Interaction of gaseous tritium with copper

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Pure copper is used in ITER as interlayer material between armor and divertor or between beryllium armor and the first wall heat sink. Copper tubing is utilized frequently in equipment handling low level tritium because of its good mechanical properties and low solubility/permeability of tritium in this metal. In spite of much knowledge on the interaction of protium with copper this is by and large not the case with tritium. Hence, the uptake of tritium by surface and bulk of copper specimens was investigated at either 300 or 473 K using a gaseous 1:1 deuterium/tritium mixture at 500 mbar. Tritium concentration profiles were determined by chemical erosion up to a depth of 3 mm using 50 % nitric acid. The progressive etching technique circumvents the problem arising from the comparatively large quantity of tritium accumulating on the surface and subsurface, which falsifies low solubility values of tritium. Tritium on the surface was also determined by beta-ray induced X-ray spectroscopy (BIXS). The observed concentrations of tritium at 473 K were essentially in line with solubility predictions from earlier work. At ambient temperature the penetration was less than 500 µm after 100 h exposure. Out-gassing of tritium from copper was studied in a flow system under controlled temperatures and observed to be much slower than that from stainless steel. Thermally liberated tritium consisted almost exclusively of HTO. Tritium release rates at ambient temperature were in the range 100 – 500 Bq/h depending on loading temperature and specimen pre-treatment. In comparison to Type SS316 stainless steel, the tritium concentrations on the topmost surface of copper were found to be much higher but the fraction of total tritium present in the bulk much smaller.

Tritium depth profiles in the bulk of copper and the release rates of tritium from this material were interpreted by a diffusion mechanism, the used diffusion coefficients being similar to those reported in the literature. The implications of the results to the disposal of tritium-contaminated copper waste will be addressed.