Positron annihilation studies of reactor pressure vessel steels treated by irradiation and hydrogen ion implantation

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Long term operation of nuclear reactors is one of the most discussed challenges in nuclear power engineering. The radiation degradation of nuclear materials limits the operational lifetime of all nuclear installations or at least decreases its safety margin. This paper is focused on experimental simulation and evaluation of materials via hydrogen ion implantation and comparison to our previous results obtained from neutron irradiated samples. In our case, German reactor pressure vessel steels, originally from CARINA/CARISMA program, were studied by positron annihilation lifetime spectroscopy and pulsed low energy positron system with the aim to study microstructural changes in RPV steels after high level of irradiation [1]. Unique specimens were irradiated by neutrons in German experimental reactor VAK (Versuchsatomkraftwerk Kahl) in the 1980s and these results were compared to results from high level of hydrogen nuclei implantation. Defects with the size of about 1-2 vacancies with relatively small contribution (with intensity on the level of 20-40 %) were observed in all "as-received" steels. The increase in the size of the induced defects due to neutron damage was observed in the irradiated specimens resulting in 2-3 vacancies. On the other hand, the size and intensity of defects reached extremely high values due to displacement damage caused due to implantation of hydrogen ions in very narrow damaged region. This fact can limit operation of new fission or fusion nuclear facilities [2].

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References

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