Inductively Coupled Plasma Etching of Benzocyclobutene with SF_6 Chemistry

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The use of benzocyclobutene (BCB) has continued to gain traction for a multitude of applications beyond interlayer dielectrics and integrated circuit packaging. Due to the intrinsically high stress of SiO_2 and SiN_x and resulting limit in film thickness, b-staged divinylsiloxane bis-benzocyclobutene (BCB) is being employed in such applications as micro-electromechanical systems (MEMS). As such, the need for fabrication capabilities of BCB with highly anisotropic and small dimension features is increasing. To this end, we have investigated the effects of chamber pressure, reactive ion etch (RIE) power, inductively coupled power (ICP) power, and SF_6 concentration on etch rate, selectivity, and sidewall morphology.

A non-photosensitive BCB (Cyclotene 3022-35, Dow Chemical) was etched in a Plasma-Therm Versaline ICP RIE. Etch experiments were carried out with a SF_6/O_2 chemistry and Ar as a carrier gas. The effect of RIE power, chamber pressure, and % SF_6 (SF_6 / ($SF_6 + O_2$)) on etch rate, selectivity, and profile slopes were investigated while holding two of the three variables constant. Additionally, the effect of ICP power on etch residue was observed at a fixed RIE power, pressure, and % SF_6. The gas ratio of SF_6 / ($SF_6 + O_2$) ranged from 0% to 100% with the total flow for all experiments held constant at 50 SCCM and an additional 5 SCCM of Ar for increased plasma stability. The temperature of the carrier was held at 25 °C, regulated by backside He cooling.

The largest effect on etch rate and selectivity was observed under conditions in which micro-masking occurred resulting in ‘grass’-like features. Micro-masking is shown to be dependent upon the gas ratio of SF_6 / ($SF_6 + O_2$), chamber pressure, and ICP power. Under all etch conditions in which micro-masking occurs, grass formation does not appear in feature sizes smaller than 10 μm (Fig. 1), indicating that micro-masking is due to re-deposition. However, the highly anisotropic features, regardless of the formation of micro-masking, were achieved with profile slopes ~88°. Optimal etch conditions which prevented the formation of micro-masking, while still maintaining significant etch rates (0.8 μm/min), selectivity (0.9) and sidewall morphology (~88°) were obtained with an ICP power of 300 W, RIE power of 300 W, pressure at 3 mTorr, and 10 % SF_6 concentration (Fig. 2).

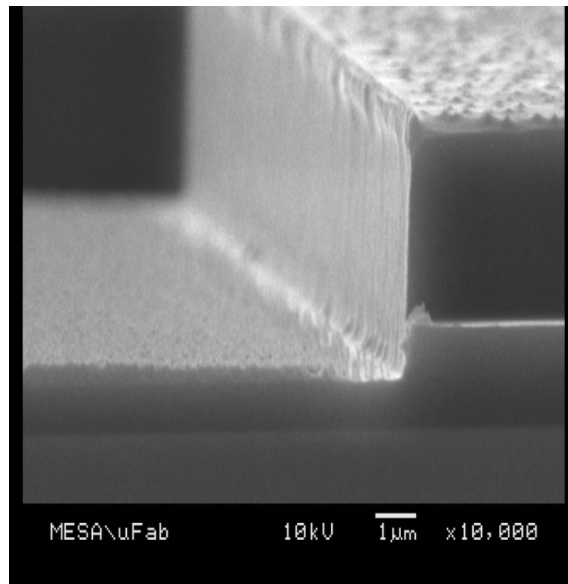

Figure 1: SEM cross-section image of sample etched at 7.5 mTorr, RIE power of 300 W, ICP power of 300 W, and 30% SF_6.

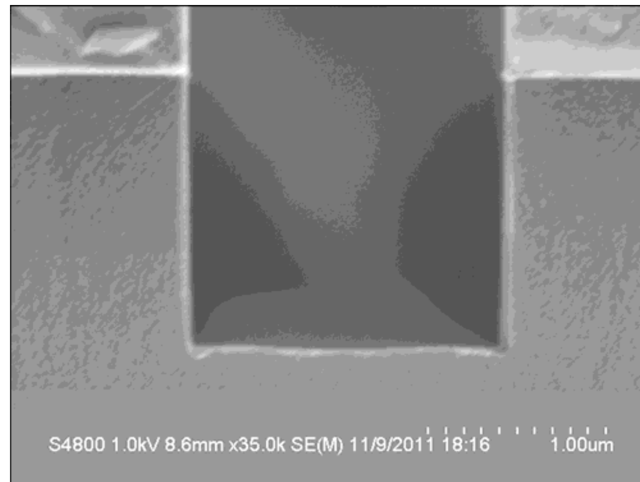

Figure 2: SEM cross-section micrograph of BCB etched at 3 mTorr, 300 W RIE, 300 W ICP, and 10% SF_6.

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