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ESRF

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

http://193.49.43.2:8080/smis/servlet/UserUtils?start

Reports supporting requests for additional beam time

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** Fracture behaviour of heterogeneous tungsten materials for fusion reactors	**Experiment number**: MA – 859
Beamline: ID15 A	**Date of experiment**: from: 25.11.209 to: 28.11.2009	**Date of report**: 15.02.2010
Shifts: 9	**Local contact(s)**: Mario Scheel, Mario di Michiel	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

J-H. You[1)]*, J. Riesch[1)]*, M. Köppen[1)]*, J. Du[1)]*, A. Zivelonghi[1)]*, T. Höschen[1)], J-I. Buffière[2)]*

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Report:

Results of MA859 lead to two peer reviewed articles, were presented in several posters and contributed to two PhD theses.

Articles

J. Riesch, Ch. Linsmeier and S.F. Nielsen. **In-situ tomographic observation of crack formation and propagation in tungsten materials in the framework of FEMaS-CA.** Challenges in materials science and possibilities in 3D and 4D characterization techniques -Proceedings of the 31st Risø International Symposium on Materials Science, 405-412, 2010

Abstract:

The EU has funded the Fusion Energy Materials Science project Coordination Action (FEMaS-CA) with the intension to utilize the know-how in the materials community to help overcome the material science problems with fusion related materials. In this framework three different material concepts, tungsten-copper-composite (W/Cu), vacuum plasma sprayed tungsten (VPS-W), and tungsten-fiber/tungsten-matrix-composite (W_f/W_m) were investigated by means of in-situ tomography during mechanical testing. The measuring campaign was conducted at the high energy beamline ID 15A at the European Synchrotron Radiation Facility (ESRF) in Grenoble. A tensile testing machine was used to perform displacement controlled tension tests. At the end of each well defined displacement step a tomogram was taken. Tomographic reconstructions were successfully produced of samples with high tungsten content and sample diameters up to 1 mm. Force-displacement curves were measured during loading to complete fracture. Crack propagation could be observed in the tomographic reconstructions. This paper describes the first results with special focus on the experimental work and the role of FEMaS-CA.

J. Riesch, T. Höschen, M. di Michiel, M. Scheel, Ch. Linsmeier, J.-H. You. **In-situ synchrotron tomography estimation of toughening effect by semi-ductile fibre reinforcement in a tungsten fibre-reinforced tungsten composite system.** Acta Materialia, Vol. 61:19, 2013, pp 7060–7071

Abstract

Tungsten-fibre-reinforced tungsten composites (Wf/W) are supposed to enable enhanced toughness owing to extrinsic energy dissipation mechanisms such as interface debonding and plastic deformation of fibre. In particular, the latter is an effective source of toughening, since ductile tungsten fibres can absorb a considerable amount of plastic work. For a precise evaluation of the toughening capability, the energy dissipation mechanisms need to be analysed in detail. To this end, single-fibre tungsten composite specimens are fabricated and the stress–strain behaviour of the tungsten fibre bridging a matrix crack is measured by means of in situ high-energy synchrotron microtomography during a uniaxial tensile test. Despite the high X-ray attenuation in tungsten, a sufficiently high resolution is achieved and clear images of crack extension and deformation are obtained. The amount of absorbed energy due to plastic deformation of the tungsten fibre is determined and compared with values obtained conventionally from single-fibre tensile tests.

Posters

J. Riesch, J.-Y. Buffière, J. Du, A. Galatanu, P. Hahn, T. Höschen, S. Kimmig, M. Köppen, S. Lindig, S.F. Nielsen, M. di Michiel, C. Prentice, M. Scheel, A. Zivelonghi, Ch. Linsmeier and J.-H. You. Tungsten-fibre reinforced tungsten composites with pseudo-ductile behavior and in-situ analysis by high energy synchrotron tomography. 2nd Brazilian-German Frontiers of Science and Technology Symposium, 2011

J. Riesch, J.-Y. Buffière, J. Du, A. Galatanu, P. Hahn, T. Höschen, S. Kimmig, M. Köppen, S. Lindig, S.F. Nielsen, M. di Michiel, C. Prentice, M. Scheel, A. Zivelonghi, Ch. Linsmeier and J.-H. You. Tungsten-fibre reinforced tungsten composites with pseudo-ductile behavior and in-situ analysis by high energy synchrotron tomography. 13th International Workshop on Plasma-Facing Materials and Components for Fusion Applications / 1st International Conference on Fusion Energy Materials Science (13th PFMC Workshop / 1st FEMaS Conference), Rosenheim, 2011

A. Zivelonghi, T. Weitkamp, J. Riesch, M. di Michiel, M. Scheel, A. Larrue, S. Nawka, A. Brendel, B. Kieback, J.-H. You. High Resolution Synchrotron Tomography and Numerical Modeling of Strongly Absorbing W-based Heterostructures. European Congress and Exhibition on Advanced Materials and Processes (Euromat 2011), Montpellier, 2011

A. Zivelonghi, T. Weitkamp, J. Riesch, M. di Michiel, M. Scheel, A. Brendel; S. Nawka, J.-H. You. Characterization of Two Microstructured Graded Joints for W-armored PFC via Synchrotron Tomography and Numerical Modeling. 13th International Workshop on Plasma-Facing Materials and Components for Fusion Applications / 1st International Conference on Fusion Energy Materials Science (13th PFMC Workshop / 1st FEMaS Conference), Rosenheim, 2011

PhD theses

J. Riesch. Entwicklung und Charakterisierung eines wolframfaserverstärkten Wolfram-Verbundwerkstoffs. Phd thesis, Technische Universität München. 2012
Link: http://mediatum.ub.tum.de/doc/1106428/1106428.pdf

Zivelonghi. Thermomechanical Behaviour of Two Heterogeneous Tungsten Materials via 2D and 3D Image-Based FEM. PhD thesis, Technische Universität München, 2011.
Link: http://mediatum.ub.tum.de/doc/1004657/1004657.pdf