Review of D retention and release behaviour of Be-relating mixed materials and consequences for ITER

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Outline

Introduction

Experimental procedure

Results

Summary and Outlook

Introduction

Wall materials in ITER

- **690 m² Be**: first wall and start-up limiter modules
- **140 m² W**: divertor dome / baffle region
- **55 m² CFC**: divertor strike point areas

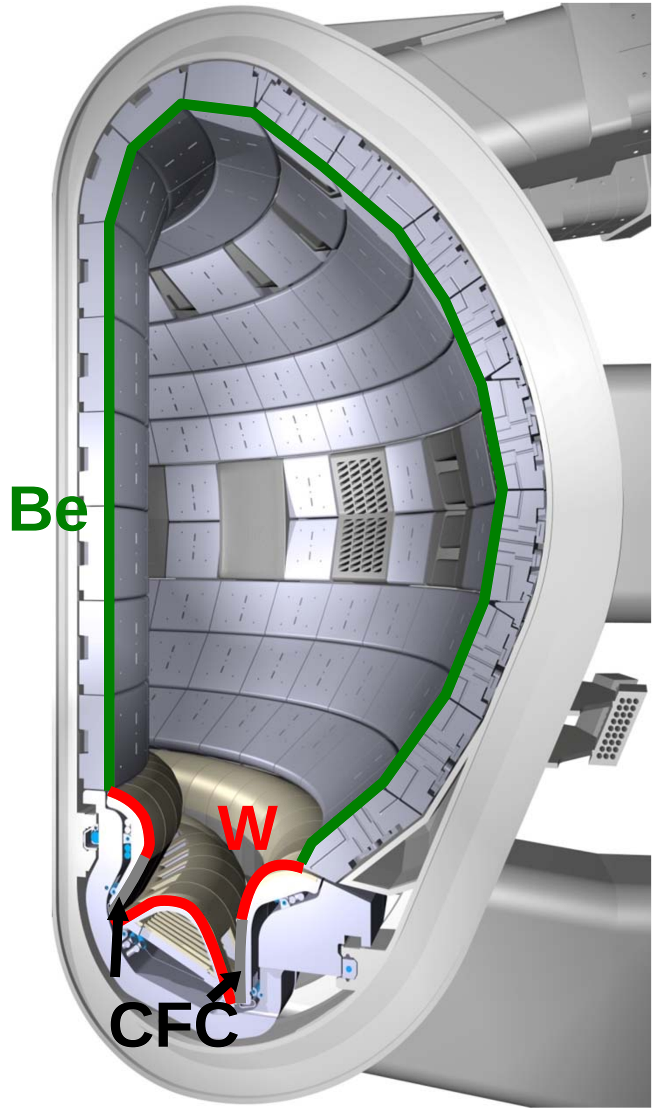
Material mixture
Tritium retention in mixed materials

Wall baking for tritium removal in ITER

- **240 ºC:** Main chamber
- **350 ºC:** Divertor region

Experimental approach in this task

- **Preparation of ITER relevant (Be-related) mixed material samples of about 300 nm**
- **Investigation of D retention and release behaviour of mixed materials**



Outline

Introduction

Experimental procedure

- Be-related layer preparation & characterization
- D implantation & Post-mortem analysis

