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Goals and presentation of the materials

Goals

- Prediction of the ageing mode by diffusion of a multilayered material,
- Determination of the diffusion coefficients,
- Study and quantification of the thermo-elastic and diffusion couplings.

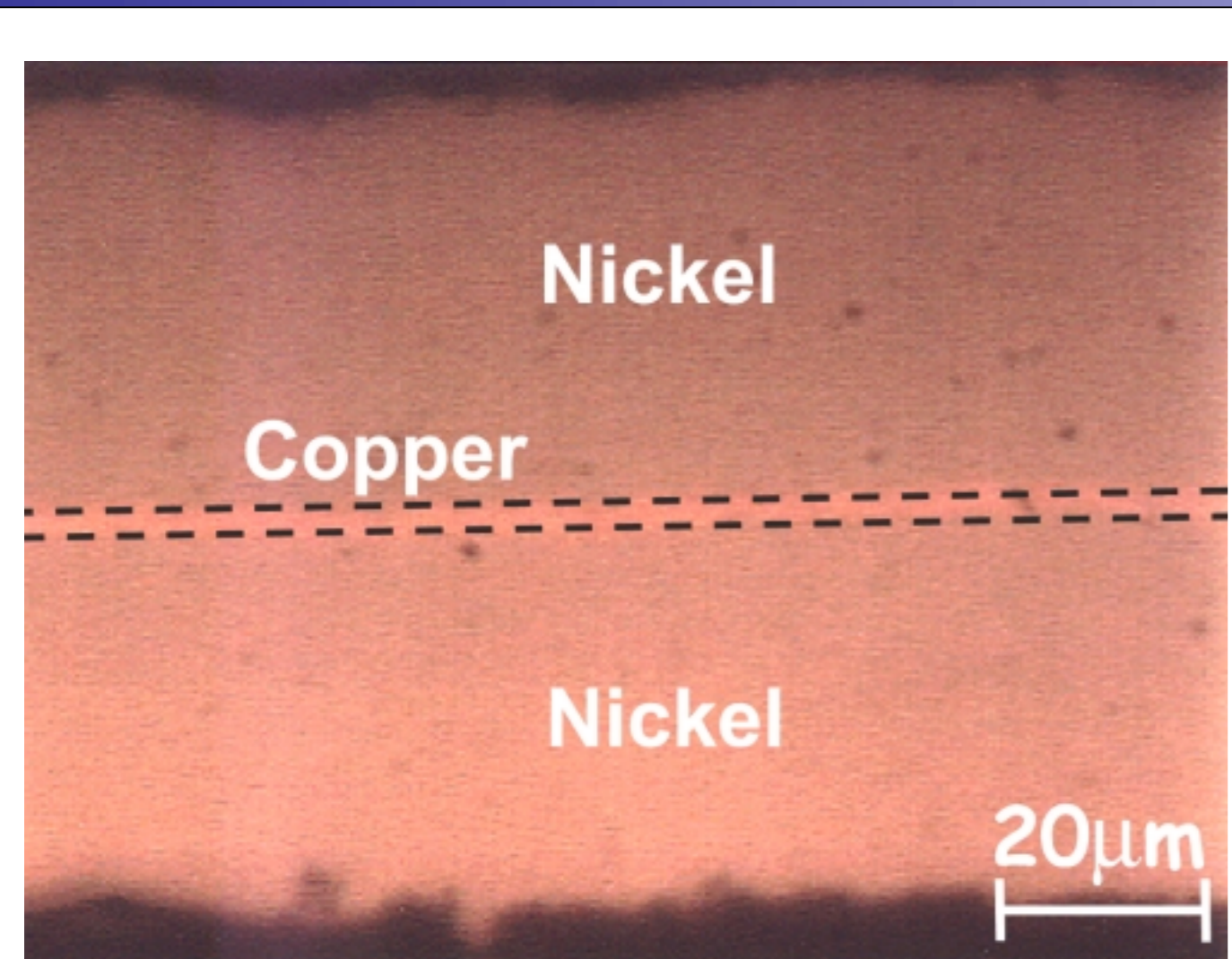
View of the made as a layered



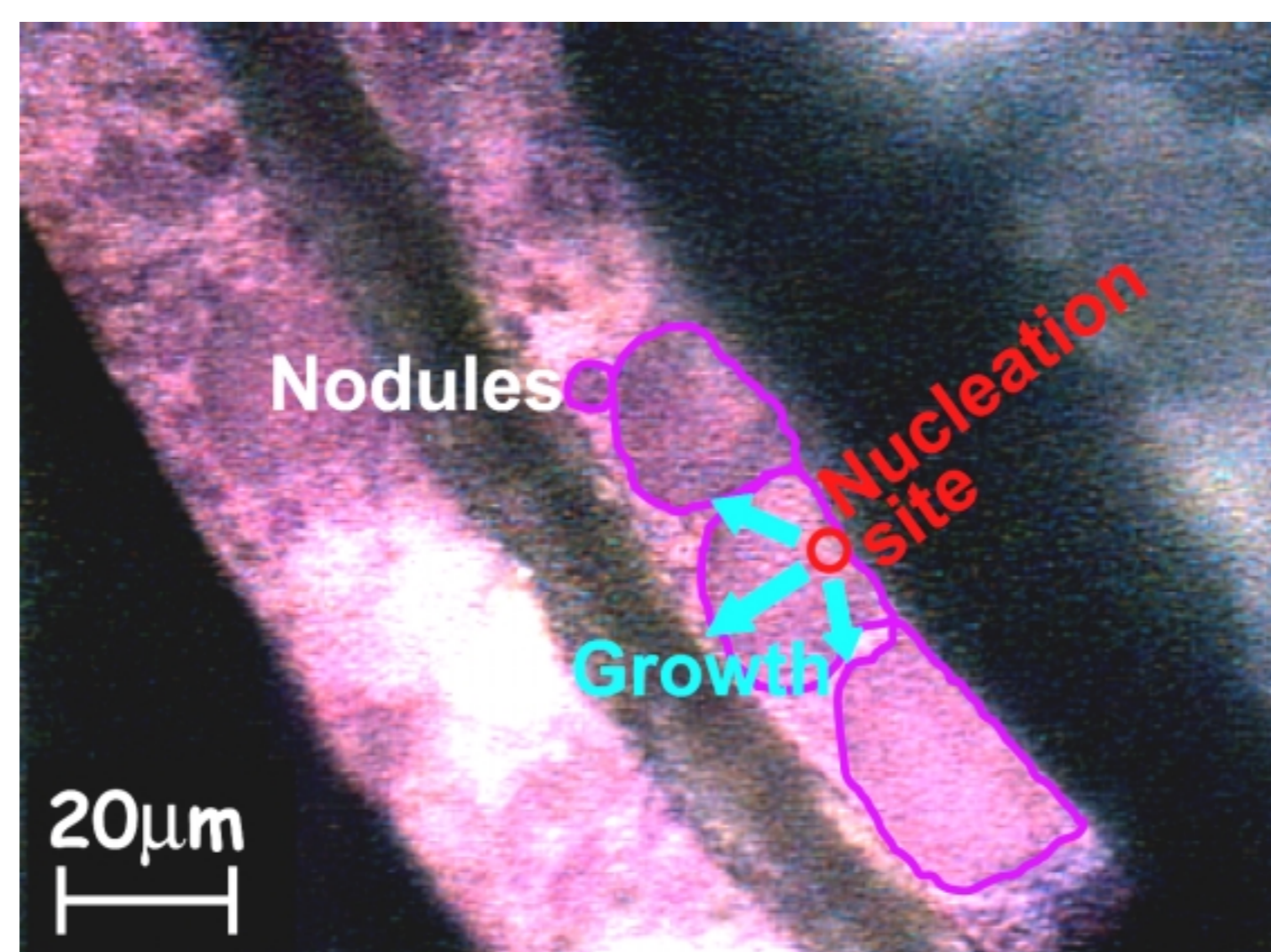
bellows Ni/Cu/Ni material

Experimental and numerical methods

- EDX microprobe in an SEM,
- Optical microscope in polarised light,
- Furnace,
- FE numerical code.

