



Experiment title: Fracture behaviour of heterogeneous tungsten materials for fusion reactors	Experiment number: MA – 859	
Beamline: ID15 A	Date of experiment: from: 25.11.2009 to: 28.11.2009	Date of report: 15.02.2010
Shifts: 9	Local contact(s): Mario Scheel, Mario di Michiel	<i>Received at ESRF:</i>
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Interim Report:

3 different material concepts, W-Cu-composite (W/Cu), plasma sprayed tungsten (VPS-W), and tungsten-fibre/tungsten-matrix-composite (W_f/W_m) were investigated in the MA-859 experiment. Tomographs were produced for both undeformed and in-situ deformed samples. The applied load was uniaxial tension. Reconstruction is ongoing and implementation into FE modelling is planned.

1. Specimen preparation

Dog bone shaped specimens (24 x 10 x 3 mm) were prepared according to machine requirements. The restrictions in material availability made it necessary to choose a segmented sample geometry consisting of a cylindrical specimen made of the material of interest (diameter 1mm) being hold by aluminum tabs (Figure 1). Spark erosion was used to fabricate the cylinders as this technique is forceless and thus allows precise cutting of highly brittle tungsten. For the fixation of the specimen into the tap a two-component epoxy resin glue was used. In order to form a crack initiator at first a wire saw was used to produce a notch (width 80 μm ; depth 100 μm) at the centre of the cylindrical specimen and subsequently a focused ion beam was used to engrave a sharp pre-crack (width 1 μm ; depth 10 μm) at the notch base.

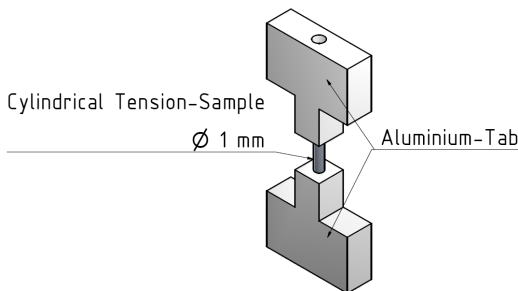


Figure 1 Tension testing sample

2. Experimental

A tension testing machine with a maximum load of 5 kN and minimal displacement rate of 0.1 $\mu\text{m/s}$ was used to conduct displacement controlled tension tests. At the end of each well defined displacement step the movement was stopped and a tomography was taken. A sufficient number of tomographs for individual specimens were taken during the tests. The force-displacement curve was measured by means of a 5 kN load cell and a LVDT (linear variable differential transformer).

The beam calibration took approximately 1 day and was done by Mario Scheel and Marco di Michiel. White beam with energy up to 200 keV was used. A difficult technical challenge was the problem of premature camera saturation at the peripheral domain of the specimen caused by its round geometry. To solve this problem an aperture of lead which was thicker at the outer part of the specimens was prepared and employed.

With the help of this tailored aperture it was possible to balance the illumination time and get homogenous quality over the volume. For most of the tomographs 3600 projections were taken over an angle of 180° . Also some small technical problems occurred during the experiment. It seemed that the glue used for the specimen preparation was not qualified for the use in high energy tomography. Either the heating of the sample or the hard radiation might have degraded the bond strength so that it was not sufficient anymore for