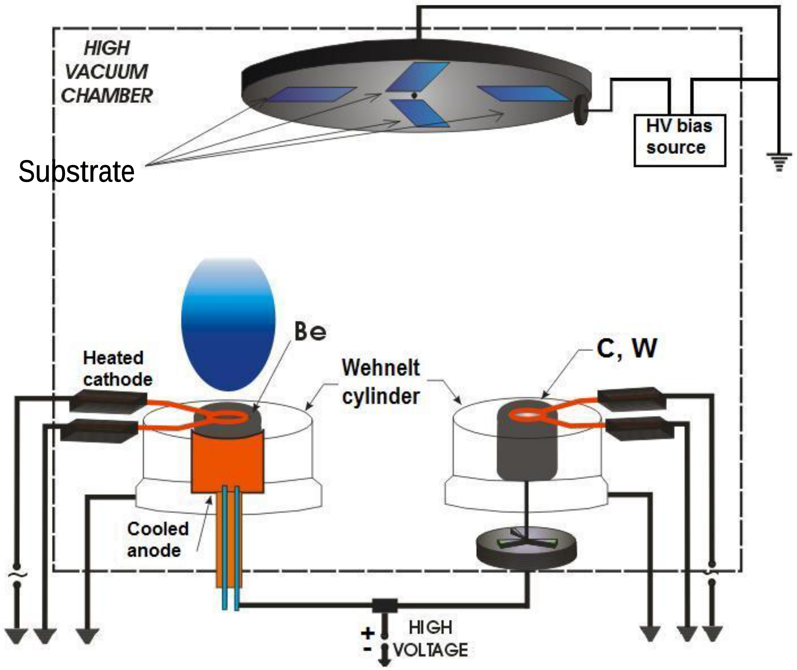
Results

Summary and Outlook

Experimental procedure

Sample preparation

- **Be-related compounds** fabrication by thermal treatment of Be-W / Be-C system
  - ✓ **$Be_{12}W$** fabrication by annealing of W film on Be substrate sample at 1073K, 10 hours
  - ✓ **Be_2C** fabrication by annealing of C film on Be substrate sample at 773K, 3 hours
- **Be-W / Be-C simultaneously deposited layers**
  - ✓ Be-related depositions were prepared by Thermionic Vacuum Arc (TVA) deposition method in MEdC
    - ➢ **Upgrade of TVA setup for the simultaneous deposition**
    - ➢ Depositions were successfully done with varying Be/W and Be/C ratios



Experimental procedure

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- **Be-W / Be-C simultaneously deposited layers**

Sample characterization

- Layer composition analysis by Rutherford Backscattering Spectroscopy
- X-ray Photoelectron Spectroscopy (if needed) for the chemical state analysis

D implantation to prepared layers

- 200 eV D ions implantation in the High Current Ion Source in IPP-Garching
- Flux ~ 10^{19} D/m^2, Fluences up to ~$5 \cdot 10^{23}$ D/m^2

Post mortem analysis for the prepared samples

- D release behaviour analysis by Thermal Desorption Spectroscopy (TDS)
- Quantitative analysis by Nuclear Reaction Analysis using D(^{3}He, p)^{4}He reaction