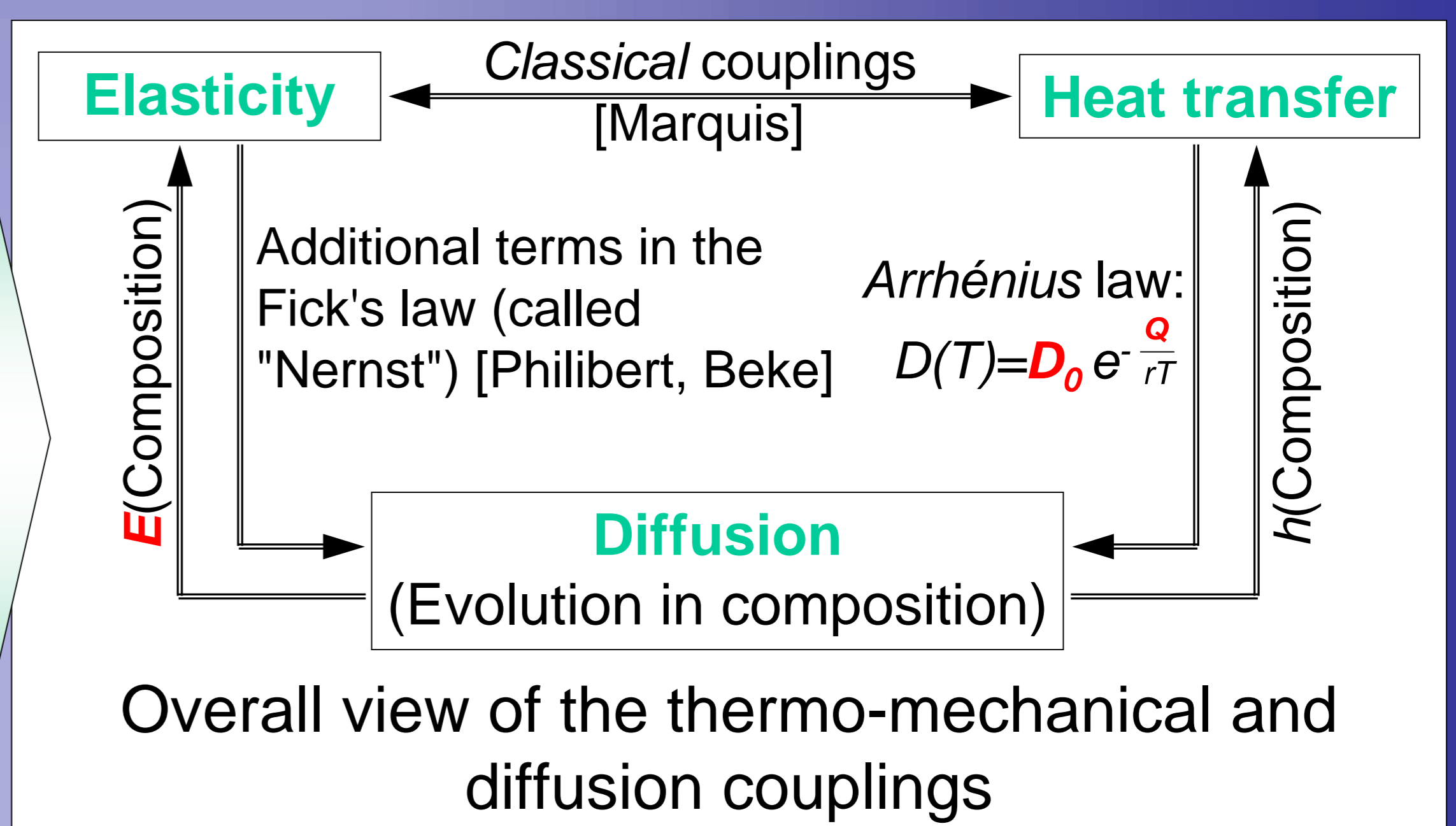


Optical micrograph