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A Study on Post-effects of Proton Beam Irradiation of Tantalum Metal Using Probe Emission Mössbauer Spectroscopy

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For the irradiations, 40 mµ thick tantalum foils were used that have been annealed after being rolled and labelled with 57Co. Diffusion impingement of evaporated radioactive atoms onto the surface of tantalum substrates was carried out for 140 minutes at 1270-1275 K (E-7 Torr) that was followed by cooling both the foils and the furnace down to the ambient temperature.
Irradiation conditions for the samples in the MGC-20 isochronous cyclotron are given in the Table below:

Conditions of Irradiation Foil 1 Foil 2
Fluence, particles/m2 2.6 E21 2.6E21
Integral beam current, µA 11.45 11.45
Proton energy losses, MeV 6.95/5.24 5.08/2.86
Heat released, Watts 19.6 25.4
Temperature of targets, K (310+/-3) (310+/-3)

The Mössbauer Spectra measured before and after irradiation are a superposition of the two single lines that correspond to different positions of the 57Co atoms in BCC Tantalum lattice: Singlet 1 corresponds to the 57Co atoms at the boundaries of crystallite grains; Singlet 2, to the 57Co atoms in the lattice sites (the isomer shift that is characteristic for interstitial atoms).
The nuclear prehistory has no practical influence on the proportion of spectral lines: the low temperature of targets in the process of irradiation excludes the possibility for the impurity atoms to migrate within bulk samples; the fraction of Singlet 1 is (37+/-2) %, for Singlet 2, it is (63+/-2)%.
The presence of a significant number of own radiation-induced defects (that are formed resulting from irradiation) in the vicinity of the Mössbauer atom causes the experimental lines to be broadened. As the proton energy decreases (i.e., as the cross section of their interaction with atoms of the target increases), this effect is enhanced and is especially strongly revealed for the interstitial 57Co atoms.

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