Romanian participation at EUROfusion WPMAT and complementary research

1) *Acronym: WPMAT-RO*
2) *Contract no.: EURATOM-RO/CDI/2024-2-002*
3) *Funding program: PNCDI IV/5.9/5.9.2/Modul EURATOM-RO + GA101052200*
4) *Project duration: 23 months (2025.02.261 – 2026.12.31)*

Project Summary

INCDFM's proposed contribution for the Work Package MAT is focused on HHFM processing and characterization. The processing part covers materials fabrication from K-doped W foils using the already demonstrated FAST-based technology and also joining technologies for dissimilar materials with FAST, diffusion bonding and brazing technologies. With the available equipment, INCDFM can cover small scale component manufacturing. In terms of characterization INCDFM can contribute as it already did in the previous work to thermo-physical properties characterization (thermal and electrical transport properties, thermal expansion) as well as microstructure investigations using XRD, SEM, HRTEM and various spectroscopic techniques (XRF, XPS, SIMS-TOF, ICP MS, FTIR, etc.). Both joining technologies and materials characterization methods can accommodate also investigations for other tasks, like steels or functional materials.. The complementary part aims to develop new materials processing routes and investigation techniques Development of non-destructive investigation of different joint types using X-ray computer micro tomography or micro XRF from INFLPR-Tiseanu partner might provide an additional tool for ND testing for components including dense materials like W. However, due to the high W absorption of X-rays, the specimens investigated until now, in spite of the incremental progress obtained (from sub millimetre to a few millimetres) are still small and usually not relevant for real scale divertor components. Based on the recent results obtained on layered materials containing at least one W part and benefiting from the new developed techniques by INFLPR-Tiseanu group, we aim to further refine this techniques. Moreover, new materials are emerging as promising for fusion applications, e.g. HEAs containing one or several high Z components, whose 3D microstructural characterizations poses increasing challenges. In terms of the materials interactions with energetic particles, we have already collaborated with INFLPR-Ticos group to investigate irradiated surfaces aiming to detect possible elements expelled from inside of composites or deteriorations of joint in multi-material structures. However the experimental set-up might be further improved in 2 directions (to expand the beam toward larger area or, oppositely to focus the beam to a smaller spot and to analyse the effects on adjacent areas which will be affected by large thermal stresses, thus analysing local thermal shock effects. In terms of processing and joining technology development we aim to develop a SPS-based technology for embedding interfaces in monoblock type components. Finally, we aim to improve our capabilities to produce new materials with an emphasis on new high entropy alloys. Many of these HEAs can be produced by arc melting and casting allowing on one side to have a more simple and scalable route to production and on the other side to compare the materials properties to those produced by powder metallurgy routes (like mechanical alloying followed by sintering).

Summary of results obtained in 2025

INCDFM's contribution to the Work Package MAT is focused on HHFM processing and characterization. In 2025 the processing part covered materials fabrication from K-doped W foils (KdWL) using the already demonstrated FAST-based technology (specimens for HHF, tensile and neutron irradiation tests and also ultra sound calibration specimens with artificial engineered defects) as well as other W materiuals for IPP-CR and CEA research units. With the available equipment, INCDFM can cover laboratory scale component manufacturing. Thus also a study regarding the processing up-scaling to industrial level was initiated. In terms of characterization INCDFM contributed to thermo-physical properties characterization, in 2025

participating in the "W stress relieved" characterization campaign. Also investigations on KdWL own materials and materials from KIT, SCK, IST and CIEMAT have been performed. Supporting the task MAT-T.03.04-T070, in 2025 new tools have been developed in INCDFM in order to improve the quality of the joints produced using our FAST equipment. INFLPR-Tiseanu partner work was focused on the assessment of the quality of the W-Cu composite produced by AM and Cu infiltration using X-ray Microtomography (XCT) as a non-destructive imaging solution for specific challenges like cracking and porosity. The analysis employed a multi-phase strategy, utilizing a 320 kV microfocus X-ray generator for the initial overview scan of relatively large rod samples. INFLPR-Ticos partner work was focused to obtain a very narrow electron beam profile at the ALID accelerator. This would increase the electron density on the surface and it would subject the materials to a harsher test under radiation.

Dissemination and visibility

1) *"Investigation of neutron irradiated W/CuCrZr joints", K. Poleshchuk, D. Terentyev, A. Galatanu, K. Verbeken, Journal of Nuclear Materials 604 (2025) 155496, doi: https://doi.org/10.1016/j.jnucmat.2024.155496*
2) *"Liquid-copper infiltration and characterization of additively manufactured W-lattice structures", A. Iveković, G.K. Muralidharan, A. Galatanu, G. Li, K. Vanmeensel, J. Vleugels, J. Alloys and Comp. 1011 (2025) 178411. https://doi.org/10.1016/j.jallcom.2024.178411*
3) *"Thermal Stability and Irradiation Resistance of (CrFeTiTa)70W30 and VFeTiTaW High Entropy Alloys", A. Pereira, R. Martins, B. Monteiro, J.B. Correia, A. Galatanu, N. Catarino, P.J. Belec, M. Dias, Materials 18 (2025) 01030, https://doi.org/10.3390/ma18051030*
4) *"Non-destructive ultrasonic inspections of small-scale mock-ups provided with advanced tungsten armours for DEMO divertor target", R. De Luca, E. Cacciotti, M. Cerocchi, F. Crea, S. Roccella, H. Greuner, K. Hunger, C. Bonnekoh, A. Galatanu, A. Ivekovic, P. Jenus, M. Wirtz, Fus. Eng. Des. 215 (2025) 115007. https://doi.org/10.1016/j.fusengdes.2025.115007*

Conference contributions:

A. Galatanu, M. Galatanu, Advanced tungsten materials produced in NIMP for divertor armor application in thermo-nuclear fusion reactors, presentation at IBWAP-2025,Constanta, Romania, 9-12 July 2025.

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