of the multilayered material

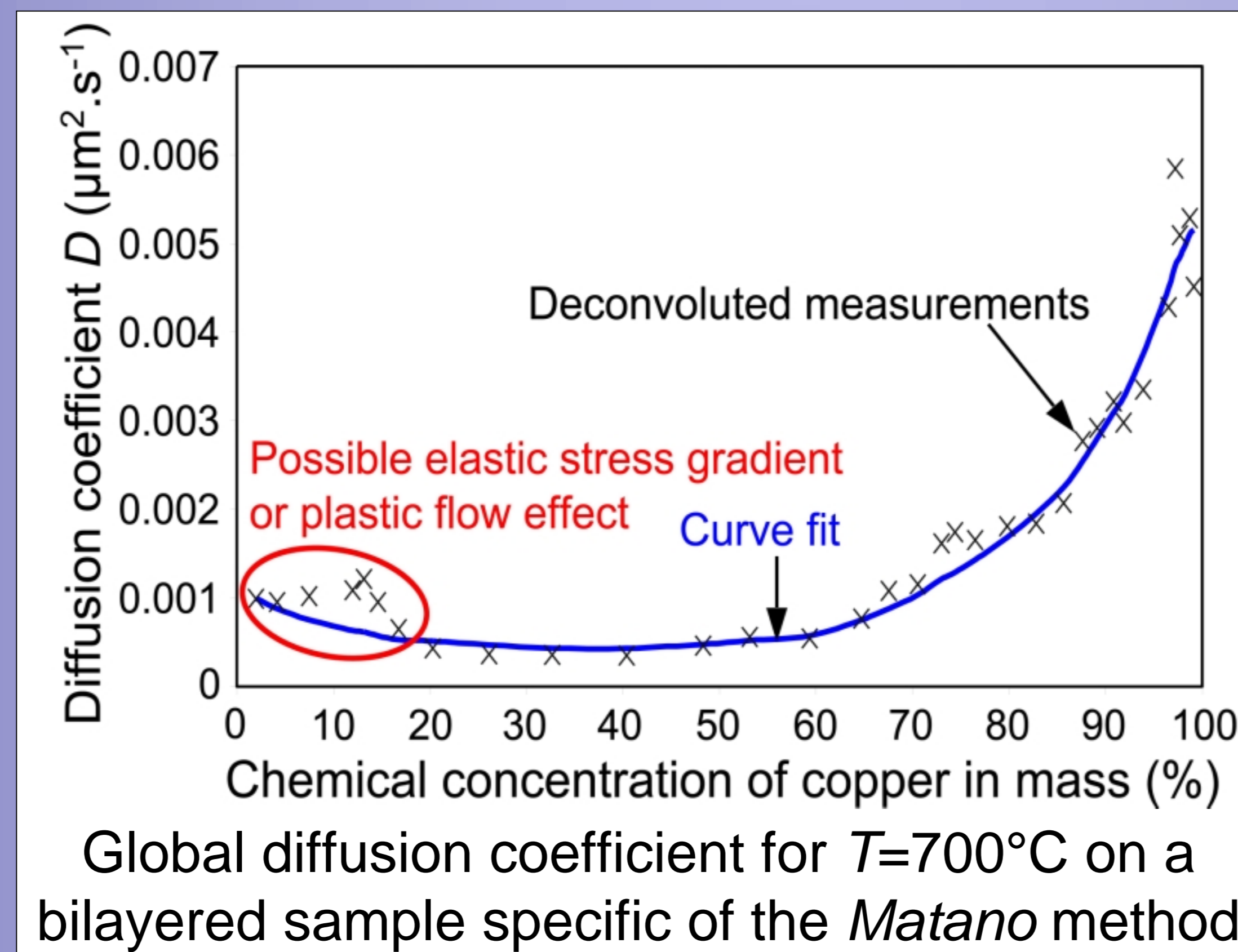
