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Control of deposition profile and properties of plasma CVD carbon films

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Wide interest in carbon films stems from their attractive properties such as biocompatibility, chemical inertness, high mechanical hardness, optical transparency, and wide band gap [1]. Deposition profile control of carbon films on fine structures is one of the concerns for MEMS and ULSI applications. Using H-assisted plasma CVD, we have realized three deposition profiles: subconformal, conformal, and anistropic ones. For anistropic deposition profile, carbon is deposited on top and/or bottom of trenches without sidewall deposition [2]. Here we report dependence of mass density, hardness, and etching resistivity of such carbon films on kinetic energy of ions incident on the films. The mass density increases from 1.5 g/cm^3 to 2.3 g/cm^3 with increasing the ion energy from 32 eV to 100 eV and decreases to 1.7 g/cm^3 with increasing further the ion energy to 225 eV. The hardness measured with a nano indenter sharply increases from 4.8 GPa to 73.8 GPa with increasing the ion energy from 32 eV to 100 eV and decreases to 46.8 GPa with increasing further the ion energy to 225 eV. The maximum hardness of 73.8 GPa is fairly close to that of diamonds of 100 GPa. To examine etching resistivity against H_2+N_2 plasma irradiation, we evaluated etching selectivity of the films with respect to SiLK^{TM} films which are widely employed as inter layer dielectrics in ULSI. The etching selectivity increases exponentially from 1 to 8 with increasing the mass density from 1.5 g/cm^3 to 2.3 g/cm^3. In summary, we have demonstrated tuning of deposition profile and film properties using the key control parameters of cabon-containing radical flux, H flux, ion flux, ion energy, and substrate temperature.

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Keywords
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