EFDA WORKPROGRAMME 2011

Call for Participation

Emerging Technologies

Fusion Materials Topical Group

Research Project:
MAT-ODSFS: Nano-structured ODS Ferritic Steel Development

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1. Introduction

At its meeting in Dublin on the 23rd June 2010 the EFDA Steering Committee approved the EFDA 2011 Workprogramme, including the tasks identified below. This Call for Participation covers the activities of the 2011-WP of the MAT-ODSFS Research Project of the Fusion Materials Topical Group, Nano-structured ODS Ferritic Steel Development, and will be implemented on the basis of the provisions given in Art. 5 of the EFDA Agreement.

2. Objectives

The foreseen applications of ODS steels are the plate supporting the tungsten tiles in the European dual-coolant lithium-lead (DCLL) breeding blanket concept and the cartridge within the finger-like units of the European He-cooled divertor concept, both for DEMO-type reactors.

The objective of the present programme is to develop an ODS ferritic steel with high tensile and creep strength and sufficient ductility and fracture toughness up to about 750°C as well as good radiation resistance. The strategy for achieving this ambitious objective consists in optimizing the chemical composition and manufacturing conditions at the laboratory scale and, at the same time, launching the fabrication of ODS ferritic steels at the semi-industrial or industrial scale. Activities should yield the industrial production of an optimized ODS ferritic steel for DEMO-type reactors in about five years from now.

The Work Programme 2011 is organised along four activities:

- Production and characterization of laboratory scale batches of nano-structured ODSFS.
  The priority issue: Identification of the optimal chemical composition, fabrication route and thermo-mechanical treatment combination.
- Production and characterization of industrial batches of nano-structured ODSFS.
  The priority issue: Production at industrial or semi – industrial scale of optimised generation of ODSFS with high tensile and creep strength at higher temperatures, and sufficient ductility and fracture toughness for DEMO relevant conditions.
- Irradiation and post- irradiation characterization of produced nano-structured ODSFS.
  The priority issue: Investigate the effect of dose and temperature on hardening and the stability of oxide particles in the grain boundaries.
- State of art of nano – structured ODSFS: Bibliographical review.
  The priority issue: Evaluation of the results obtained mostly by USA and Japan in developing this kind of materials

The main objective of these activities is to produce optimized ODSFS material with a well defined chemical composition, fabrication route and a set of thermo-mechanical treatments, with a first delivery foreseen mid 2011.

The strategy for achieving this ambitious objective consists in optimizing the different relevant parameters involved in the production of ODSFS on small scale batches, i. e., laboratory scale, and, at the same time, developing an industrial or semi - industrial route of fabrication for the optimized material.

3. Work Description and Breakdown

3.1 Work Breakdown

Within the structure and the objectives defined above the Work Breakdown will be as follows.

(i) Production and characterization of laboratory-scale batches of nano-structured ODSFS.

The goal of this activity is to optimize the chemical composition and the conditions of manufacturing by powder metallurgy, including mechanical alloying followed by either hot isostatic pressing (HIPping) or hot extrusion and thermo-mechanical treatments, like cross hot rolling, high speed hot extrusion, etc., in order to obtain a dense population of small nano-clusters and submicrometre grains, both conditions being required for high creep strength and reasonable fracture toughness after irradiation. Small batches up to about 1 kg will be produced at the laboratory scale.

Characterization before irradiation of the produced ODSFS will be done. This includes microstructural investigation and mechanical characterization:

- Microstructural investigation: Optical microscopy, SEM, TEM, APT, SANS, XRD, laser confocal microscopy, chemical analyses, etc.
- Mechanical characterization: Tensile tests, compression tests, fatigue tests, Charpy impact tests, fracture toughness measurements, microhardness measurements, nano-indentation experiments, etc.

The deliverables are summarised in the table below:

2011-WP: Production and characterization of laboratory-scale batches of nano-structured ODSFS
Deliverables
12/2011: Report on optimisation of the chemical composition Range of chemical compositions: Fe-(12-14)Cr-(1-3)W-(0.1-0.5)Ti-(0.2-0.4)Y2O3
12/2011: Report on optimisation of MA and HIPping and /or hot extrusion conditions
12/2011: Report on optimisation of thermo-mechanical treatments Cold/hot pressing, rolling, forging, …etc Severe plastic deformation methods
12/2011: Report on mechanical characterization Tensile/compression tests Fatigue tests Charpy impact tests Creep tests Fracture toughness measurements Hardness measurements Nano-indentation experiments
12/2011: Report on microstructural examination Optical microscopy

SEM/FIB
TEM
APT
SANS
XRD
Laser confocal microscopy
Chemical analyses

Emphasis on analyses of the grain size distribution, the oxide particles (chemical composition, crystallographic structure, size distribution, number density), and the interfaces between the matrix and the oxide particles, before and after annealing/aging experiments.

(ii) Production and characterization of industrial batches of nano-structured ODSFS.

