Divertor materials for ITER - Tungsten and carbon/carbon composite behavior under coupled ionic irradiation and high temperature

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In the frame of the International Thermonuclear Experimental Reactor ITER, the physical-chemical characterization of plasma-facing components (divertor and structural materials) is essential because they are subjected to simultaneous high thermal and ionic fluxes.

In this paper, an experimental and theoretical study of the physical-chemical behavior of carbon/carbon composite and tungsten (materials for ITER divertor) under extreme conditions is performed. The simulation of the interaction of hydrogen ions with the material, the theoretical study of physical erosion (TRIM and TRIDYN codes) and the chemical erosion (GEMINI code) are carried out. The conditions of nominal or accidental mode that can occur during the operation of the reactor (high temperature 1300 - 2500 K, high vacuum, H⁺ ionic flux with different energies) are experimentally simulated. In this work, we have studied the material degradation, the mass loss kinetics, the characterization of the emitted neutral and charged species of heated and both heated and irradiated materials, and the determination of the thermo-radiative properties versus time.

This study, done in collaboration with CEA Cadarache, is realized using the MEDIASE experimental device (Moyen d’Essai et de Diagnostic en Ambiance Solaire Extrême) located at the focus of the 1000 kW solar furnace of PROMES-CNRS laboratory in Odeillo. Material characterization pre- and post-processing is performed with classical techniques as SEM, XRD and XPS and also by measuring the BRDF (Bidirectional Reflectivity Diffusion Function).

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