An update on SMART material studies

within the work package PWIE SP A3

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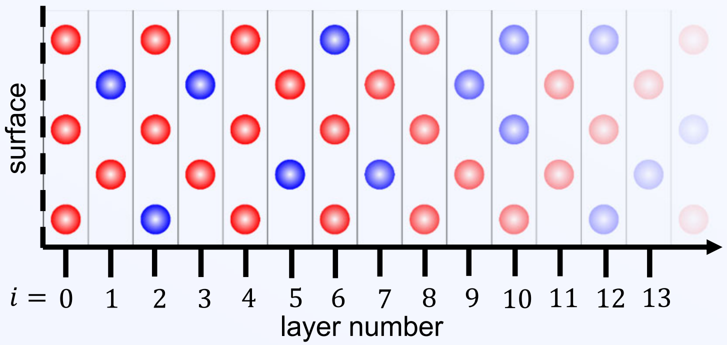
Understanding of WCrY response to plasma exposure

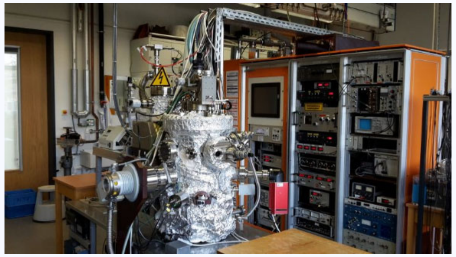
sputter erosion | **diffusion** | **segregation**

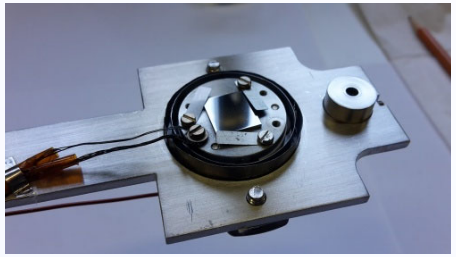
Goal: predicting the concentrations of W, Cr and Y with respect to time and depth inside the material

Discrete Layer Model (DLM)



Low Energy Ion Scattering (LEIS)





Discrete Layer Model (DLM) [1]

Darken Law: $\Gamma_{Cr} = -M_{Cr} \cdot \rho_{Cr}\big|_x \cdot \underbrace{\frac{\partial \mu_{Cr}}{\partial x}\Big|_x}_{\text{driving force}}$

- M_{Cr} = atomic mobility
- μ_{Cr} = chemical potential of Cr
- ρ_{Cr} = atomic density in $\#_{atoms}$ / m^3

Discretized Darken Law:

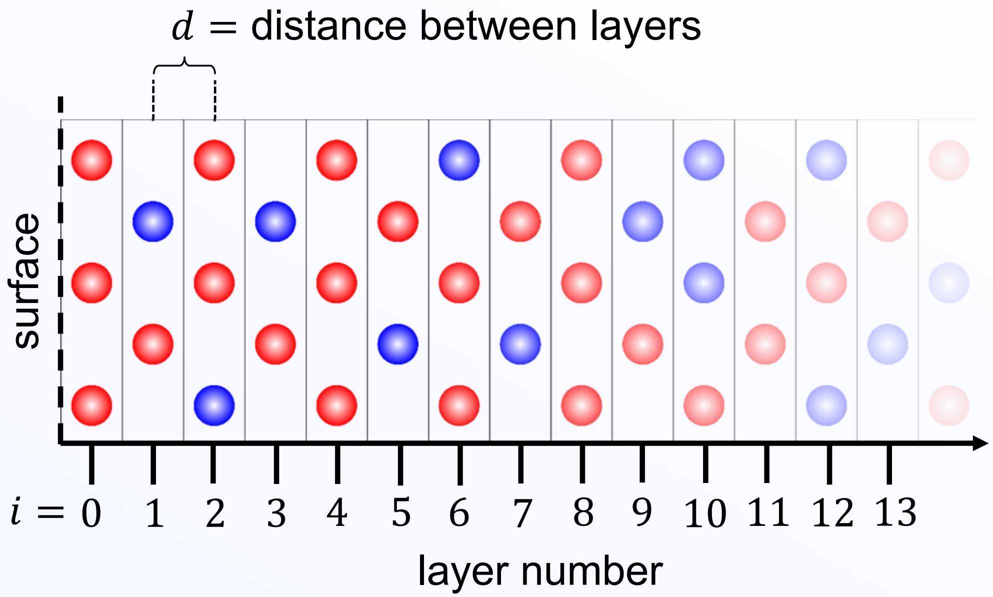
$$\Gamma_{Cr}^{i+1\rightarrow i} = -M_{Cr}^{i+1\rightarrow i} \cdot \rho_{Cr}^{i+1} \cdot \frac{\Delta\mu_{Cr,W}^{(i+1,i)}}{d}$$

$$\Delta\mu_{Cr,W}^{(i+1,i)} = \left(\mu_W^{i+1} - \mu_W^i\right) - \left(\mu_{Cr}^{i+1} - \mu_{Cr}^i\right)$$

$$\mu_{Cr}^i = {}^0G_{Cr}^i + k_B T \cdot \ln\left(c_{Cr}^i\right) + \Omega_{Cr,W}^i \cdot \left(1 - c_{Cr}^i\right)^2$$

