Journal of Nuclear Materials 492 (2017) 52–55

Contents lists available at ScienceDirect

Journal of Nuclear Materials

journal homepage: www.elsevier.com/locate/jnucmat

Short communication

Water erosion tests on a tantalum sample: A short communication

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ARTICLE INFO

Article history:
Received 24 January 2017
Received in revised form
2 May 2017
Accepted 3 May 2017
Available online 6 May 2017

ABSTRACT

This paper reports results from an experiment exposing the hot isostatic pressed tantalum cladding of a tungsten spallation target sample to a 34 m/s water jet. The unpolished tantalum surface was placed under the jet for 4.5 months with a view to quantifying pitting and erosion. Micrographs and laser profilometry records of the sample surface taken before and after the experiment are reported here.

1. Short communication

Tungsten is of great interest as a target material for a number of existing and future physics research facilities (ISIS [1] [2], ESS, Neutrino Factory [3] [4], LANSCE [5], KENS [6], etc.). Its advantages over Tantalum include higher strength, higher thermal conductivity and melting temperature lower residual activity after irradiation. However unlike tantalum, tungsten suffers corrosion when in contact with water and oxidation at high temperatures in air [7]. A number of oxidation protection coatings exist which include chemical vapour deposition (CVD) of silicon carbide (Fig. 1, bottom right) or tantalum (Fig. 1, top left) layers, cold gas spray of tantalum particles (Fig. 1, bottom left) [8] and Hot Isostatic Pressing (HIP) of tantalum (Fig. 1, top right). The latter is a somewhat traditional and accepted method for protecting water cooled tungsten targets which is currently adopted by ISIS.

A tantalum HIPped tungsten target has been selected for some of the next generation of neutron spallation facilities including SNS [9] second target station and CSNS [10]. At high heat loads targets will require relatively aggressive high speed water (of the order 10 m/s) to maintain reasonable target operating temperature.

High speed water erosion is a well-documented issue for copper components and the literature recommends a maximum velocity around 3 m/s for water flowing at around 65 °C [11]. However little literature exists about cooling of tantalum with high speed water and so this study aims at determining if a tantalum cladding can be compromised by water induced pitting or erosion.

Fig. 2(a) show the layout of the water erosion rig used for the experiments reported here. In the rig 100 L of fresh water were stored in a tank and circulated by a multistage pump through a filter and UV steriliser. The 6.4 L/min at 14 bar water circulated by the pump was forced though a 2 mm diameter orifice plate to produce a 34 m/s coherent jet which impinged on a tantalum sample placed ~25 mm from the nozzle. The angle between the jet and the surface of the sample was set to ~25°. The water in the rig

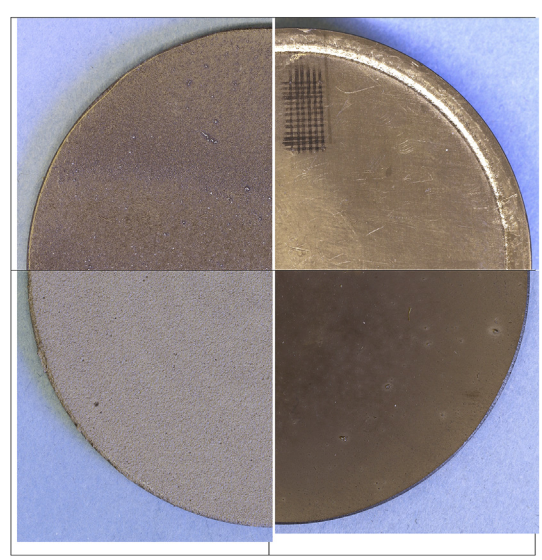

Fig. 1. Tungsten oxidation protection coatings. Clockwise from noon: Ta HIP, SiC CVD, Ta cold spray, Ta CVD.

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http://dx.doi.org/10.1016/j.jnucmat.2017.05.003
0022-3115/

was replaced every 2 weeks to prevent growth of organic contaminants.

The area impinged by the jet was punched with 4 peripheral reference marks. This target zone was 4 mm wide by 8 mm high and was scored with a permanent marker into in a grid of 5 by 12, i.e. rectangles approximately 0.8 mm wide by 0.6 mm high.

The experiment was interrupted monthly for examination and run for a total of 3168 h (i.e. approximately 4.5 months).

The samples were examined with an optical microscope which was used to record micrographs along the scored gridlines. The pictures were then compared qualitatively to look for changes in the surface of the sample.

