

DIFFUSION STUDY AFTER REACTIVE ELEMENT ADDITION IN NiAl ALLOYS

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REACTIVE ELEMENT ADDITION AND EFFECTS

KEY POINTS

- Oxygen-active elements
- Driving force - oxidation potential gradient
- Doping - Scale grain boundaries/metal-oxide interface
(poorly adherent, buckled forms to more adherent and protective scales)

RE effects

- Improvement in scale adhesion or resistance to spallation
- Reduction in the macroscopic growth rate is the result of a change in the oxidation mechanism
- Modification of the scale microstructure

Basis of Theory

- Indigenous sulfur negatively affects scale adhesion.
- RE doping suppresses cation transport in both Al_2O_3 and Cr_2O_3 .
- RE ions are found to segregate at scale grain boundaries and metal-oxide interfaces.
- RE ions actively diffuse toward the gas interface during oxidation.

DYNAMIC SEGREGATION THEORY

- Oxygen potential gradient in metal-scale-gas system
- Effect noticeable only when dense external oxide scale, not prevalent in transient stages
- An alloy addition, oxide dispersion or ion implant, the result is the same

Oxidation Rate

Reduction in the parabolic oxidation rate constant
more pronounced in Cr_2O_3 than Al_2O_3

Scale adhesion

Improves scale adhesion at the metal-scale interface

Microstructure

Solute-drag effect
Smaller average grain sizes

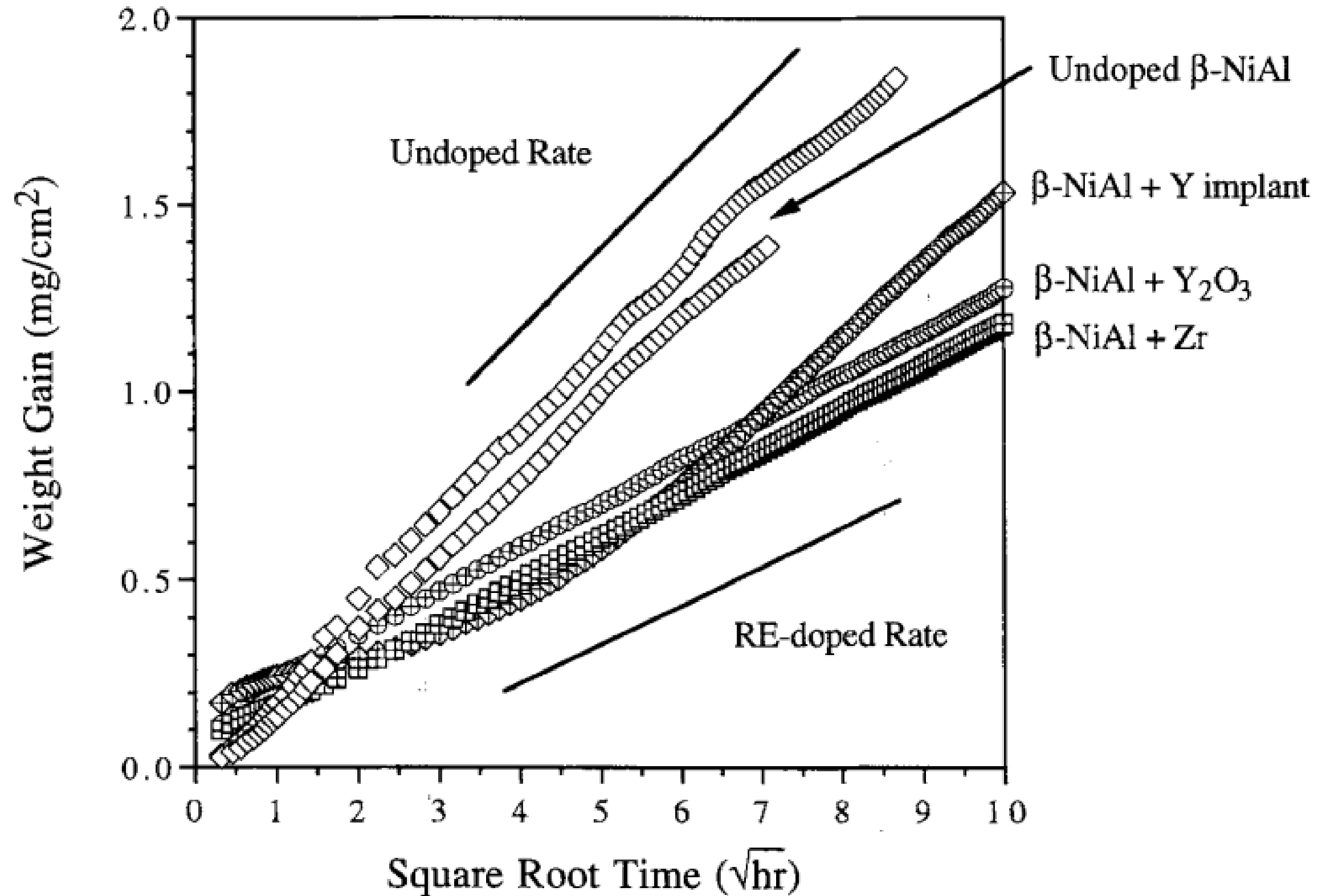
Temperature

Low temperatures - less affected
High temperatures - more significant
Very High temperatures - effects diminish

THE SEGREGATION OF RE IONS (Y, Zr, Ce, La, and Hf)

- Reduces the number of sites available to diffusing species
- Change in migration energy
- Modify structure of the boundary
- Change in concentration and defects at the boundary
- Alters the electrostatic potential at the boundary
- Changes the segregation factor of other solutes

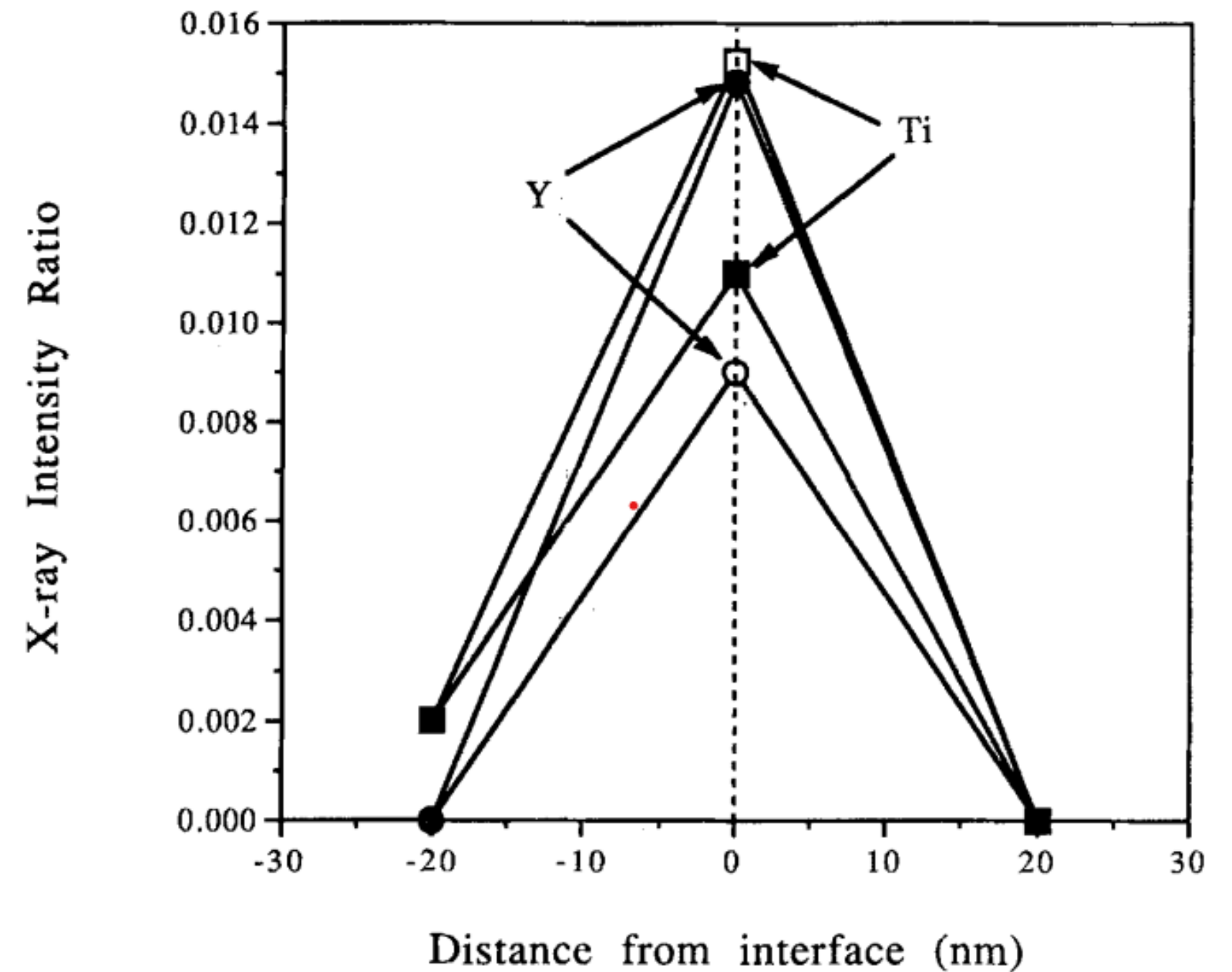
Weight gain against the square root of time for different samples