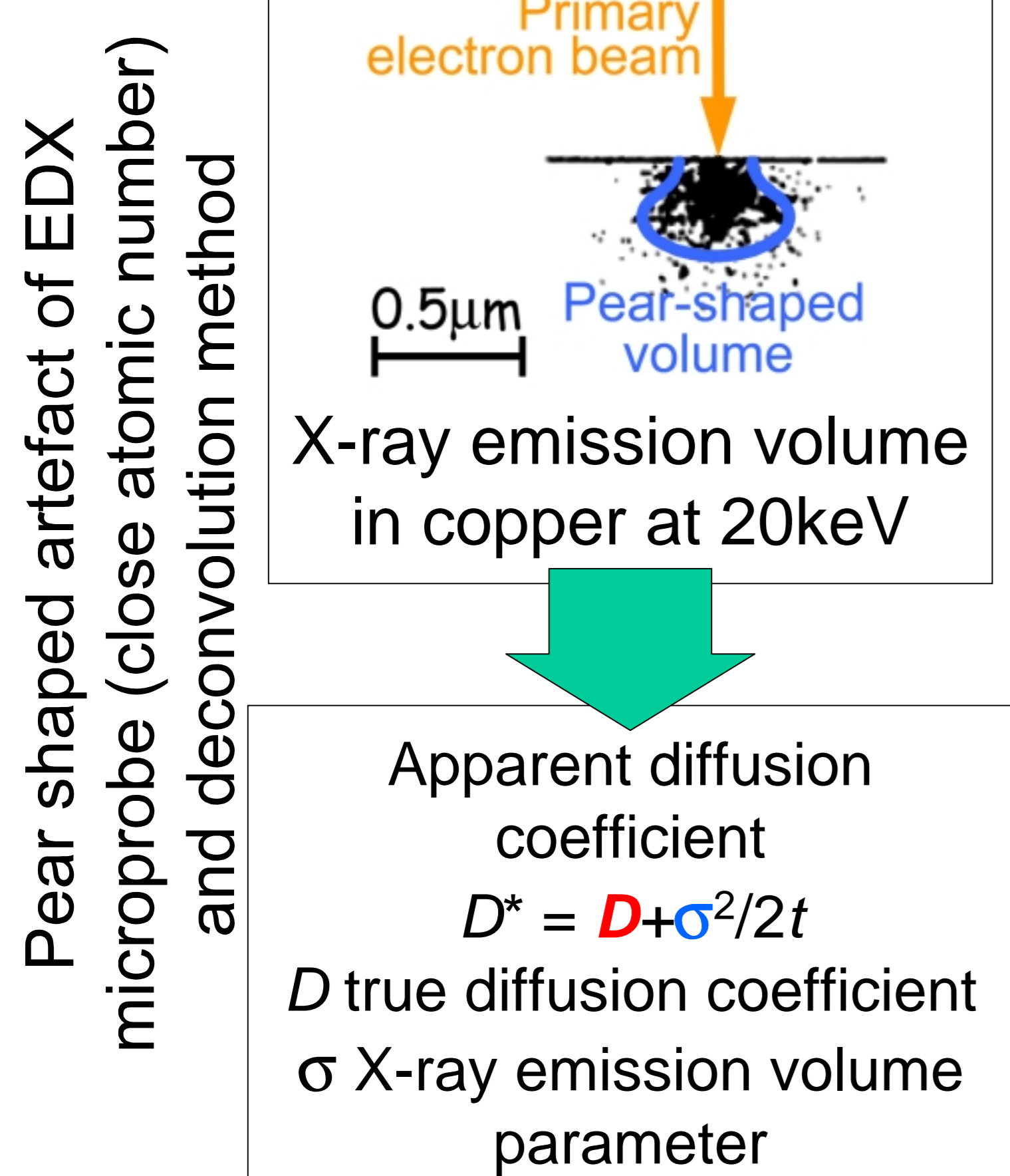


