A variety of important characteristics associated with the interaction of hydrogen plasma with the metallic walls of fusion devices are either entirely due to, or at least strongly influenced by surface impurities and chemical composition. Understanding of the roles of additional elements in defect structure evolution and deuterium uptake is important for the design of fusion reactor materials.

The influence of deuterium on material microstructure, deuterium trapping and release was investigated using transmission electron microscopy, thermal desorption spectrometry and the nuclear reactions $D(\text{^3He},p)\text{^4He}$. Reemission, retention and evolution of depth distribution profiles of deuterium in stainless steels 06Kh18Ni10, 08Kh18Ni10Ti, 12Kh18Ni10Ti, the commercially available and modified 316L and Cr12Mn20W2V) were studied for 12 keV $D_2^+$ implantation up to $1 \times 10^{19}$ - $1 \times 10^{22}$ $D$/$m^2$ at room and 600 K temperatures followed by annealing from 290 to 1500 K. Changes in hardness were measured using Vickers hardness indentation.

Total amount of retained deuterium in Kh18-Ni10 SS saturated for ion fluencies above $4.0 \times 10^{21}$ $D$/$m^2$ and maximum saturation level was $2 \times 10^{21}$ $D$/$m^2$. The radiation-induced dislocation microstructure had no well-defined influence on the deuterium trapping. The results of performed experiments provide evidence of hydrogen trapping at irradiation vacancies end their complexes. A behavior of the deuterium retention is influenced by the manufacturing process and the sample history of stainless steels. Certain thermo-mechanical treatments stimulate the nucleation of martensitic phase acting as an anomalous strong gas trap, so the retained deuterium desorbs mainly at around 1200 K.