Tungsten as First Wall Material in Fusion Devices (PL5-O-545)

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In the PLT tokamak with a tungsten limiter strong cooling of the central plasma was observed. Since then mostly graphite has been used as limiter or target plate material. Only a few tokamaks (limiter: FTU, TEXTOR; divertor: Alcator C-Mod, ASDEX Upgrade) gained experience with high-Z-materials. With the observed strong co- deposition of tritium together with carbon in JET and as a result of design studies of fusion reactors, it became clear that in the long run tungsten is the favourite for the first-wall material. Tungsten as a plasma facing material requires intensive research in all areas, i.e. in plasma physics, plasma wall-interaction and material development. Tungsten as an impurity in the confined plasma reveals considerable differences to carbon. Strong radiation at high temperatures, in connection with mostly a pronounced inward drift forms a particular challenge. Turbulent transport plays a beneficial role in this regard. The inward drift is an additional problem in the pedestal region of H-mode plasmas in ITER-like configurations. The erosion by low energy hydrogen atoms is in contrast to carbon small. However, erosion by fast particles from heating measures and impurity ions, accelerated in the sheath potential, play an important role in the case of tungsten. Radiation by carbon in the plasma boundary reduces the load to the target plates. Neon or Argon as substitutes will increase the erosion of tungsten. So far experiments have demonstrated that in most scenarios the tungsten content in the central plasma can be kept sufficiently small. The material development is directed to the specific needs of existing or future devices. In ASDEX Upgrade, which will soon be a divertor experiment with a complete tungsten first-wall, graphite tiles are coated with tungsten layers. In ITER, the solid tungsten armour of the target plates has to be castellated because of its difference in thermal expansion compared to the cooling structure. In a reactor the technical concept depends on the cooling medium water or helium. The latter requires relative high pressure of the coolant. Specific developments are devoted to the suppression of the production of volatile tungsten oxide in case of a loss of coolant accident, to reduce the risk of releasing radioactive material. Altogether tungsten as the plasma facing material looks promising but a series of open questions still have to be solved.