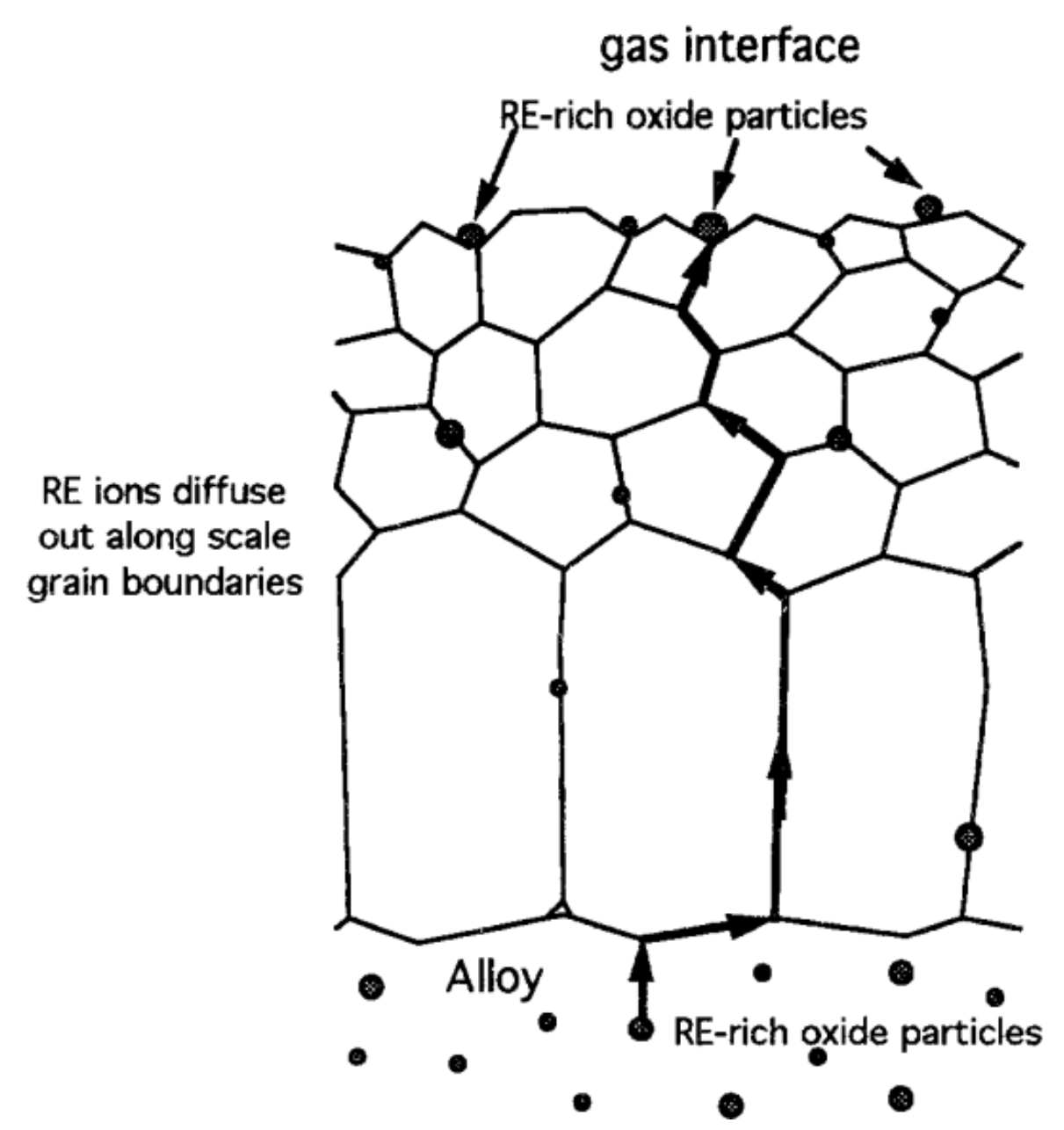