Optical micrograph in polarised light of nickel nodules after chemical corrosion with regal water

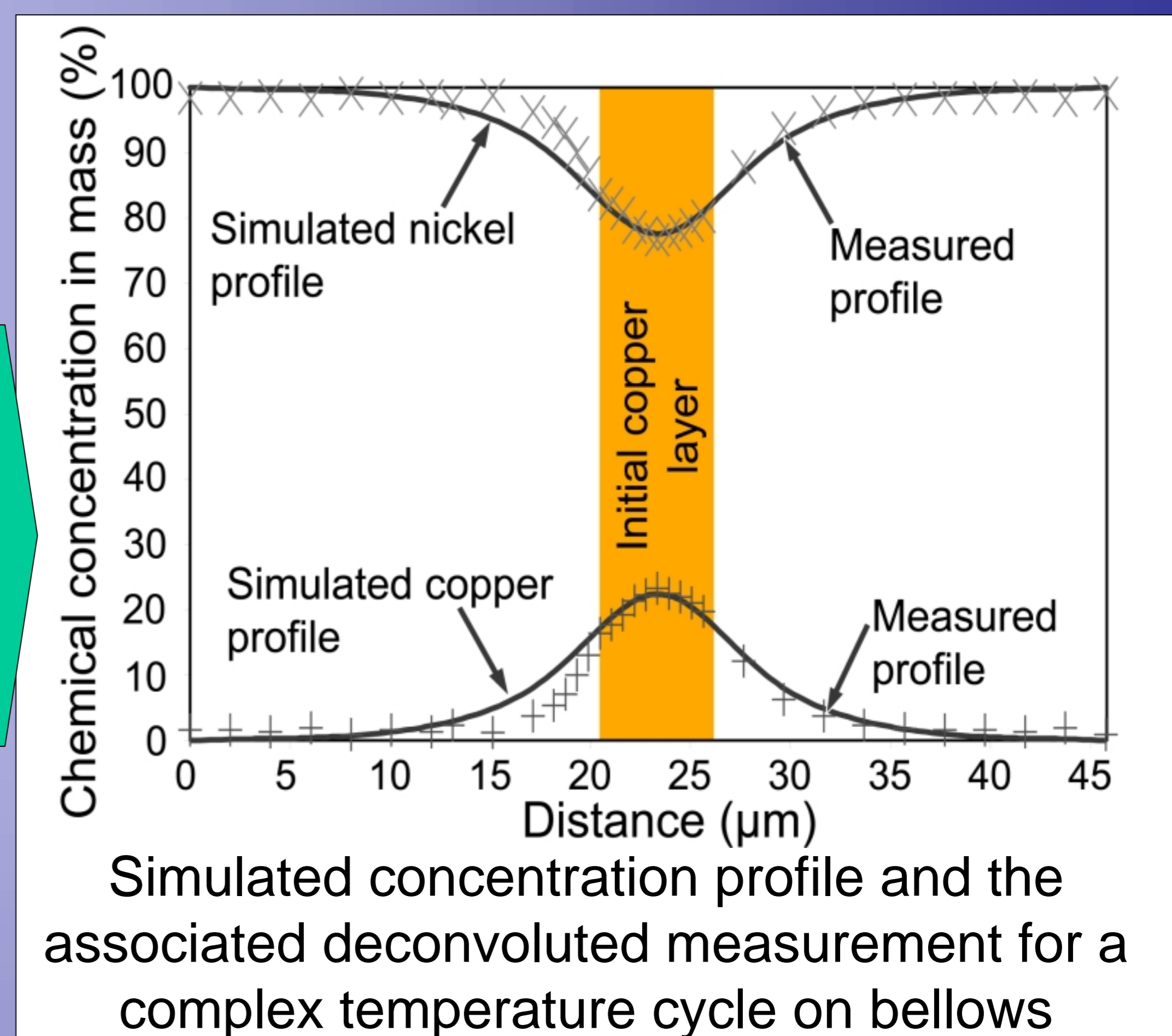
Thermo-Mechanical and Diffusion couplings



