JET

sequent remote handling procedures. Thereafter, all remaining tiles will be removed and stored. The empty vessel is then cleaned and surveyed, the diagnostic beam is put back in and the infrastructure for some of the new or enhanced diagnostics is installed. Beginning about 42 weeks into shutdown, the new wall tiles will be fitted, followed by the limiters and finally the divertor. After removing all previously installed access-facilities and remote handling equipment, JET can be pumped down.

Besides installing the new wall, the neutral beam duct scrapers will be replaced during the shutdown. The duct scrapers are located in the neutral beam ports of the vessel, protecting the ports from neutral particles in the edge of the beams that would not pass through the ports and from particles that are re-ionised as they pass through the port. Since the enhanced neutral beams will supply much higher power, the new scraper needs to be actively cooled.

During the entire shutdown period, significant attention will be devoted to the calibration and adjustment of JET diagnostics for the operation of the machine with the ITER-like wall. The main in-vessel activities on diagnostics will be the calibration of the neutron measurements and the calibration of the spectroscopic systems.

Thanks to Lorne Horton, JET, for his input

EFDA-JET's newsletter "Shutdown Weekly" will highlight the most exciting aspects of this shutdown week by week:

http://www.jet.efda.org

MEdC chosen to provide tungsten coatings for JET

When JET starts up at the end of 2010, after the 15-months shut down which started on 26 October 2009, it will be equipped with a new all-metal wall – the ITER-like Wall (ILW) – to conduct tests for the deuterium-tritium phase of ITER. A total of 2000 wall and divertor carbon-fibre reinforced carbon (CFC) tiles with a tungsten coating need to be produced for the project. Such tungsten coated CFC tiles will be used both for parts of the divertor and for certain recessed areas of the main chamber which do not have direct plasma contact, but are nevertheless subject to high heat loads.

Applying the required 10 – 25 µm thin tungsten coating is not an easy task, as its anisotropic thermal expansion does not match that of CFC. Indeed most of the layer types that have been tested have shown buckling (bending or forming bulges) or delamination (splitting off in layers). The "Combined Magnetron Sputtering and Ion Implantation" technology (CMSII) of the Romanian Fusion Association (Euratom/MEdC) has yielded the best quality coatings without buckling defects at high heat loads. EFDA therefore chose to use this technique for the JET ITER-like wall and funded the development of the process to an industrial scale. The production is set up in the laboratory of the Romanian National Institute for Laser, Plasma and Radiation Physics (NILPRP) where CMSII was developed. Today, about 90% of the divertor tiles (the most challenging area due to the high temperatures and the resulting thermal expansion issues) and 25% of the main chamber tiles have been successfully coated.

Material scenarios for ITER

ITER is intended to operate in two phases: It will start in a non-activated regime, using hydrogen and deuterium as fuel. For this phase, the high heat flux areas of the divertor are foreseen to be lined with CFC tiles due to their good thermal properties. The second phase will use a mix of tritium and deuterium as fuel. Since carbon has an affinity for hydrogen and its isotopes, CFC tiles would retain tritium. Therefore, in the second phase, all divertor tiles will be made of tungsten. It is planned to use beryllium as the main chamber wall material for both phases.

Magnetron sputtering is a standard technique used to produce a large variety of coatings (metallic or non-metallic). In principle, the atoms, which are to be deposited on the surface, are ejected from a target sample. For this purpose, a low pressure discharge is generated in front of the target using a special configuration of electric and magnetic fields. The CMSII process superposes a high voltage pulse discharge over the magnetron deposition which generates high energy ions that periodically bombard the growing coating. Consequently, an extremely dense, pore free, nano-crystalline structure is produced. At the same time, the stress in the coating relaxes and it is possible to generate relatively thick layers between 10 and 30 µm. For the tungsten coating of CFC, the adhesion was improved by applying a molybdenum interlayer of 2 – 3 µm with the aim of adjusting the thermal expansion mismatch between CFC and tungsten.

Thanks to Cristian Ruset, NILPRP, and Guy Matthews, JET, for their input

More information:

C. Ruset et al, *Industrial scale 10μmW coating of CFC tiles for ITER-like Wall Project at JET*, Fusion Engineering and Design 84 (2009) 1662–1665

G6 and G7 divertor tiles for JET coated with tungsten by CMSII technology *(Picture: C. Ruset, MEdC)*

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For more information see the websites:
http://www.efda.org
http://www.jet.efda.org
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