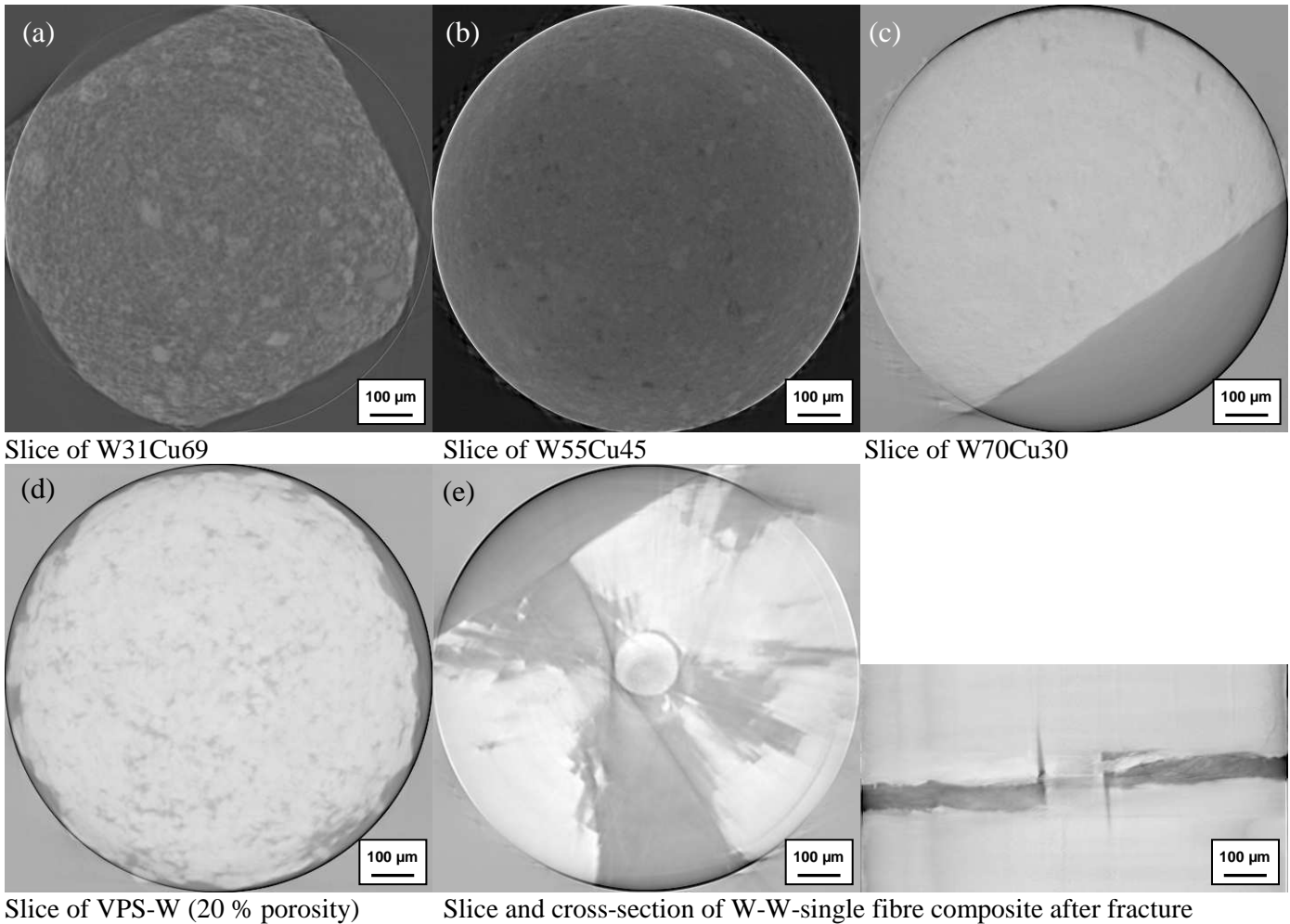


Figure 2 Tomographic slices of different materials tested during MA-859

the W-Cu samples. By manual thinning of the specimen it was possible to reduce the global strength into a region where the bonding strength was sufficient.

Due to problems related to computer infrastructure no tomography could be done between 26th Nov 8.00 and 27th Nov 10.00. As compensation we were able to extend our beamtime until 13.00 at the 28th of Nov.

3. Results

It was possible to produce tomographs for all materials also for the specimens of high tungsten content. In Figure 2 reconstructed slices are shown for each material. Force-displacement curves were measured for all samples. A typical curve is shown in Figure 3. In this case 15 single tomographs were taken. For 4 samples loading up to complete fracture was performed. The crack is visible in the tomographs (see Figure 2 (e)). For the VPS-W and W_f/W_m samples several tomographs were taken during the fracture. Altogether 135 tomographs were made for 14 different specimens.

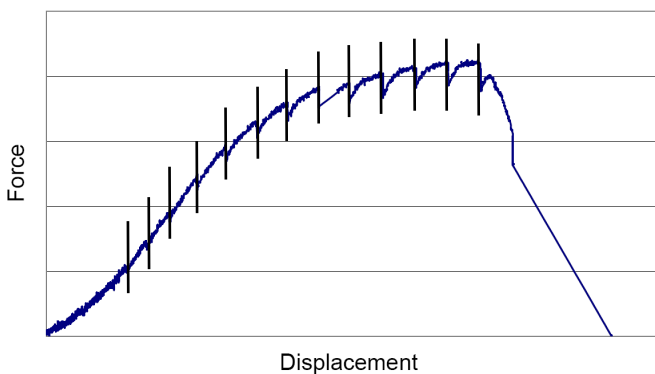


Figure 3 Representative Force-Displacement-Curve; Material W31Cu69; Displacement steps (between tomographs) $0.01 \mu\text{m}$; Displacement rate $0.001 \mu\text{m/s}$; 15 tomographs taken (indicated by vertical lines)