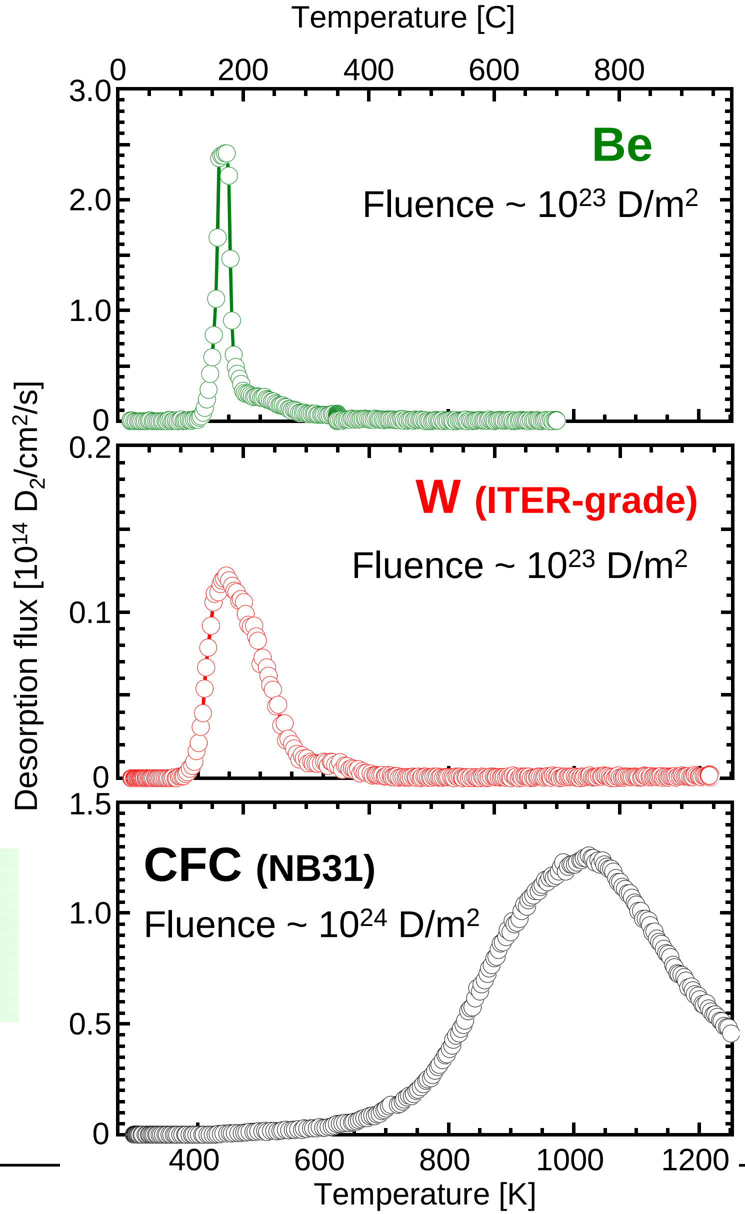
Outline

Typical desorption from pure materials

Typical D desorption spectra from pure materials

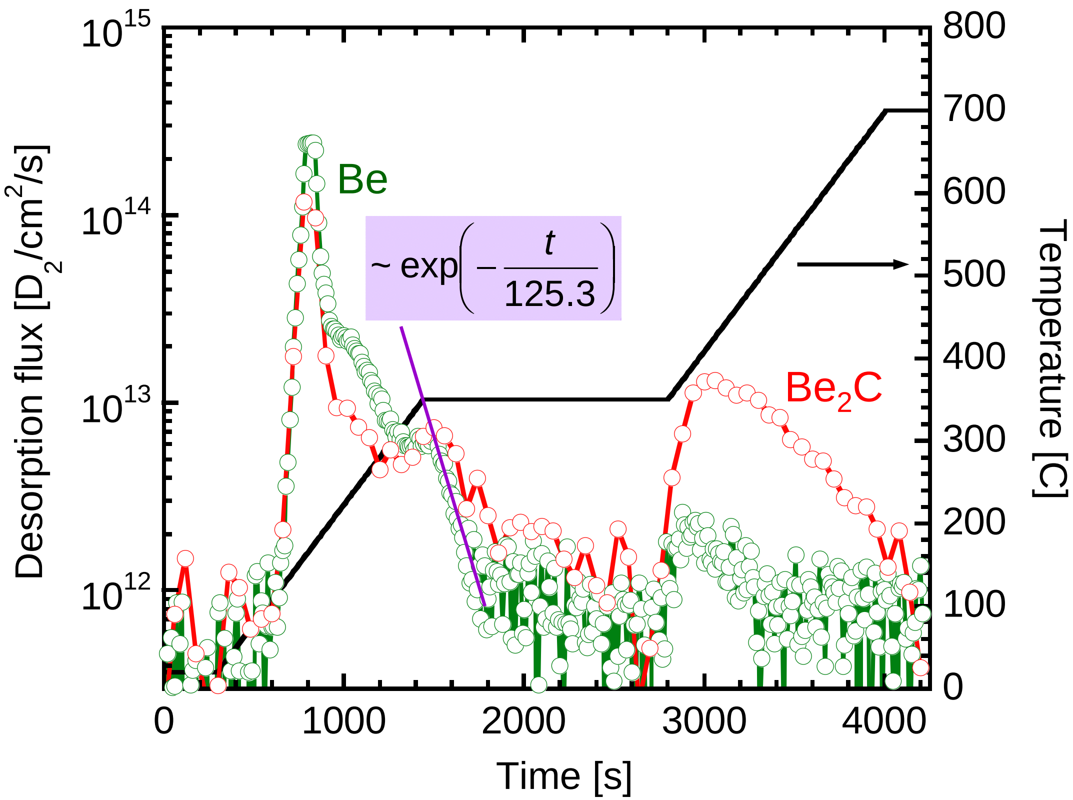
D implantation to each material

- 200 eV D implantation in the High Current Ion Source in IPP-Garching
- Flux ~ 10^{19} D/m^2
- Implantation temperature: RT



- ➢ Be: Sharp desorption peak at 150 -200 ºC
- ➢ W: Primary desorption at 150 - 300 ºC
- ➢ CFC: Broad desorption at 500 - 1000 ºC