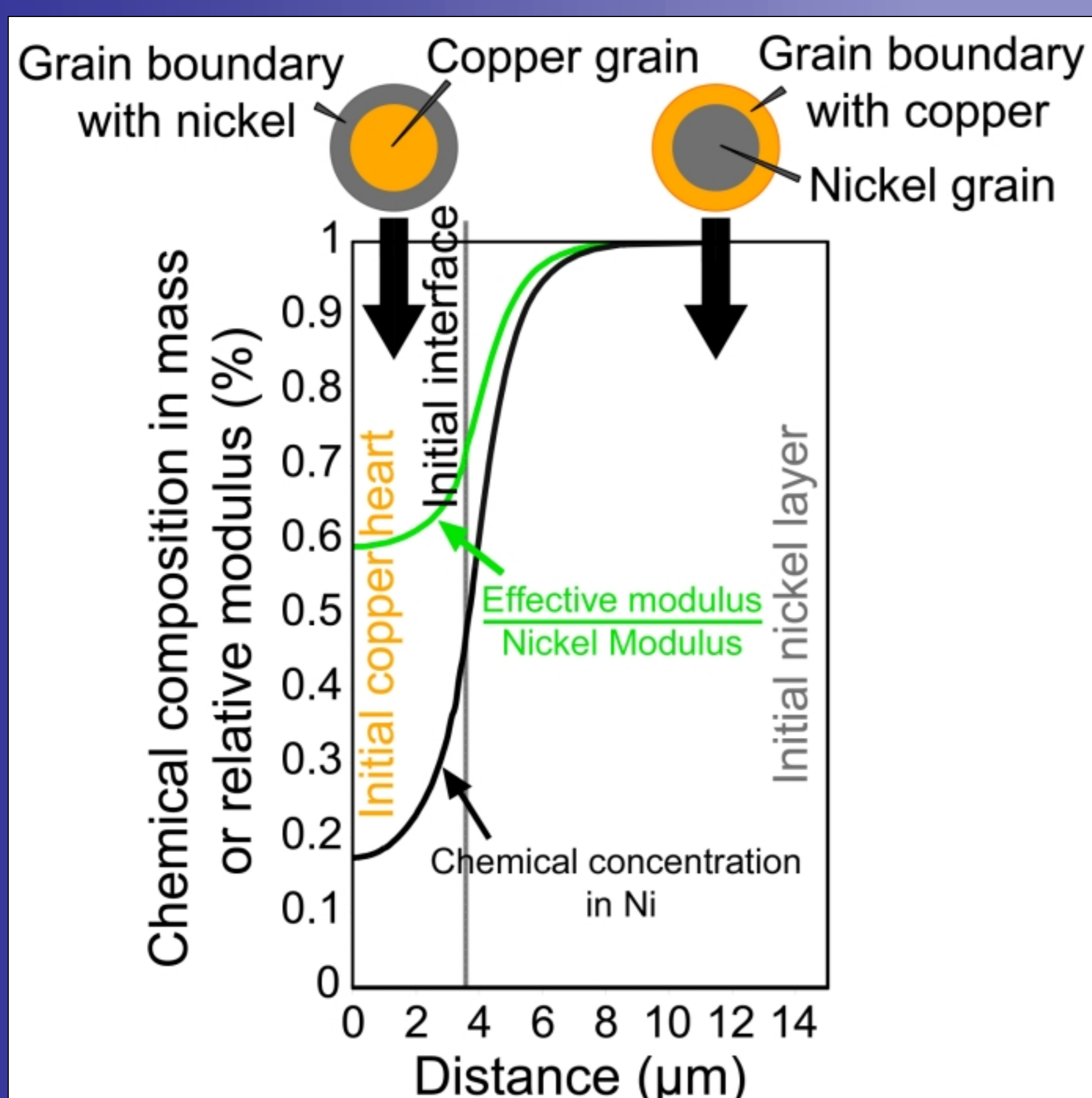
Practical studies of diffusion



Validation(s)

