Bragg Institute Neutron Beam Instrument Proposal

ID	**P2391**
Title	**Measurement of residual stresses in Tungsten/Copper composites**
Round	**2012-2 Neutron**
Type	**Normal**
Status	**Completed**
Date Created	**21/2/2012**
Date Submitted	**6/3/2012**
Date Completed	**7/8/2012**

Schedule

The experiment has been scheduled using the following equipment and scientists.

Equipment	Start Date	End Date	Length
Kowari	02/07/2012	05/07/2012	4
Luzin, Vladimir	02/07/2012	05/07/2012	4

Researchers

Name	Role	Attending
Michael Law (ANSTO - IME)	Principal Scientist	Yes
David Gregory Carr (ANSTO - IME)	Co-proposer	Yes

Instruments

Name	Desired Date	No. days requested
Kowari	01/07/2012	4

Name	Requested
Luzin, Vladimir	Yes

Details

Scientific Area	**Materials**
Impossible Dates	**23-26 September, 13-16 October**

Proposed Research (Text): Measurement of residual stresses in Tungsten/Copper composites

Background

Tungsten is a leading candidate for a plasma facing material (PFM) in the ITER experimental fusion system because material properties including a high melting point and low sputtering erosion. The tungsten facing must be intimately bonded to the cooling structure. The cooling structure must have high thermal conductivity and a relatively high melting point; copper has been chosen for this role. These materials are difficult to join by welding or brazing, but have been joined successfully by various forms of sintering and diffusionless bonding. Any stresses that occur as a result of the bonding may affect the integrity of the system in operation [1,2].This experiment is designed to measure the residual stresses that occur in the bonding process.

Strains are locked in at the bonding temperature. On cooling there are significant thermal stresses caused by the different thermal expansions and Young's Moduli of the two materials.

Previous measurements have been made which suggest that plastic deformation occurs in the copper [3]. This is also suggested by FEA analysis (Figure 1) of the composites assuming a bonding temperature of 400 ^{o}C and cooling down to room temperature.

When model validated, the stresses in a full scale composite can be estimated using an inverse FEA technique similar to eigenstrain analysis [4].

After neutron stress measurements are done, we will perform EBSD on a cross-section of the sample at IME. This will give information on the sample texture, grainsize, and morphology; and may help interpret the diffraction data and stresses.

Samples

Two composite samples will be measured; a single tungsten/copper couple of 6 mm thickness, and a functionally graded W/Cu composite. The single W-Cu joint sample is a disc of 14 mm diameter and 6 mm thickness and is composed from a 2.5 mm thick Cu layer and 3.5 mm thick W layer. The functionally graded material is a stack comprising a series of layers with the following composition: 100W-0Cu, 80W-20Cu, 60W-40Cu, 40W-60Cu, 20W-80Cu, 0W-100Cu. Each layer is 1 mm thick [5].

Measurement strategy

A scan will be made through-thickness in the centre of each sample. In the single W-Cu stack we will measure 15 points (6 in Cu layer and 9 in W layer); in the graded composite we will measure 18 points (3 individual point in each of 6 layers with one point in the exact center of the layer and two others at ±0.25 mm away from the local center). The 2 in-plane strain components are assumed to be equal; only one of the in-plane strains and the normal stress component will be measured. A gauge volume of down to 0.3 x 0.3 x 5.0 mm^3 will be used to provide good spatial resolution required for the given samples in through-thickness dimension and at the same time this size will allow sufficient counts to obtain statistically valid data. The in-plane gauge volume size, 5mm, is chosen to maximize diffraction signal but to avoid edge effects that can be seen in Figure 1a. To keep high spatial through-thickness resolution and good localization of the gauge volume the wavelength will be adjusted to have the strongest diffraction peak at 90°: Cu(311): λ = 1.55 ? and W(211): λ = 1.83 ?.

A stress free sample (D_0) has been designed with input from the instrument scientist. Alternatively, with two directions measured, the plane stress condition can be used to recalculate in-plane stress.

Time estimate

In time estimate it is necessary to take into account that Cu and W have different scattering properties, e.g. Cu has diffraction signal ~70% of iron and W has only 20% of that. Therefore, depending on diffraction peak to measure, phase content and background conditions, the actual measurement time can vary greatly from point to point. The following estimate is our best guess based on our previous experiences.