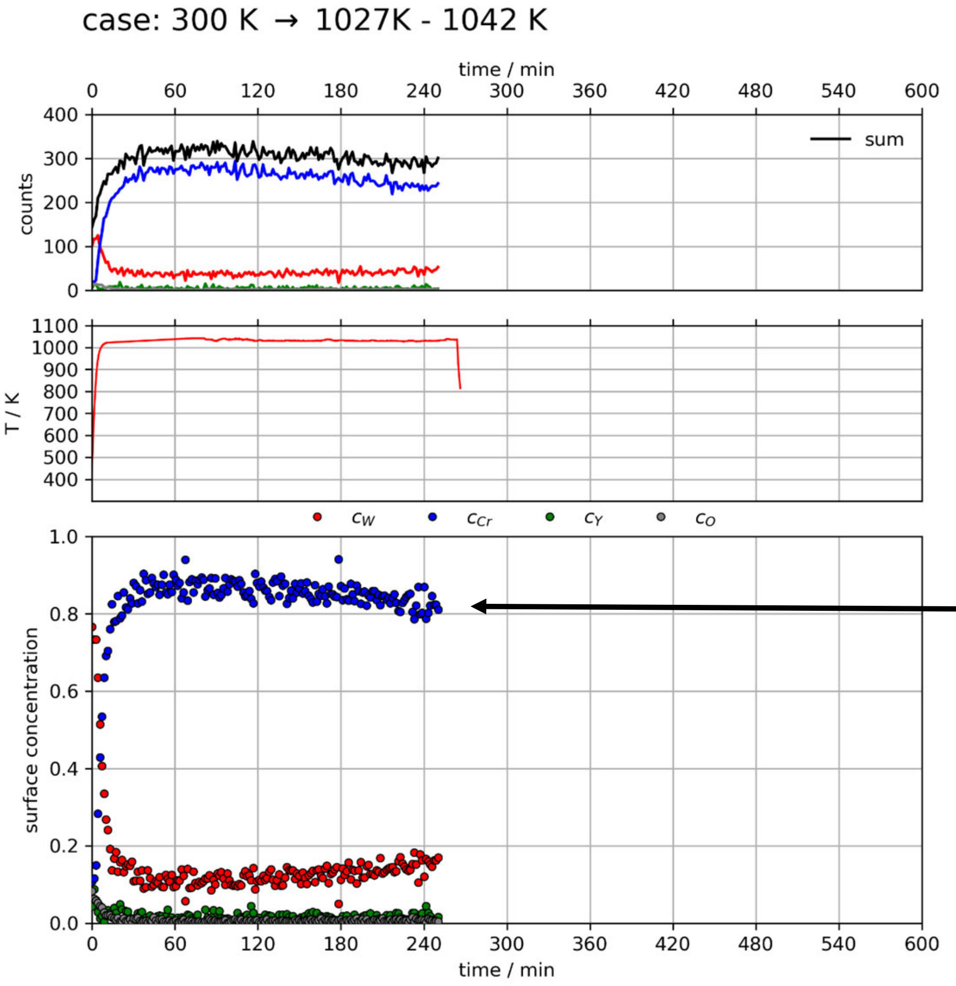
Rate Equations:

$$\frac{\partial c_{Cr}^i}{\partial t} = 4d^2\left(\Gamma_{Cr}^{(i+1,i)} + \Gamma_{Cr}^{(i,i-1)}\right) + \text{term for sputtering}$$



[1] J. du Plessis., Surface Segregation, Solid State Phenomena Volume 11 (1990)

LEIS results: 300 K → 1027 K – 1042 K (April)



