AMD Unit Coordinated Research Projects I

Plasma-wall Interaction with Reduced-activation Steel Surfaces in Fusion Devices

("Steel Surfaces")

Objectives

- To enhance the knowledge base and develop new databases on the interaction of fusion plasma with the reduced-activation steel alloys that are being considered for constructing the plasma-facing components of a fusion reactor.
- To quantify the erosion due to exposure to plasma and to quantify the retention and transport properties of tritium in the surface

Research Coordination Meetings (RCMs)

9 – 11 December 2015 (IAEA HQ)

16 – 18 October 2017 (IAEA HQ)

25 – 27 March 2019 (IAEA HQ)

https://amdis.iaea.org/CRP/steel-surfaces

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AMD Unit Coordinated Research Projects I

Plasma-wall Interaction with Reduced-activation Steel Surfaces in Fusion Devices
("Steel Surfaces")

8 Participants, 7 Member States

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Vadym MAKHLAI, Institute of Plasma Physics, Kharkov Institute of Physics and Technology, Ukraine
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AMD Unit Coordinated Research Projects I

Plasma-wall Interaction with Reduced-activation Steel Surfaces in Fusion Devices

(“Steel Surfaces”)

Comparison Experiment for the Sputtering of Steel (CESS)

- A set of coordinated experiments on steel surfaces to compare sputtering yields in different experimental devices. As far as possible, identical samples (with comparable histories) will be exposed to deuterium plasma or ion irradiation under comparable exposure conditions.
- Coordinated by IPP Garching (W. Jacob); delays due to COVID

Materials and Techniques

- Pure Fe, Eurofer-97, Rusfer, CLAM, F82H
- SIESTA: 200 eV D ion beam, fluence 5×10^{24} D m^{-2}, sample temperature 450 K
- Mass loss, SEM, TDS, (EBSD), (EDX), (FIB), (TEM), (Ion beam analysis), (NRA), (XPS), (Optical spectroscopy), (GDOES), …

https://amdis.iaea.org/workshops/cess

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AMD Unit Coordinated Research Projects I

Comparison experiment on the sputtering of EUROFER, RUSFER and CLAM steels by deuterium ions

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ABSTRACT

In this work, the RAFM steels EUROFER, RUSFER and CLAM, along with a reference pure Fe sample, were all exposed to the same source of deuterium and analyzed using the same techniques, allowing a direct comparison of the experimental results. A 200 eV/D mass-selected deuterium ion beam at the SIESTA facility was used to bombard the samples to a fluence of 5×10^{24} D m^{-2} at 450 K. The surface morphology of the samples was investigated with Scanning Electron Microscopy. The sputter yield of the samples was determined by weight-loss measurements and confirmed by measurements of the eroded depth. The near-surface enrichment of W and Ta was investigated via Energy-dispersive X-ray spectroscopy, X-ray Photoelectron Spectroscopy and Rutherford Backscattering Spectrometry. Grain-orientation-dependent sputtering was studied with Confocal Laser Scanning Microscopy and Electron Backscatter Diffraction. Lastly, Nuclear Reaction Analysis and Thermal Desorption Spectrometry were employed to analyze deuterium retention in all the samples. The erosion behavior of all three steels under deuterium bombardment was confirmed to be similar. The measured sputter yield was comparable for all three steels, and significantly lower than that of pure Fe. Likewise, all steels develop a needle-like surface morphology under the given exposure conditions and a W- and Ta-enriched layer in the range of few nanometers, while the Fe sample remained smooth. Retained deuterium amounts were also comparable among the steel samples, and were overall larger than the retention measured for the pure Fe sample.

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AMD Unit Coordinated Research Projects I

Data for Atomic Processes of Neutral Beams in Fusion Plasma **("Neutral Beams")**

Objective

To provide evaluated and recommended data for the principal atomic processes relevant to heating and diagnostic neutral beams in fusion plasmas. The primary emphasis is on processes of hydrogen (H, D, T) neutral beams in the high temperature core plasma.

Research Coordination Meetings (RCMs)

19 – 21 June 2017 (IAEA HQ)

18 – 20 February 2019 (IAEA HQ)

24 – 26 November 2021 (Virtual)

Code Comparison Workshops

26 – 28 August 2019 (ATOMKI, Debrecen, Hungary): Penetration and Photoemission

18 – 20 May 2022 (IAEA HQ): Electron Dynamics in Atomic Collisions

https://amdis.iaea.org/CRP/neutral-beams

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AMD Unit Coordinated Research Projects I

Data for Atomic Processes of Neutral Beams in Fusion Plasma **("Neutral Beams")**

11 Participants, 10 Member States

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AMD Unit Coordinated Research Projects I

Data for Atomic Processes of Neutral Beams in Fusion Plasma **("Neutral Beams")**

Code Comparison Workshop I: Neutral Beam Penetration and Photoemission

Objective

To assess the sensitivity of predictions of hydrogen beam penetration and of beam emissions in relevant fusion plasma conditions to different modelling codes and uncertainties in atomic data.

