

## Erosion/deposition measurements using marker techniques

M. Mayer<sup>a</sup>, E. Fortuna<sup>d</sup>, A. Hakola<sup>b</sup>, K. Krieger<sup>a</sup>, J. Likonen<sup>b</sup>, S. Lindig<sup>a</sup>, G. Matern<sup>a</sup>,
R. Neu<sup>a</sup>, M. Rasinski<sup>d</sup>, V. Rohde<sup>a</sup>, C. Ruset<sup>c</sup>, K. Schmid<sup>a</sup>,
K. Sugiyama<sup>a</sup>, and ASDEX-Upgrade team

<sup>a</sup> Max-Planck-Institut für Plasmaphysik, EURATOM Association, Garching, Germany
<sup>b</sup> Association EURATOM-TEKES, VTT Processes, Espoo, Finland
<sup>c</sup> National Institute for Laser, Plasma and Radiation Physics,
Association EURATOM-MEdC, Bucharest, Romania
<sup>d</sup> Warsaw University of Technology, Warsaw, Poland

#### **Motivation**

# Understanding of material transport in fusion devices

- Light versus heavy elements
  - ⇒ Investigation of divertor erosion/deposition in AUG during transition from C-dominated to full-W machine
  - ⇒ Transport of light and heavy elements in the same device
- ITER will start with a full-W divertor into the DT-phase
- A full-W device is the most promising option for DEMO
  - ⇒ AUG already allows to study W transport in a full W machine





### Experimental methods

#### **Methods:**

- Analysis of marker layers before and after exposure for one campaign
- Analysis of regular tiles (D inventory)





### Experimental methods (2)

#### Marker stripes in full-W machine

- W marker stripe for net erosion/deposition
- Uncoated C area for net deposition
- Layer thicknesses by RBS

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Net erosion<sub>PostMortem</sub> = N_{Before} - N_{After}
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 $N_{\text{Before}},\,N_{\text{After}}$ : Amounts of W before and after exposure







#### W erosion/deposition in the AUG divertor

#### Morphology of W erosion: Outer divertor







Initial: 1.5 μm W Mean erosion: 0.28 μm Max erosion: > 1.5 μm

#### Very inhomogeneous erosion of marker

- $\Rightarrow$  5 to 10 times larger local erosion on plasma-exposed surfaces than mean
- $\Rightarrow$  Some W deposition in shadowed areas

### Erosion of W on rough surfaces



- Inhomogeneous erosion due to combined effect of magnetic field + electrical sheath K. Schmid et al., NF 50 (2010) 105004
- Erosion by D, B, C, O-ions predominantly on leading faces
- Small (or no) erosion in shadowed areas and pores



### Deposition of eroded W on rough surfaces



 Almost homogeneous re-deposition of eroded W on rough surfaces
K. Schmid et al., NF 50 (2010) 105004



### Surface modifications after 2009 campaign



After exposure



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PP

- ~10  $\mu$ m thick CMSII layers (C. Ruset) at outer strike point
- 5275 plasma seconds

MF Ringberg November 2010 © Matej Mayer

#### Surface modifications



#### Before exposure

#### After exposure



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### Properties of re-deposited layers





M. Rasinski et al. SOFT 2010

### Marker samples for JET ITER-like wall



- Main chamber: Be on Inconel
- Divertor: W (bulk + 20 µm on CFC)
- PWI questions:
  - Mixed material formation?
  - D inventory?
  - Erosion, re-deposition, transport?
  - Transport of Be, D to remote areas?
  - Comparison to C?



### Marker coatings: Divertor

IPP

- 4 6 µm W marker coatings for erosion/deposition studies
- on 30 divertor tiles
- on 12 lamellas for tile 5





• Marker stripes: Mo, W on W  $\Rightarrow$  demanding data analysis: roughness + plural scattering

 $\Rightarrow$  Simulation improved for complex samples

### Conclusions



#### Marker measurements provide important information on

- Net erosion and deposition areas
- Global material transport
- Properties of redeposited layers
- Deuterium inventory

#### **ASDEX Upgrade**

- Net W erosion in outer divertor, W redeposition in inner divertor
- Very inhomogeneous W erosion on rough surfaces

#### JET

 Marker samples for W erosion/deposition measurements on bulk W and thick W coatings