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R&D on full tungsten divertor and beryllium wall for JET ITER-like wall project

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Abstract

The ITER reference materials have been tested separately in tokamaks, plasma simulators, ion beams and high heat flux test beds. In order to perform a fully integrated material test JET has launched the ITER-like Wall Project with the aim of installing a full metal wall during the next major shutdown. As a result of R&D projects in 2005–2006, bulk tungsten tiles are foreseen at the outer horizontal target and tungsten coating at the other divertor tiles. In some regions of the main chamber, beryllium coated Inconel tiles and bulk beryllium tiles are utilised which include marker tiles as erosion diagnostics. This paper gives an overview of the R&D carried out in the frame of the ITER-like Wall Project on the development of an inertially cooled bulk tungsten tile design and the characterization of tungsten and beryllium coating technologies.

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Keywords: Tungsten; Beryllium; CFC; Coating; JET; ITER; Plasma-facing materials; High heat flux test

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1. Introduction—the ITER-like wall project

Currently, the primary ITER material choice is beryllium (Be) for the entire main chamber wall, carbon fibre composite (CFC) at the divertor strike points and tungsten (W) on the baffles and dome (Fig. 1a). These ITER reference materials have been tested separately in tokamaks, plasma simulators, ion beams and high heat flux test beds [1]. However, an integrated test demonstrating both compatibility of metal plasma facing components (PFC) with high-power operation and acceptable tritium retention has not yet been carried out. At JET, it is possible to test the full combination of ITER wall materials. In JET the size, magnetic field strength and high plasma current make it possible to conduct tests at the most ITER-relevant parameters accessible today. The ITER-like Wall (ILW) project [2–5] has been launched to design, manufacture and test all the necessary components in view of their installation in a dedicated shutdown.

The objective of the ILW Project is to install in JET beryllium PFC in the main chamber and a W divertor (the favoured back-up materials solution for ITER, Fig. 1b and Fig. 2). The chosen material configuration is technically more demanding, but gives a clearer physical case than the ITER-reference combination with CFC tiles at the strike point. It also opens the option to replace specific rows of divertor tiles with CFC at a future date. The ILW Project will be a test bed for integrated scenarios with ITER-relevant edge conditions and compatibility with the wall thus providing essential information for the next-step devices.

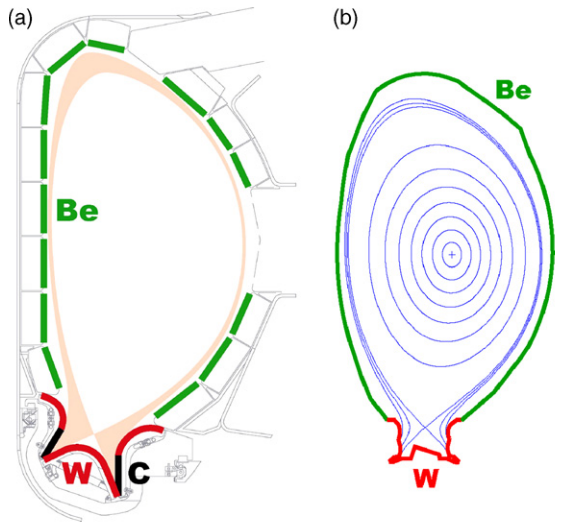

Fig. 1. (a) ITER material configuration and (b) material configuration for the JET ITER-like Wall Project.

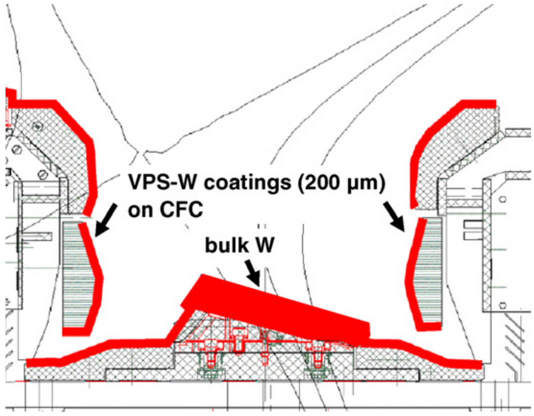

Fig. 2. Poloidal cross section of the JET divertor showing the material selection and the magnetic field configuration of an ITER-like plasma shape.

This paper gives an overview of R&D projects launched in the frame of the ILW Project for the W divertor (both W-bulk and W-coated tiles), and the development of Be coating and marker tiles.

2. Bulk tungsten

2.1. Tungsten lamellae divertor tile design

A crucial step in the preparatory phase of the ILW is the development of a concept for the outer horizontal divertor plate (see Fig. 2), so-called load-bearing septum replacement plate. This PFC has to withstand heat fluxes of up to 7 MW/m^2 for 10 s (swept configurations). Owing to the brittleness of W, only a “castellated” design is thought to withstand high temperature gradients in cyclic operation. A rough estimate gives operational temperatures of 1200 °C on the top surface with possible peak temperatures up to 2200 °C keeping the margin of temperature increase (∼800 °C) during ELM-events. At the same time, the temperature at the bottom of the component should not exceed 500–700 °C [6,7] because of the temperature limit of metallic fittings made of Inconel (operation temperature, lower than 700 °C). The design values require