OVERVIEW OF R&D ACTIVITIES WITHIN IFERC IN SUPPORT OF FUSION DEVELOPMENT IN THE CONTEXT OF THE BROADER APPROACH AGREEMENT PHASE II

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ABSTRACT

- The International Fusion Energy Research Centre (IFERC) is one of the three projects executed by EU and Japan under the Broader Approach Agreement. IFERC has three lines of activity: the DEMO Design and DEMO R&D activities, the Computational Simulation Centre (CSC) and the ITER Remote Experimentation Centre (REC).
- The progress of DEMO R&D activities in BA Phase II are briefly overviewed; R&D on tritium technology and development of structural material for fusion DEMO in-vessel components.

BACKGROUND

- Fuel retention studies in plasma-facing materials (PFMs) are important for controlling tritium (T) inventory in the vacuum vessel. ITER has excluded carbon (C) wall components to avoid potential risks of rapid T accumulation by co-deposition with eroded from the wall.
- Under the framework of DEMO R&D activity, JET samples cut from the Be limiters, W-coated CFC and bulk W lamellae divertor tiles retrieved after ILW-1 and ILW-3 campaigns were shipped to QST for detailed analyses of morphology with emphasis on T content. The aim was to obtain the global T distribution pattern in JET with metal walls.

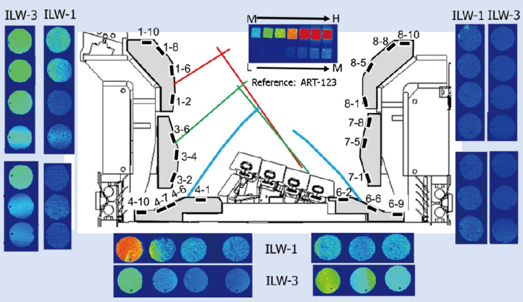
METHODS

NONDESTRUCTIVE ANALYSIS

Scanning electron microscopy analyses (SEM), electron micro-probe analyser (EPMA), X-ray photoelectron spectroscopy (XPS and T mapping using the IP technique and β-ray induced X-ray spectrometry (BIXS).

DESTRUCTIVE ANALYSIS (not shown here)

The samples were sectioned for transmission electron microscopy (TEM) and T measurements using thermal desorption spectroscopy (TDS), including full combustion method (FCM).



Cross-sectional view of divertor region of JET together with 2-dimensional β-ray images of disk samples cored from W-coated CFC tiles (Tiles 1, 3, 4, 6, 7 and 8) and sample taken from W lamella tile (Tile 5, Stack C, C3 lamella). Reproduced from Fig.7 in Ref.[1].

OUTCOME

- In the divertor region, the T-containing co-deposits were preferentially formed on the W-coated CFC tiles located at the upper-inboard region (Tile 1) and shadowed regions of floor tiles (Tile 4 and Tile 6).
- The co-deposit formed on the shadowed region of Tile 4 (Sample 4-10) in ILW-1 showed outstandingly high T concentration. Such co-deposits with high C and T contents were not observed after ILW-3.
- The T retention in the W-coated CFC divertor tile after ILW-3 was higher than that after ILW-1.
- The T retention on plasma-facing surfaces of the bulk W tile lamellae was negligibly small, while co-deposition of T with Be and O were observed on the side surfaces facing to toroidal and poloidal gaps.

BACKGROUND

- To develop the technical basis for DEMO SDC for in-vessel components; Breeder Blanket and Divertor and respective material Annexes for RAFM steels, Cu-alloys, and W-based materials.
- Due to the limited number of existing data (F82H), this study specifically employs a Bayesian prediction method based on Monte Carlo simulations to determine a material reference value with statistical reliability and to investigate its effectiveness.
- In parallel, MPH based on conventional method has been developed for EUROFER97-3.

METHODS

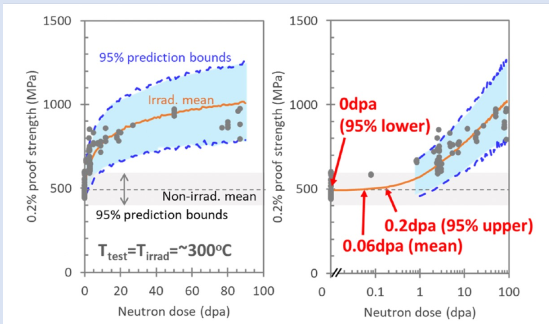
PROBABILITY-BASED DESIGN

Log-Normal model ϕ : Neutron dose ϕ_0 : Threshold

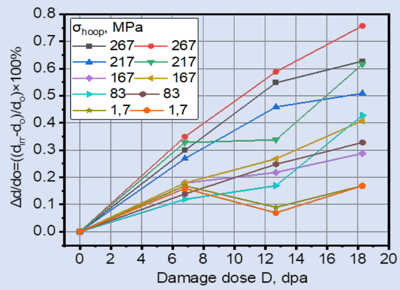
$$\frac{1}{\sqrt{2\pi\sigma^2}} exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)$$

$$\phi < \phi_0 \quad \begin{cases} \mu(\phi) = \mu_0 \\ \sigma(\phi) = \sigma_0 \end{cases}$$

$$\phi > \phi_0 \quad \begin{cases} \mu(\phi) = \mu_0 + \beta_1 log_{10}(\phi - \phi_0 + 1) \\ \sigma(\phi) = \sigma_0 + \beta_2 log_{10}(\phi - \phi_0 + 1) \end{cases}$$



0.2% proof strength vs. neutron dose dependence with mean and 95% Bayesian prediction bounds (Log-Normal model). Reproduced from Fig.7 in Ref[2].



High dose data on irradiation creep of EUROFER97-3 at Tirr=325 ° C obtained in BOR-60 reactor. Reproduced by the presentation in Ref.[3].

OUTCOME

- Bayesian method is applied to determine reference standard strength for neutron-irradiated F82H. 'Log-Normal' distribution gave better predictions for 0.2% proof strength.
- MPH of EUROFER97-3 has been developed using high dose on irradiation creep.

REFERENCES

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