The sample was also scanned and analysed with a TaiCaan Xyris 4000 WL/CL laser profilometer with a location resolution of 100 nm, a depth resolution of 10 nm, and sensor spot size of 2 μm.

The sample was a 12 mm thick 61 mm diameter tantalum clad tungsten disk. The cladding had been manufactured from 2 mm thick tantalum plate peripherally welded and then hipped. The surface of the tantalum had been machined but not polished. It was thought that the machining imperfections on the surface offered a range of ideal nucleation sites for high speed water erosion. Fig. 3 show electron scanning microscope pictures of the sample surface.

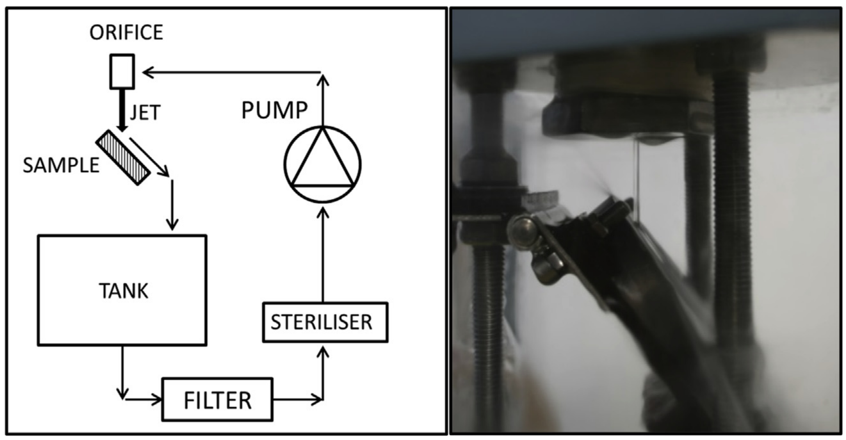

Fig. 2. Layout of the water erosion rig (A) and water jet impinging on the sample (B).

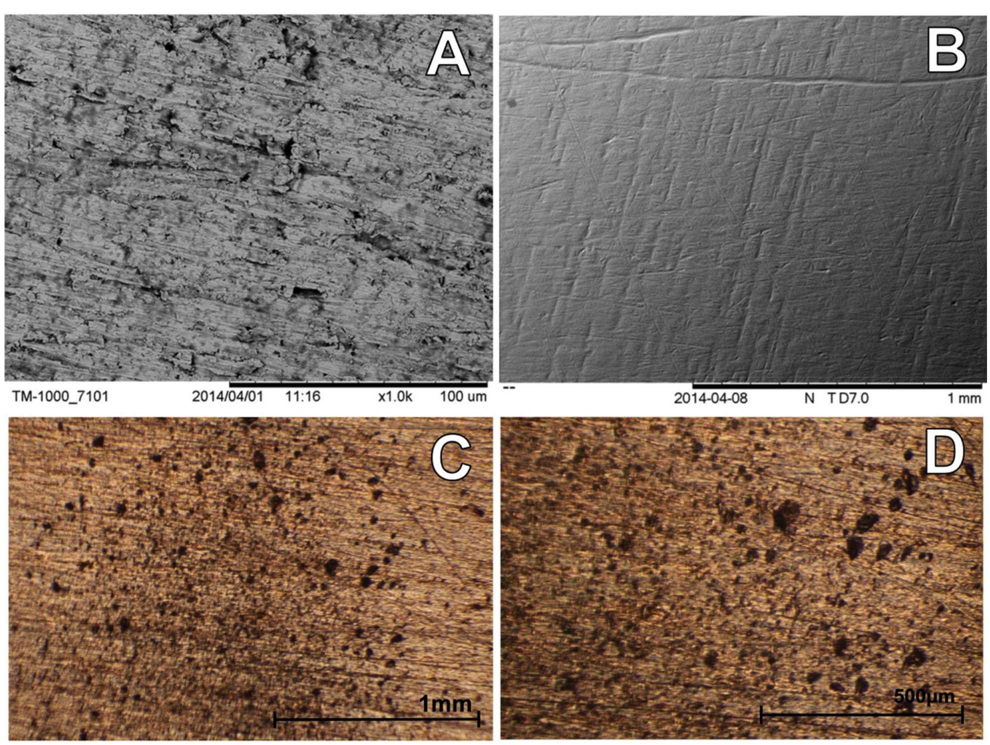

Fig. 3. A) and B) Scanning electron microscope pictures of the tantalum sample surface. C) and D) water erosion of a copper sample (~70hrs).