Nanoporous SiO2 /Si thin layers produced by ion track etching: Dependence on the ion energy and criterion for etchability

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Vitreous SiO_2 thin films thermally grown onto Si wafers were bombarded by Au ions with energies from 0.005 to 11.1 MeV/u and by ions at constant velocity (0.1 MeV/u ^{197}Au, ^{130}Te, ^{75}As, ^{32}S, and ^{19}F). Subsequent chemical etching produced conical holes in the films with apertures from a few tens to ~150 nm. The diameter and the cone angle of the holes were determined as a function of energy loss of the ions. Preferential track etching requires a critical *electronic* stopping power S_e^{th} ~2 keV/nm, independent of the value of the nuclear stopping. However, homogeneous etching, characterized by small cone opening angles and narrow distributions of pore sizes and associated with a continuous trail of critical damage, is only reached for S_e>4 keV/nm. The evolution of the etched-track dimensions as a function of specific energy (or electronic stopping force) can be described by the inelastic thermal spike model, assuming that the etchable track results from the quenching of a zone which contains sufficient energy for melting. The model correctly predicts the threshold for the appearance of track etching S_e^{th} if the radius of the molten region has at least 1.6 nm. Homogeneous etching comes out only for latent track radii larger than 3 nm.