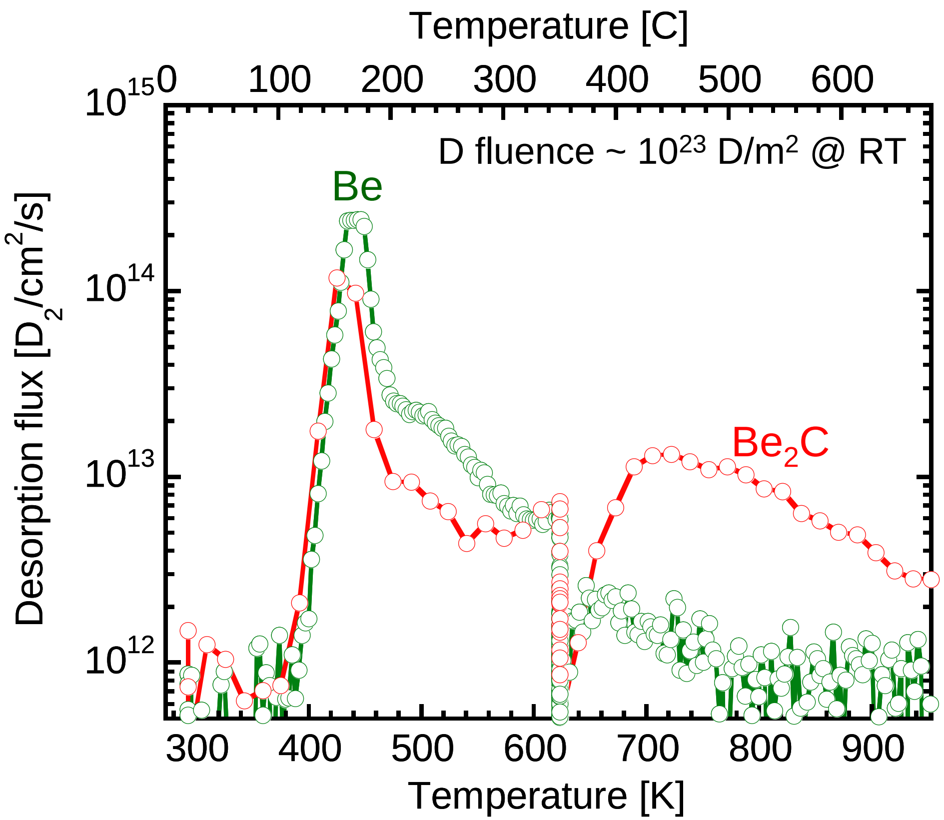
D release during the temperature hold at 350 ºC



- The desorption flux decreases when the temperature reaches the plateau at 350 ºC.
- 5-10 % of retained D additionally released during the 20 min. hold at 350 ºC.

D desorption from Be-related compounds

D implantation to Be-related compound layers

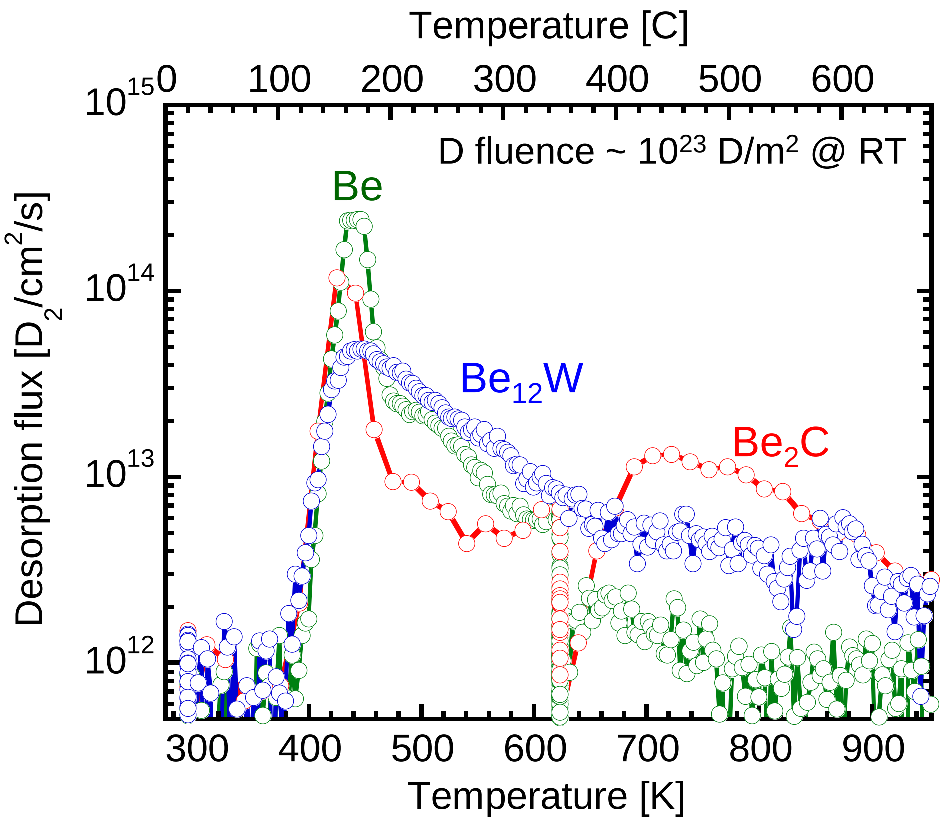


Be: Primary desorption peak at 150-200 °C, 90 % released at 350°C

Be_2C: Additional desorption stage in the high temperature range (> 400 °C)

