Steel-based materials surface damage and modification under high power plasma exposures

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Simultaneous impacts of high energy and particle loads to the material surface are typical for material performance in various extreme conditions: fusion devices (both magnetic and inertial), space apparatus in upper atmosphere, operation of turbines, nuclear engineering etc. Influence of powerful plasma impacts on number of the energy system materials, i.e. RAFM steels, coatings of various materials etc. has been discussed. Material exposures with hydrogen and helium plasma streams have been performed in several high current pulsed and quasistationary plasma accelerators providing variation of power load to the surface as well as the particle flux in vide range: energy density 1 – 25 MJ/m^2, particle flux up to 10^{26} – 10^{29} ion/m^{2}s, pulse duration 1 – 250 μs [1, 2].

A response of the investigated materials to extreme plasma loads, which are relevant to transient events in fusion reactors, is briefly discussed. It is demonstrated that a broad combination of mechanisms of powerful plasma interactions with various materials includes not only a surface damage caused by different erosion mechanisms, but under certain conditions it may also result in a significant improvement of material properties in the near-surface surface layer of several tens μm in thickness [1]. Some improvement of the structure and substructure of such a layer may be caused by the high-speed quenching, the shock wave formation and material alloying with plasma-and coating-species [1, 3]. The creation of unique surface structures and a considerable improvement of physical and mechanical properties of different materials can be achieved by the pulsed plasma alloying, i.e. pre-deposited coating modifications and mixing caused by the impacting plasma streams. First results on hydrogen outgassing from modified steels are also discussed [4].

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