Both presently identified applications of ODSFS for DEMO-type reactors require quantities of materials that are orders of magnitude larger than those currently manufactured at the laboratory scale and, hence, material should be fabricated using semi-industrial or industrial scale-methods. Therefore, the goal of this line is to probe the feasibility of the production of ODSFS in large batches around 5-15 kg.

Activities will include the joint definition of the chemical composition and manufacturing conditions, the production of one or several batches, and the preliminary characterization of the batche(es) in the unirradiated condition. Characterization activities should be comparable to the ones described under the previous line, but should also include analysis of the physical properties (thermal, electrical and magnetic properties).

The deliverables are summarised in the table below:

2011-WP: Production and characterization of industrial batches of nano-structured ODSFS
Deliverables
06/2011: Report on the delivery of the semi-industrial scale batch(es) of 5-10 kg of ODSFS based on powder metallurgy fabrication routes Range of chemical compositions: Fe-(12-14)Cr-(1-3)W-(0.1-0.5)Ti-(0.2-0.4)Y2O3
12/2011: Report on optimisation of MA and HIPping and /or hot extrusion conditions
12/2011: Report on optimisation of thermo-mechanical treatments
12/2011: Report on mechanical characterization

(iii) Irradiation and post-irradiation characterization of produced nano-structured ODSFS.

The goal of this line is obtain preliminary information about the irradiation-induced microstructure, with a focus on the stability of oxide particles, and the radiation hardening by performing ion irradiations of the laboratory scale batches in the JANNuS facility in various conditions as well as post-irradiation characterization.

Activities will include joint definition of the irradiation conditions, irradiation experiments (including eventually in-situ TEM) and post-irradiation characterization of the batches. Post-irradiation examination (PIE) will include TEM analyses and hardness measurements.

The deliverables are summarised in the table below:

2011-WP: Irradiation and post-irradiation characterization of produced nano-structured ODSFS.
Deliverables
12/2011: Report on irradiation-induced microstructure and hardening Emphasis on effects of irradiation temperature, damage, damage rate, helium and/or hydrogen contents.

(iv) State of the art of nano-structured ODSFS: Literature review.

This line refers to an evaluation of the available information about ODSFS produced in USA and Japan.

The deliverables are summarised in the table below:

2011-WP: State of the art of nano-structured ODSFS: Literature review.
Deliverables
12/2011: Report on the evaluation of the available information about ODSFS produced in USA and Japan

Priority Support:

The 2011 Work-Programme described above is proposed under Baseline Support, except the fabrication of the semi-industrial batch ~10 kg of 14YWT type nano-structured ODSFS via sub-contracting to industrial companies specialised in the various fabrication processes, which is proposed under Priority Support for 0.5 PPY and 60 k€, for powder procurement, Mechanical Alloying (MA) and TMT sub-contracting; and the investigation of the effect of dose and temperature on hardening and the stability of oxide particles in the grain boundaries, which is proposed under Priority Support for 0.3 PPY and 100 k€

Projects	**Manpower PPY**	**Other Expenditure k€**
Semi-industrial fabrication of a 10 kg batch of ODSFS	0.5	60
Investigate the effect of dose and temperature on hardening and the stability of oxide particles in the grain boundaries	0.3	100
TOTAL	**0.8**	**160**

3.2 JET related activities

Non-applicable.

3.3 Publications

A list of publications produced on the basis of results of the 2011-WP, will be compiled after the completion of these tasks.

4. Scientific and Technical Reports

4.1 Progress reports

At the end of each calendar year and at intermediate times where appropriate, the Task Coordinator shall submit a report on activities under the Task Agreement to the EFDA Leader for his approval. These reports shall describe the progress made by each Association on each activity, and they shall indicate the level of achievement of the objectives, the status of the activities, the allocation of resources and recommendations for the next year where applicable. The EURATOM financial contribution will be made through the usual procedures for baseline support through the Contract of Association.

4.2 Report of achievements under Priority Support (final report and, when appropriate, intermediate reports):

The progress of tasks undertaken under Priority Support and the status of deliverables will be reported separately to the EFDA Leader. A final report (and intermediate reports indicating any substantial progress in the achievement of deliverables, if requested by the EFDA Leader) shall be prepared by the Task Coordinator and submitted to the EFDA Leader. These reports shall include specific sub-sections for each of the Associations involved. They shall document the degree to which the deliverables outlined have been achieved, and shall include a breakdown of expenditure for each Association. The EURATOM financial contribution will be made after approval by the EFDA Leader of these reports.

4.3 Milestones.

The results obtained within the Research Project Nano-structured ODS Ferritic Steel Development will be presented by the principal investigators and reviewed during joint monitoring meetings held twice a year. On this basis the progress accomplished by the contributing Associations will be reported by the Coordinator to the EFDA Leader.

The report on the Association activities under Priority Support will be prepared by the Coordinator to be presented to the EFDA Leader at the end of every calendar year.

The final and technical report will be submitted to the Responsible Officer of the Topical Group for approval and uploading in the IDM database.

5. Association Proposal

The Associations are requested to complete the Association Response via the ECoM system.