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Repair of the cracked surface of W using high energy pulsed laser

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W is a promising plasma facing material for fusion devices. It is expected to suffer from the transient heat flux during normal ELMs, abnormal VDEs and plasma disruption events. In the next fusion device such as the ITER, the transient high heat flux can reach up to several MJ/m2 in a very short pulse (˜ms), which is as high as enough to cause the surface damages especially in form of cracks [1]. The cracks, to some extent degrade material perfomance. To alleviate the influence of the cracks, the repair of the cracked surface using high energy pulsed laser has been proposed and investigated [2].

In the present work, the repair of cracked surface of W was performed in the laser and wall material evaluation device. The W was pre-damaged by the transient heat flux exposure in EMS-60 with parameters of 400MW/m2 for 1ms and 100 cycles. The net-like macro cracks were successfully generated as expected. Then, the damaged surface of W was repaired in the laser and wall material evaluation device with a high vacuum circumstance. The damaged W was preheated to a elevated temperature exceeding DBTT of W, then the high energy pulsed laser with a wavelength of 532 nm, a energy of 0.2˜0.8 kJ, a frequency of 10 Hz and a circular beam diameter about 0.4 mm was scanned on the damaged area with the adjustable single spot repetition numbers and overlapping ratio between adjacent spots from 10-50%.

After the repair process, the net-like cracks successfully disappeared at the laser scanned areas, meanwhile, there were no any other type cracks founded. It is should note the high energy pulsed laser can also cause other type of crack patterns at room temperature. Thus, the pre-heating process suppressed the cracks formation by laser shocks. The residual trace for the net-like cracks could be also distinguished by micro observation. In addition, the surface seemed to become rough from micro perspective, identifying that the surface underwent the plastic deformation during laser scanning. The repair mechanism may different with the laser re-melting method with an initial room temperature [3]. The single spot repetition numbers, the overlapping ratio between adjacent spots, the laser energy and spot dimension have the important influence on the repair effect and need in-depth optimization. Moreover, the behavior and properties of the repair surface under the subsequent plasma and heat exposure is unknown and need future relevant tests.

[1] Xiang Liu, Youyun Lian, Lei Chen, et. al., Experimental and numerical simulations of ELM-like transient damage behaviors to different grade tungsten and tungsten alloys, J. Nucl. Mater. 463 (2015) 166-169.

[2] Y. Ueda, Pulsed heat load effects on plasma facing materials, 2015 ITER International School, Hefei, China, 2015,14 - 18

[3] Th. Loewenhoff, J. Linke , J. Mat ˇejíˇcek, et. al., Laser re-melting of tungsten damaged by transient heat loads, Nuclear Materials and Energy 9 (2016) 165–170

Eligible for student paper award?

No

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