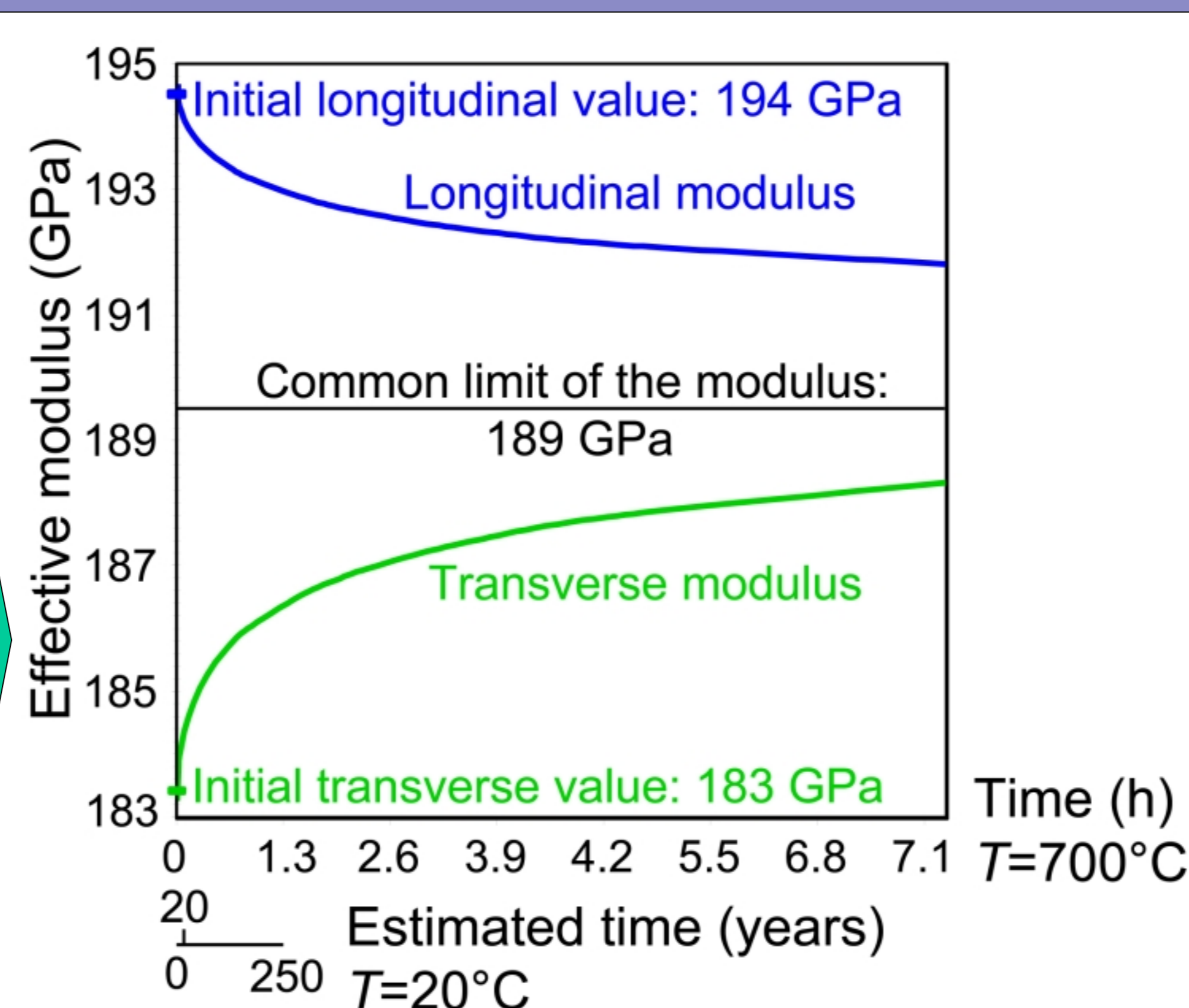


Change of the elastic modulus: conclusions on ageing by diffusion



Self-consistent homogenisation on one half of the multilayered material (diffusion: 37minutes, 700°C)

Composite homogenisation



Effective elastic modulus vs. time for $T=700^\circ\text{C}$ and an estimation of the equivalent time for $T=20^\circ\text{C}$ based on a measured profile

Conclusions

- Variation of the modulus depends on the relative thickness of the material layers,
- Most of the effects of ageing is obtained for low time durations or temperatures,
- Adapted studies at low temperatures have to be performed,
- Interactions with other mechanisms (crystallisation,...) have to be studied,
- Competition between the Frenkel effect in the copper layer and the Kirkendall effect in the nickel layers on the airtightness of bellows must be evaluated.