D desorption from Be-related compounds

D implantation to Be-related compound layers

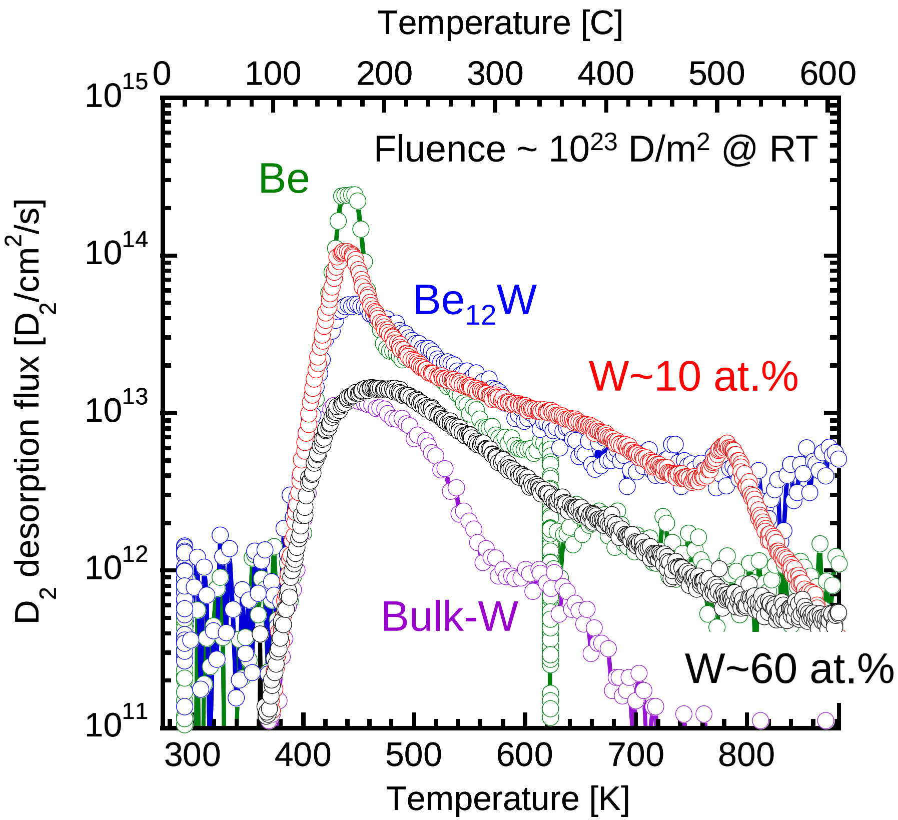


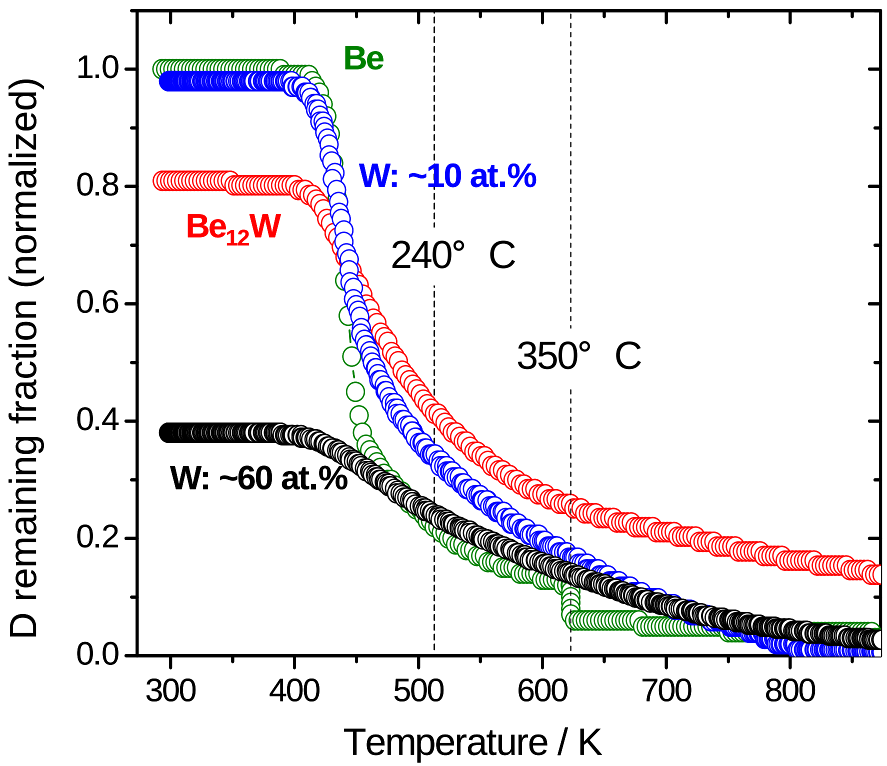
Be: Primary desorption peak at 150-200ºC, 90 % released at 350ºC

