Analysis of surface damages of tungsten mono-blocks with intrinsic bonding defects

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ITER-like tungsten (W) mono-block will be used in vertical target regions of the KSTAR divertors. The most important engineering part of the divertor vertical target is the quality of joint between armour materials to heat sink [1, 2]. We are interested especially in the surface conditions of tungsten blocks with defects at the interfaces of joints, caused intrinsically during the manufacturing process and/or induced by thermal fatigue. The surface condition of the blocks is directly correlated to the lifetime of the tungsten divertor, and gives severe restriction of the operation condition. The issue is strongly linked to the ITPA DSOL task 36, which is one of high priority issues of ITER.

Seven mock-ups were manufactured with intrinsic defects by brazing technology. Those mock-ups are measured by ultrasonic test (UT) to identify the defects: the size and location of defects. High heat flux (HHF) test has been performed to verify the effect of bonding defects between W mono-block and heat sink. The thermal cycle fatigue test at 10 MW/m² was carried out for 1000 cycles. All mock-ups were tested to estimate the eventual degradation of the thermal behavior of the mono-blocks due to an increase in the defect size. W mono-block with defects of size less than 3 mm also withstood 1000 cycles of heat flux about 10 MW/m² like the mock-ups joined perfectly. And surface condition was not changed much. However, W mono-block with defect size about 30% of the facing area did not withstood thermal cycle fatigue test, and the surface was heated and degraded, which is consistent with the authors’ observation [3]. By comparing the results of UT and HHF test, threshold of defect size on joint between W mono-block and heat sink is determined during HHF test, and surface conditions were classified.