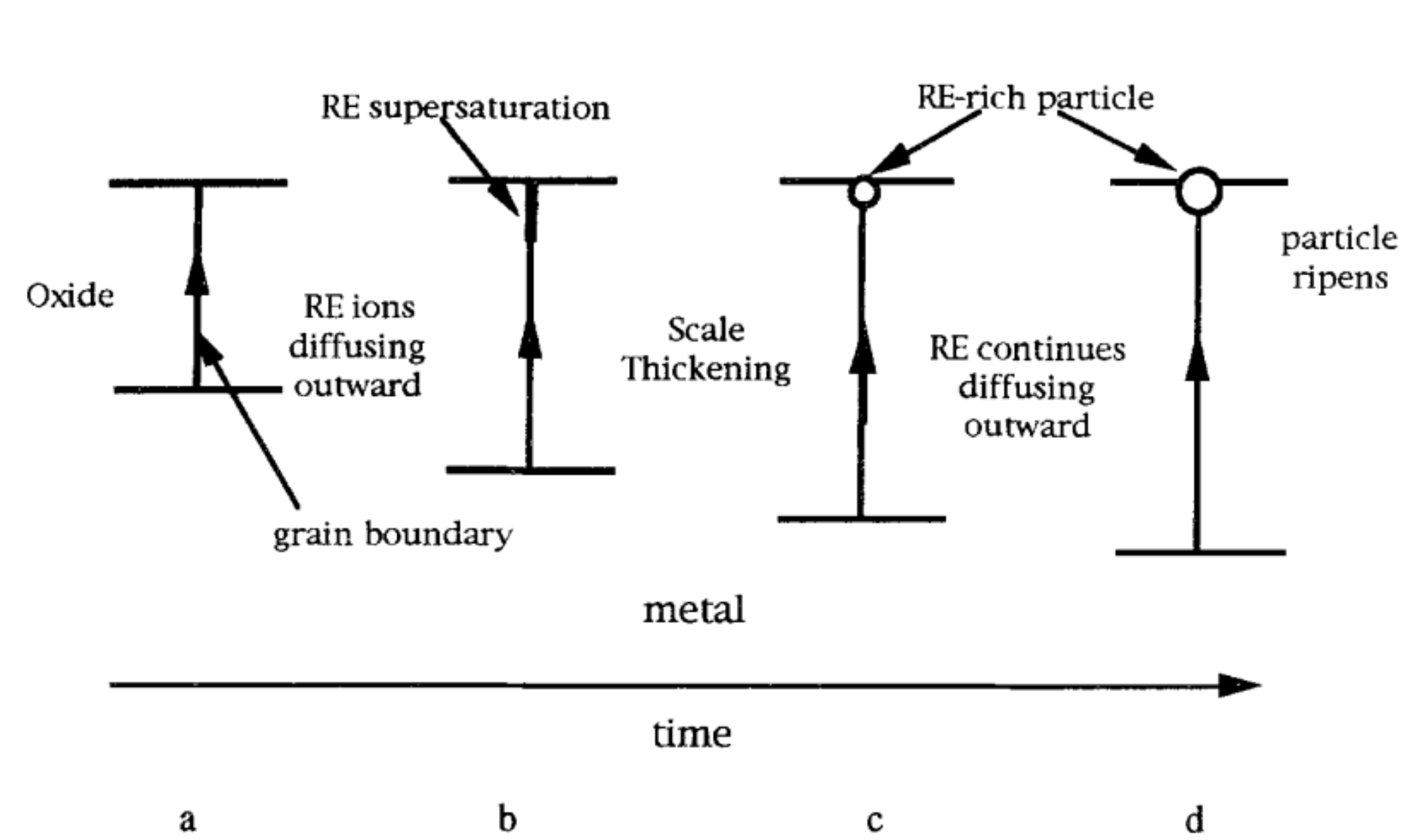
RE IONS size - cation size importance

