Advanced materials for a fusion power plant

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Plasma-facing materials (PFMs) in a future fusion power plant will be subjected to high fluence of plasma particles, significant neutron loads and intensive radiation exceeding those in present and future fusion experiments by orders of magnitude. Such a severe environment imposes an ultimate challenge for plasma-facing materials questioning the use of traditional PFMs in a power plant.

In order to address the challenge of power plant feasibility, a series of so-called advanced materials is under development. Among those advanced materials, the fiber-reinforced tungsten aims at providing pseudo-ductility at nearly room temperature. Fiber-reinforced tungsten features extremely high fracture toughness compared to that of monolithic tungsten and exceeding 20 $MPa*m^{1/2}$. Another concept, the micro-structured tungsten should increase the tolerance of PFMs to thermal loads and suppresses the tungsten damage due to e.g. transient events. In order to counteract tritium penetration into the structural components, barrier coatings are developed. Yttria barrier coatings feature 1000-fold reduction of tritium flux into the bulk of a machine.

The safety aspect is extremely important for a future power plant. Self-passivating, so-called “smart” tungsten alloys are under development. During regular plasma operation, these alloys must exhibit the advantageous properties of tungsten: low tritium retention, high resistance to sputtering, good thermal conductivity and ductility at elevated temperature. In case of an accident assuming exposure of the vacuum vessel to the atmosphere, the alloying elements remaining in the bulk of the smart alloys will react with air and form the protective coating on tungsten. This protective coating will prevent the oxidation and subsequent sublimation of neutron-activated and therefore, radioactive tungsten oxide. Presently, smart alloys feature more than 40-fold suppression of tungsten oxide sublimation as compared to that of pure tungsten. These and other innovative materials and concepts will be presented and discussed in the talk.