Effect of surface roughness of the neutralization grid on the energy and flux of fast neutrals and residual ions extracted from a neutral beam source

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A directional fast neutral beam was extracted from an inductively coupled argon plasma in contact with a neutralization grid. Ions expelled from the plasma converted into fast neutrals by grazing angle collisions with the internal surfaces of the openings of the grid. The effect of surface roughness of the neutralization grid was studied experimentally by using two grids: an array of holes drilled in an aluminum plate, and a set of atomically smooth Si parallel plates. With the atomically smooth Si grid, the ion translational energy lost in the surface collision was relatively small, and agreed well with the prediction of a specular reflection model. For the relatively rough metal grid, however, the translational energy loss was substantial due to the reduced probability of specular reflection from the rough surface. The residual ion flux and fast neutral flux were observed to be two to four times higher for the Si grid than for the metal grid, due to a higher percent open area and specular reflections off the smooth Si surfaces. The neutralization efficiency with the Si grid was between ~50% and 90%, depending on plasma conditions. At the highest neutral beam energies, the Si grid neutralizes about half of the incoming ions and thus would provide a sufficient flux of directional neutrals for anisotropic etching at commercially viable rates. [DOI: 10.1116/1.2433983]