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Material modifications due to the plasma irradiation

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In many areas of energy production and application, materials with superb thermal and mechanical properties are required. In particular in fusion devices, first wall materials are exposed to extreme heat, neutron and particle fluxes, leading to material degradation. In solar tower power plants the exposure to highly concentrated and alternating solar fluxes, leading to cyclic thermal loads, and operating in humid air environment combined with high operational temperatures of above 1000℃ required for commercially competitive electricity production imposes comparably challenging requirements on materials for solar receivers. New production methods, material combinations and complex materials concepts are investigated to develop new materials with improved properties, reduced production costs and larger flexibility with respect to manufacturing of final components, as well as increasing the overall efficiency of energy systems. We produce material modifications due to plasma for several applications.
1. Deposition of antifriction and antisintering coatings of solid lubricants (MoS2) that are very effective at high loads close to the yield stress of contacting materials, at low sliding speed. In aerospace field, such coatings are used to prevent friction in friction units; in the oil and gas industry, threads are coated to prevent sticking; in nuclear fusion facilities they are used to protect fixing articles in construction elements of tokamaks (ITER, France; JET, England) and stellarators (Wendelstein 7-X, Germany). The coatings underwent tests at high temperature (250℃) in vacuum environment.
2. Plasma nitriding in an inductively coupled plasma (ICP) source facility, and ICP combined with plasma immersion ion implantation (PIII) method for material surface hardening. Duplex treatment of surfaces by first-stage plasma nitriding followed by magnetron sputter deposition of hard and/or wear-resistant coatings. Duplex treatment allows drastic improvement of surface parameters without compromising the coating adhesion. Coating materials include CrN, CrAlN, TiN. These technologies are being used for improving performance of cutting tools in machining industries.
3. He plasma interaction with advanced W-Cr-Y alloy for production of nearly black body to prevent loss of heat for solar tower power plants.
4. Developing plasma-based technology for titanium implant surface engineering. For this purpose, ion flux from ICP source is used to bombard the surface of the implant and to produce the anticipated topology. Technology allows preparing surface topologies with nanometer features for improving the antibacterial properties and those with micrometer features for improving the proliferation of osteoblasts. Combined laser and plasma technology for controlled surface patterning as an eco-friendly wasteless method for preparation of surfaces of a wide range of bone integrated materials.

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