Be_2C: Additional desorption stage in the high temperature range (> 400 ºC)

$Be_{12}W$: The primary desorption peak becomes less intense and broader

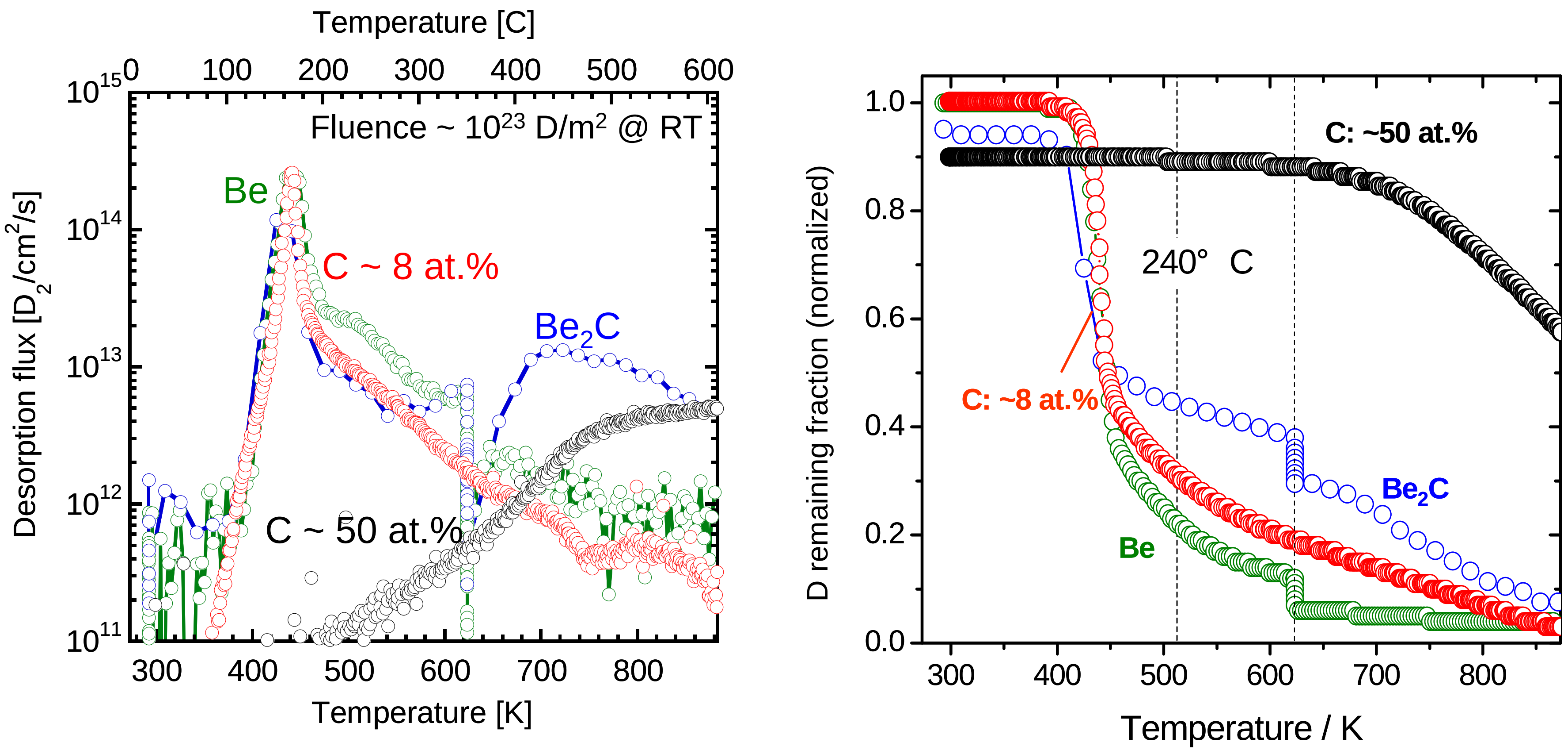
D release from Be-W simultaneously deposited layer





- Mixing of W in Be slightly changes the D desorption behaviour.
- The retention amount decreases by increase of W fraction in Be.