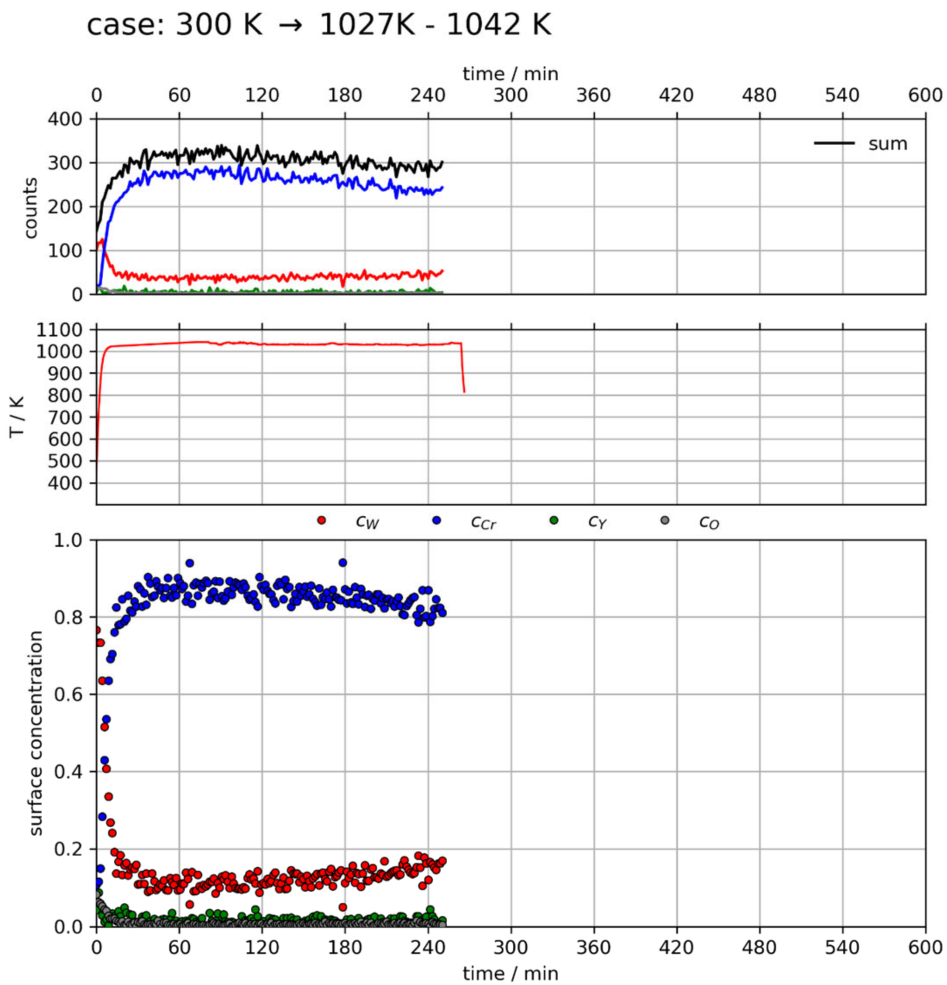
step 1	sputter cleaning of the sample at room temperature with $500\ eV\ Kr^+$ ions
step 2	start LEIS measurments ($1000\ eV\ He^+$): one spectrum every $\sim 85\ s$
step 3	increase temperature to $\sim 1000\ K$ as fast as possible

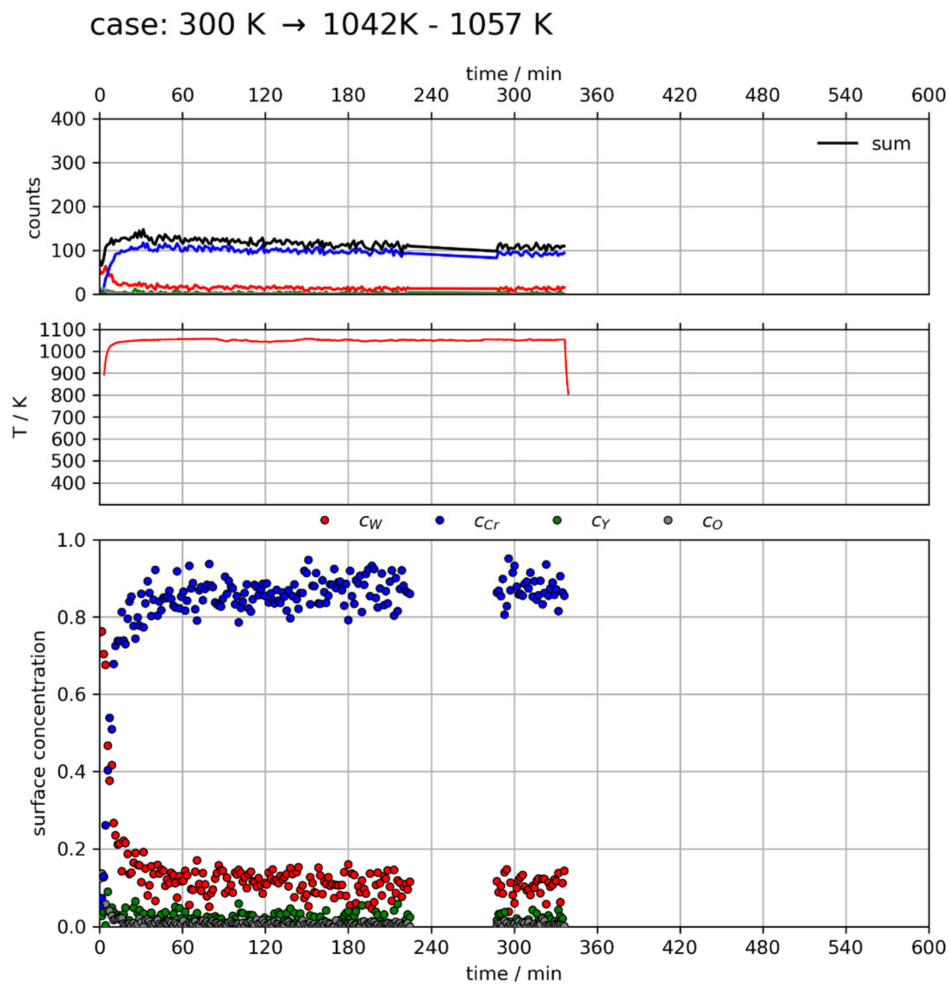
result:

