Differential surface charging of the dielectric during plasma etching and surface charge leakage kinetic.

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The flux of charged particles on to the surface during plasma processing of dielectric materials results in surface charging. The charge density and its distribution along the surface depend on plasma parameters (plasma uniformity, energy and angle distribution of ions and electrons) and structure geometry (1-3). This differential surface charging can result in distortion of the etch profile, and it is one of possible sources of etch stop phenomena during dielectric etch process. The plasma induced surface charge can be quantified using the contact potential difference (CPD), a non-contact material analytical technique (4-5).

In a previous study we have investigated the geometry structure dependent charging of the dielectric surface during plasma processing (5). It was shown that the magnitude of the residual charge accumulated on the surface during the plasma processing is a function of the aspect ratio.

In this study, we report results of our investigation of the kinetics of a charge leakage from structure similar to one presented in (5). Two type samples were used in the experiment:

- 20000A thick film of boron-phosphorous doped silicate glass (BPSG) deposited on p-type Si;

- 20000A thick film of BPSG deposited on 2000A thick thermal oxide on p- type Si.

8300A thick DUV photo resist with a hole patterns of 0.19 micron in diameter was used as the etching mask. To improve the pattern definition 300A thick DARC (Deposited Anti-reflective Coating) underlay was deposited on BPSG. Samples were etched at different etch times to produce holes of different aspect ratios in BPSG. After ashing of the photo resist in the oxygen plasma, wafers have been processed through a wet clean to neutralize the surface charge. Then they were exposed to the Ar plasma for recharging the surface. Applied Materials P5000 MRIE etchers were used for generating the Ar plasma. Profile and depth of holes were observed by scanning electron microscopy (SEM). The surface voltage versus time after plasma processing has been measured using CPD technique.

The experimental data show that the magnitude of the residual charge accumulated on the surface during the plasma processing is a function of the aspect ratio. The surface voltage is not a monotonic function of the etch depth, but has a maximum at a certain depth. The surface voltage reduces considerable versus time for deep holes (thin remained dielectric), while it was relatively constant for shallow holes. These results suggest that the charge does leak between the bottom of a hole and the Si substrate. The charge leaks faster for thinner remained dielectric film.

1. J. S. Arnold, H. H. Sawin, J. Appl. Phys., 70, 5314 (1991) 2. A. Shibkov, M. K. Abatchev, H. K. Kang, M. Y. Lee, Electronics Letters, 32, 890 (1996) 3. Gyeong S. Hwang, Konstantinos P. Giapis, J. Vac. Sci. Technol. B15, 1741 (1997) 4. C. Cismaru, J. L. Shohet, K. Nauka, J. B. Friedman, Appl. Phys. Lett., 72, 1143 (1998) 5. M. K. Abatchev, B. J. Howard, K. G. Donohoe and G. T. Blalock, Plasma Processing XIII , G.S. Mathad, D.W. Hess. PV 2000-6, Toronto, Canada, 2000, pp. 160-167