Test Cases

- H, D, He, (Li, Na)
- 30, 100, 1000 keV
- Plasma densities representative of MCF devices (ITER, W7-X)

https://amdis.iaea.org/workshops/neutral-beam-penetration-and-photoemission

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AMD Unit Coordinated Research Projects I

Data for Atomic Processes of Neutral Beams in Fusion Plasma **("Neutral Beams")**

Code Comparison Workshop I: Neutral Beam Penetration and Photoemission

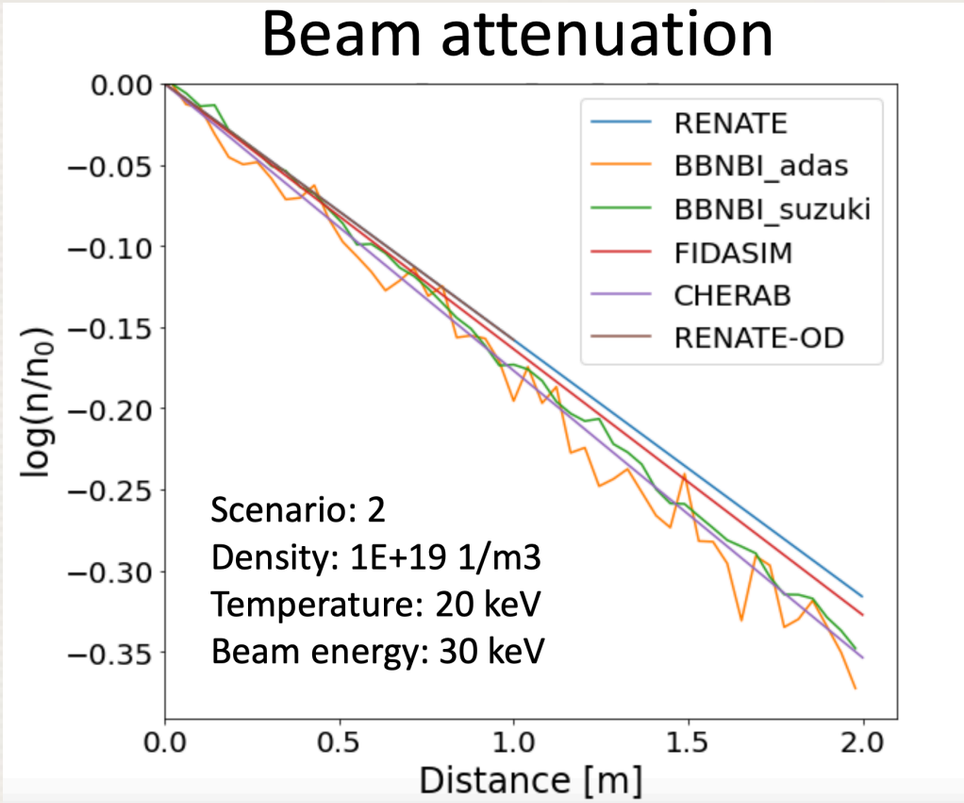
Preliminary Results

- Good agreement across codes
- Good agreement between ALADDIN- and ADAS-based codes

Ongoing Work

Results presented at the 47th EPS Conference on Plasma Physics, 21 – 25 June 2021 (Virtual Conference):

To be published as: Pokol et al. "Neutral Beam Penetration and Photoemission Benchmark"



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AMD Unit Coordinated Research Projects I

Data for Atomic Processes of Neutral Beams in Fusion Plasma **("Neutral Beams")**

Code Comparison Workshop II: Electron Dynamics for Atomic Collisions

Objective

To compare the theoretical approaches, methodologies and computational implementations for the calculation of ion-atom collision cross sections.

Test System: Be^{4+} + H

- 20, 100, 500 keV/u
- H in 1s, 2s, $2p_m$ (m=0, ±1) states
- Processes:
  - Total electron capture
  - Total ionization
  - Total excitation
  - State-selective processes

Computational Techniques

- SC MO close-coupling
- Classical CTMC
- Semiclassical BGM close-coupling
- CCC
- SC AO close-coupling

https://amdis.iaea.org/workshops/atomic-collisions-ccw

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AMD Unit Coordinated Research Projects I

Data for Atomic Processes of Neutral Beams in Fusion Plasma **("Neutral Beams")**

Code Comparison Workshop II: Electron Dynamics for Atomic Collisions

Published Work

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