- decrease probably caused by preferential sputtering of Cr by He from the LEIS measuring beam

➢ conduct a second experiment where the He-Beam is turned off for ~ 1h, so that the surface can relax toward ist equilibrium concentration

LEIS results: 300 K → 1042 K – 1057 K (April)





Next steps

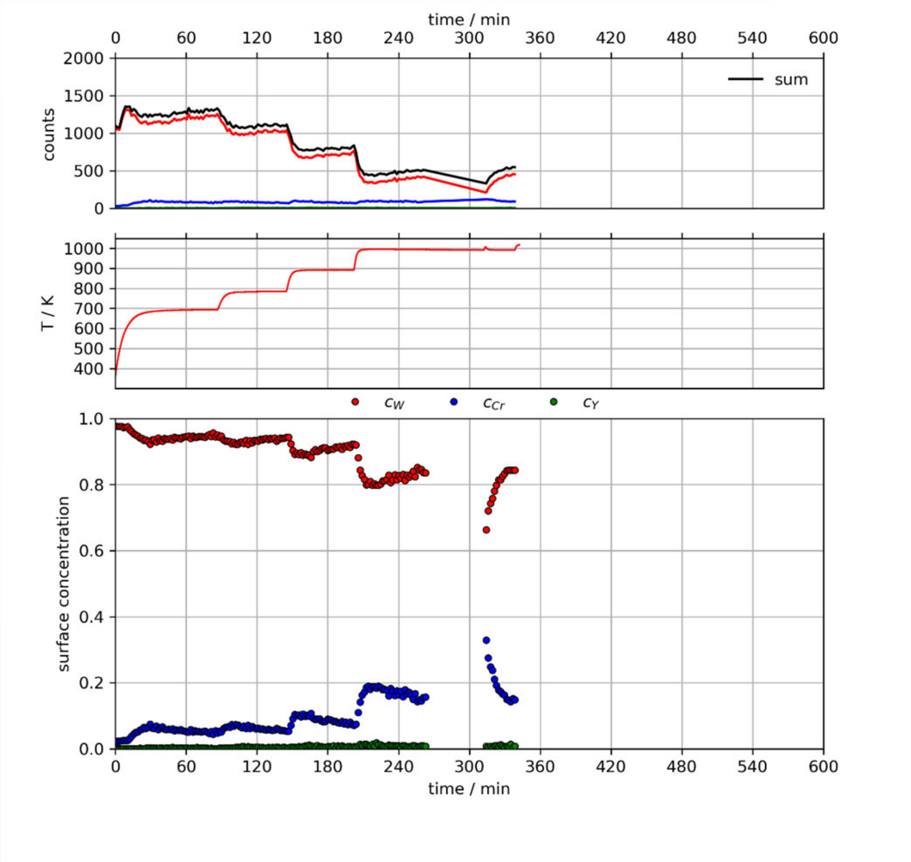
reference measurements:

- get LEIS spectra for pure W and pure Cr
- will be conducted in September 2022

LEIS measurments with Neon instead of Helium

- better peak separation of W, Cr, and Y in LEIS spectra
- no background in spectra
- higher sputter yields
  - ➢ effect of decreasing Cr-concentration caused by sputtering from the Ne-Beam should be clearly visible even at low beam flux densities

$1000\ eV\ Ne^{+} \rightarrow WCrY$



Thank you

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