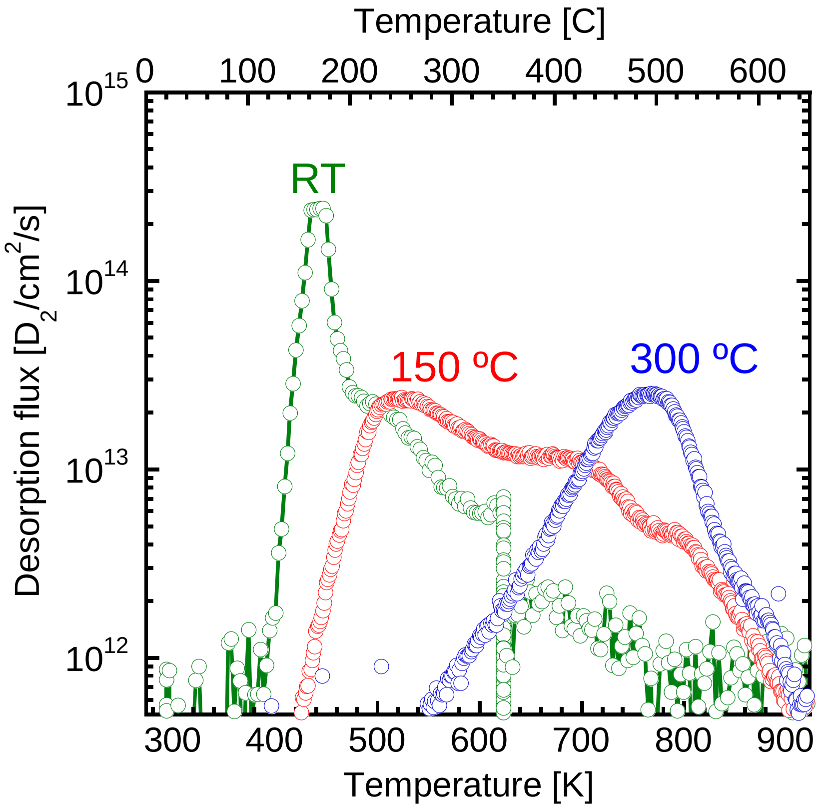
D release from Be-C simultaneously deposited layer

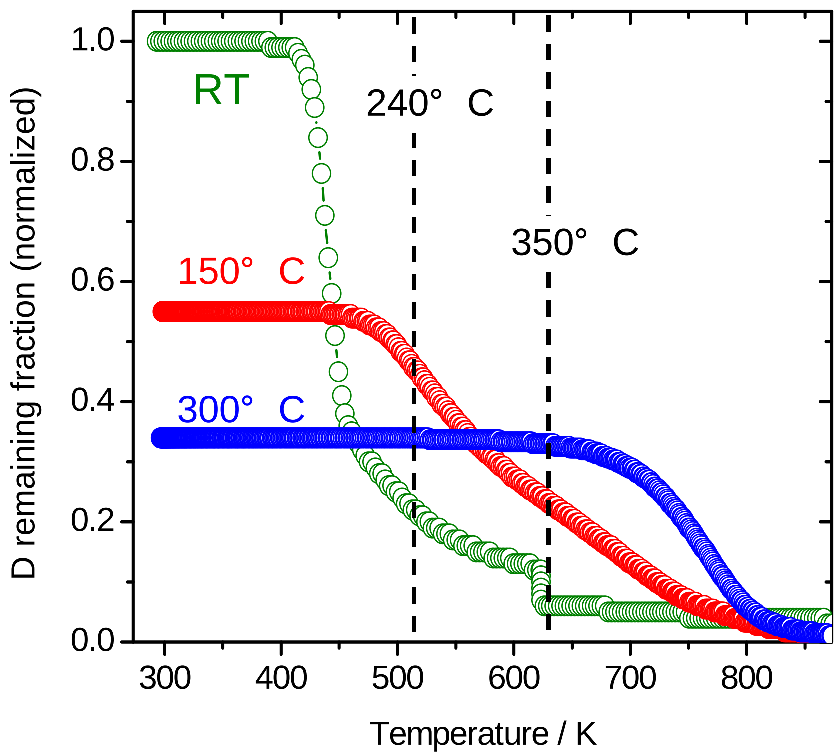


- ➢ D release behaviour totally changes in the case of C-rich mixed layer sample
- ➢ at 50 at% C most of D is trapped at C atoms

