Diffusion of Alkali Species in Porous Tungsten Substrates used in Contact-Ionization Sources[*]

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Abstract

Contact ionization (doped) sources used in current Heavy Ion Fusion experiments consist of a porous tungsten substrate doped with an alkali carbonate. During the early stages of the heating cycle (T ~ 600 °C), the carbonate breaks down and releases the alkali atoms that then diffuse through the substrate. At the emitter surface there is a balance between the fast desorption rate of the alkali atoms (mostly as neutrals) and the slower replenishment rate from the substrate by diffusion. Time-resolved measurements of neutral particle evaporation rates at the emitter surface have been used to estimate the effective diffusion coefficient (D) that characterizes the migration of alkali species in the substrate. These estimates are consistent with the observed source lifetimes (tens of hrs.) and establish the alkali migration in the bulk as a diffusion-limited process. The measurements suggest that the faster migration rates ($D \approx 10^{-5}$ - 10^{-6} cm^2/s) occur early during the heating cycle when the dominant species are the neutral alkali atoms. At operating temperatures there is a slower migration rate ($D \approx 10^{-7} cm^2/s$) due to the dominance of ions, which diffuse by a slower surface diffusion process.

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