures.

In this study, organic low-k films were etched by a dual frequency capacitively coupled plasma employing the mixture of H2/N2 gases. A 100-MHz power was supplied to an upper electrode for plasma generation. The Si substrate was electrostatically chucked to a lower electrode biased by supplying a 2-MHz power. To investigate the effects of H and N radical on the etching profile of organic low-k films, absolute H and N atom densities were measured by vacuum ultraviolet absorption spectroscopy [2]. Moreover, using the optical fiber-type low- coherence interferometer [3], substrate temperature has been measured in real time during etching process. From the measurement results, the temperature raised rapidly just after plasma ignition and was gradually saturated. The temporal change of substrate temperature is a crucial issue to control of surface reactions of reactive species. Therefore, by the intervals of on-off of the plasma discharge, the substrate temperature was maintained within

±1.5○C from the set value. As a result, the temperatures were kept within 3ºC during the etching process. Then, we etched organic films with line-and-space pattern using this system. The cross-sections of the organic films etched for 50 s with the substrate temperatures at 20ºC and 100ºC were observed by SEM. From the results, they were different in the sidewall profile. It suggests that the reactions on the sidewalls changed according to the substrate temperature. The precise substrate temperature control method with real-time temperature monitoring and intermittent plasma generation was suggested to contribute on realization of fine pattern etching.

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