Influence of implantation temperature

D implantation to Be layers at different temperatures

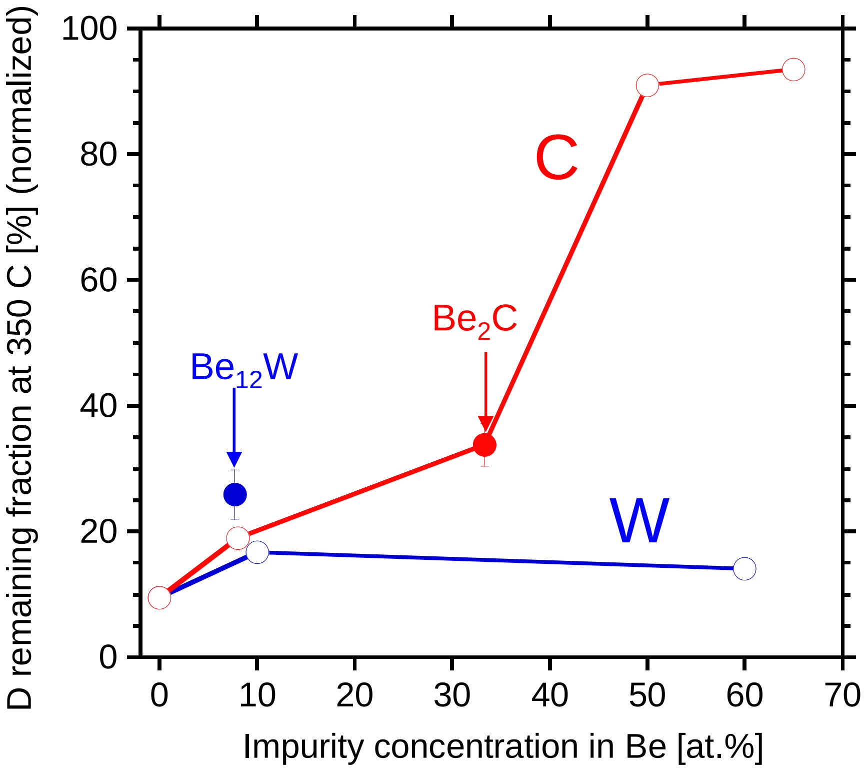




- D retention in the low temperature stage is reduced by the increase of the implantation temperature.
- However, after 350 ºC annealing more D is retained at high implantation temperatures

Consequences for ITER

How will the wall baking work in ITER ?



- Best performance will be expected for:
  - removal from clean Be deposit
  - the removal from Ben codeposition in “cool” areas

- The efficiency is marginal for:
  - Be-W codeposited layer and compounds
  - “Be-rich” Be-C mixed deposition

- The efficiency is low for:
  - “C-rich” (C conc. > 50 at.%) Be-C mixed deposition

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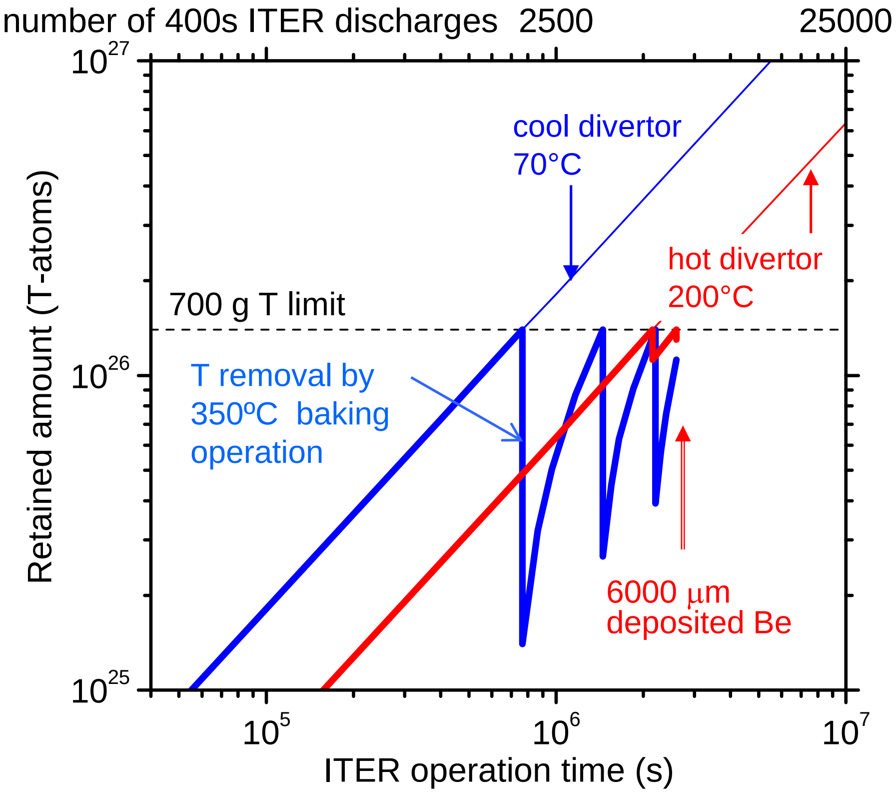

Assumptions:
90 % release for 70 ºC implantation
20 % release for 200 ºC implantation
Same behaviour for subsequent implantation/annealing cycles

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Enhanced retention at low surface is compensated by higher outgassing efficiency for retained D