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| **Project Title** | **Qualification of low pressure plasms spraying for fusion application and** **design of an in-situ application usable within a fusion-relevant device**  |
| **EUROfusion RO** | Dr. Sebastijan Brezinsek, WP PWIE |
| **Background** | The exchange of damaged plasma-facing components (PFCs) in fusion devices is time- and resource-taking. The *in situ* coating of PFCs can save resources and minimize the idle time. The low-pressure plasma spraying (LPPS) is an option for making tungsten coating for campaign-long operation without the exchange of components. The operation of LHD with the divertor plate coated with tungsten using LPPS demonstrated positive results [M. Tokitani et al. NME 2019]. This project scope comprises making the robust tungsten coating on carbon, steel and tungsten using the LPPS, coating qualification under fusion-relevant conditions and a pilot LPPS design for operation inside the fusion device usable for larger area coating as well as repair. The *in situ* tungsten coating is of potential interest for several devices such as W7X, JT60-SA, WEST, etc. possibly ITER at the later stages of its exploitation and certainly, for the DEMO divertor.  |
| **Objectives** t | The proposed project aims the training of the candidate with an engineering background in the leading EU laboratories and research centres to explore and to qualify the option of LPPS tungsten coating for the *in situ* application inside fusion devices in the EU and abroad.Besides the general training purpose, the project will have three main objectives:1. Obtaining the robust tungsten coating on carbon, steel and tungsten substrates with the necessary thickness of 100 microns and more.
2. Qualification of the best coatings under fusion-relevant plasma and heat load condition
3. Making a pilot design of the LPPS system for in situ tungsten coating inside fusion devices (e.g. on a remote handling arm)
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| **High-level work description**  | a) The project will start with the literature research and introduction to the LPPS and material testing facilities at FZJ. b) Then the candidate will learn and perform under the guidance of FZJ professionals the coating on carbon, steel and tungsten substrates using the LPPS systems and analyse the quality of the coatings: porosity, adhesion, thickness and homogeneity.c) Subsequently the trainee will receive the introduction to plasma and heat load qualification and participate in the coating qualification using the linear plasma device PSI-2 at FZJ. The training is planned to be extended by the specialists from DIFFER in the Netherlands and IPP Garching in Germany, followed by the qualification of the best LPPS coatings under high plasma and particle loads in MAGNUM PSI and e.g. GLADIS facilities respectively. Sputtering resistance and robustness of the coating will be evaluated. The optimization of the coating technology will be made based on qualification. d) Optimized coating technology will provide an input to the third phase of the project – the conceptual pilot design of the *in situ* LPPS system for fusion. It is expected that this phase will be enforced by an intensive exchange between the trainee and the specialists from interested EU facilities such as e.g. the WEST tokamak in France and the W7X stellarator in Germany. CAD and other trainings will be organized at FZJ. It is also planned to present the conceptual pilot design to the interested fusion facilities and to discuss its further realization.e) The project will end with final analyses and writing the final report

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| Months: | 1-3 | 3-12 | 13-18 | 19-24 | 25-30 | 31-36 |
| Introduction, literature research, gaining the initial experience with LPPS  |  |  |  |  |  |  |
| Making tungsten coating using LPPS, initial evaluation of coating quality and optimization of coating technology |  |  |  |  |  |  |
| Qualification of the best coatings in fusion – relevant plasma and high heat load conditions |  |  |  |  |  |  |
| Evaluation of required performance of the LPPS system for in situ coating and repair. |  |  |  |  |  |  |
| Pilot design of the LPPS system for in situ fusion application.  |  |  |  |  |  |  |
| Completion of the project, final analyses data logging and final report on project |  |  |  |  |  |  |

*Gantt chart of high-level activities* |
| **Competences required** before start of EEG (bullet points)* General engineering background, master’s degree in engineering preferable, engineering of energy systems is of advantage…
* Practical experience in material testing is of advantage, good CAD knowledge highly desirable
* Good communicability, ability to work both individually and within the group are highly desired, fluent English both in writing and speaking is required
 | **Competence development** during project (bullet points)* General knowledge on fusion energy system, practical knowledge in fusion-related experiments, deep understanding of fusion-specific, magnetic, temperature, particle and heat load environment in fusion devices
* Vast practical experience in material testing, in design of fusion components, CAD knowledge at professional level
* Better communicability, vast connections and collaborations within fusion community in the EU.
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| **Facilities used** | Required facilities* The low-pressure plasma spray facility in the Jülich Thermal Spray Center at the FZJ with several plasma guns for tungsten coating and its optimization
* The linear plasma device PSI-2 at FZJ for plasma qualification of the coating

Optional, but highly desired:* The MAGNUM PSI facility at DIFFER, The Netherlands of qualification of the best coatings under divertor-relevant high plasma fluxes (tbc)
* GLADIS facility at IPP Garching for the high heat load tests (tbc)
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| **Mobility needs** | Mobility trips between FZJ, DIFFER and IPP Garching, and possibly IRFM CEA Cadarache and IPP Greifswald for exchange with engineers from WEST tokamak and W7X advanced stellarator. (total 4 months) |
| **Future career possibilities**  | In case of the project success, it is planned to get the highly skilled engineer with motivation to continue his career on the EU fusion facilities, well implemented in the fusion community, with excellent knowledge and practical skills on:* Design of *in vacuo* devices for fusion facilities
* Component engineering
* Material properties
* Understanding of magnetic, plasma, neutron and heat load environment in fusion devices

Upon fulfilment of the project the trainee is expected to be on high demand for e.g. ITER diagnostic systems (still in progress), filling the potentially, critical gap in the project, strengthening the EU participation in the JT-60SA project and contributing to design of the EU DEMO components.  |