Sample #1 (gauge volume 0.3x0.3x5 mm^3)

Cu: 6 points x 2 directions @ 10 minutes per point = 2 hours

W: 9 points x 2 directions @ 40 minutes per point = 12 hours

Set up time: ~6 hours

Sample #2 (gauge volume 0.3x0.3x5 mm^3)

	100W-0Cu	80W-20Cu	60W-40Cu	40W-60Cu	20W-80Cu	0W-100Cu
Cu(311)	-	60	30	20	15	10
W(211)	40	60	80	120	240	-

(time is given in minutes, 2 directions, 3 individual points per each of 6 layers)
Additional set up time: ~6 hours

The total requested time is 4 days.

Experimental Needs:

Special Requirements:

Hazards:

References: [1] R. Mitteau, J.M. Missiaen, et. al. "Recent developments toward the use of tungsten as armour material in plasma facing components" Fusion Engineering and Design 82 (2007) 1700-1705
[2] M. Kaufmann, R. Neu "Tungsten as first wall material in fusion devices" Fusion Engineering and Design 82 (2007) 521-527
[3] G. Bokuchava, N. Shamutdinov, J. Schreiber and M. Stalder "Determination of residual stresses in W Cu gradient materials" Textures and Microstructures, Vol. 33, pp. 207-217
[4] H. Lee, H. Nakamura, H. Kobayashi "Utilization of thermo-elasto-plastic analysis of welding eigenstrain for improvement of the bead flush method" Engineering Fracture Mechanics 71 (2004) 2245-2255
[5] Z. Zhou, J. Du J, S. Song, Z. Zhong, C. Ge "Microstructural characterization of W/Cu functionally graded materials produced by a one-step resistance sintering method" Journal of Alloys and Compounds 428 (2007) 146-150

Part of a Thesis: No

Samples

Sample Desc / Name	Form	Hazardous	Prepared
Tungsten Copper composite	Solid		Yes

Comments:

Composition:

Hazards: Not hazardous

Name	Formula	CAS	Amount	Hazards
Tungsten	W	7440-33-7	20	Toxicity: 2 Body Contact: 2 Reactivity: 2 Chronic: 2
Copper	Cu	7440-50-8	20	Toxicity: 2 Body Contact: 2 Reactivity: 2 Chronic: 2

Figures

figure1 proposal.jpg

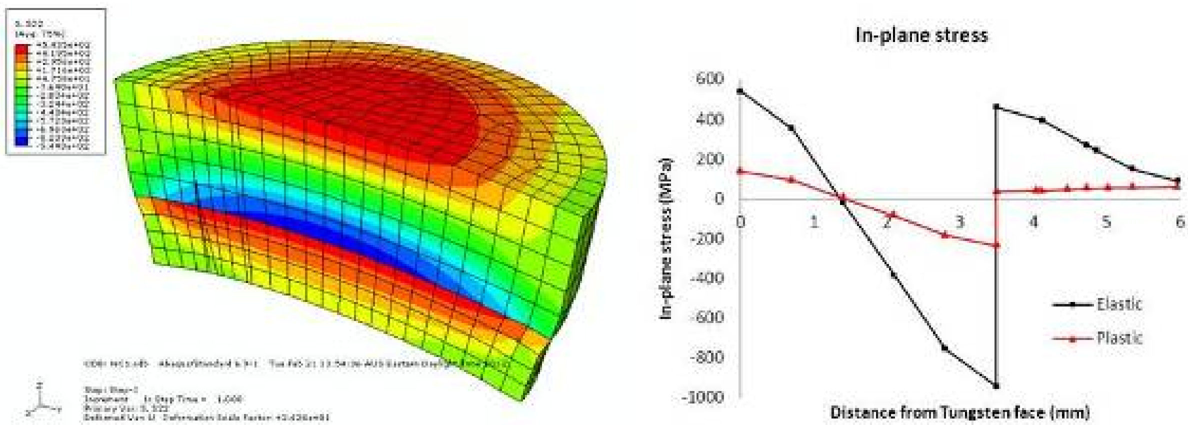

Figure 1. (a) FEA model of stresses due to bonding at 400 °C and cooling to room temperature, elastic-only analysis. Tungsten top and copper bottom. (b) Simulated stresses due to bonding at 400 °C and cooling to room temperature, elastic-only and elastic-plastic analyses.