- Smaller ions such as Sc and Ti do not appear to be effective in doping Cr₂O₃, but show some effects in Al₂O₃
- Larger ions such as La and Ce are very effective in doping Cr₂O₃, but La has not produced positive effects in Al₂O₃

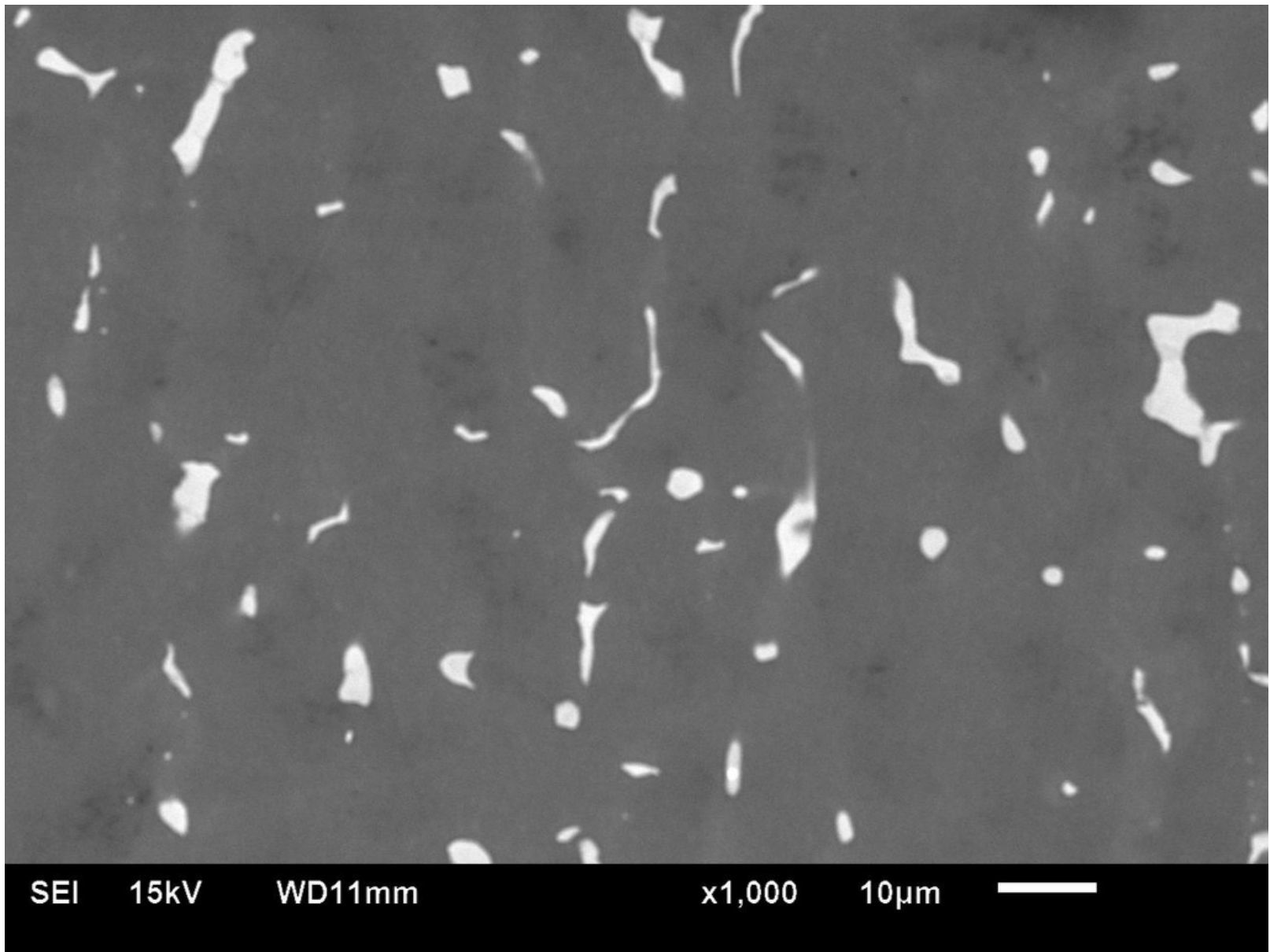
RE IONS outward diffusion



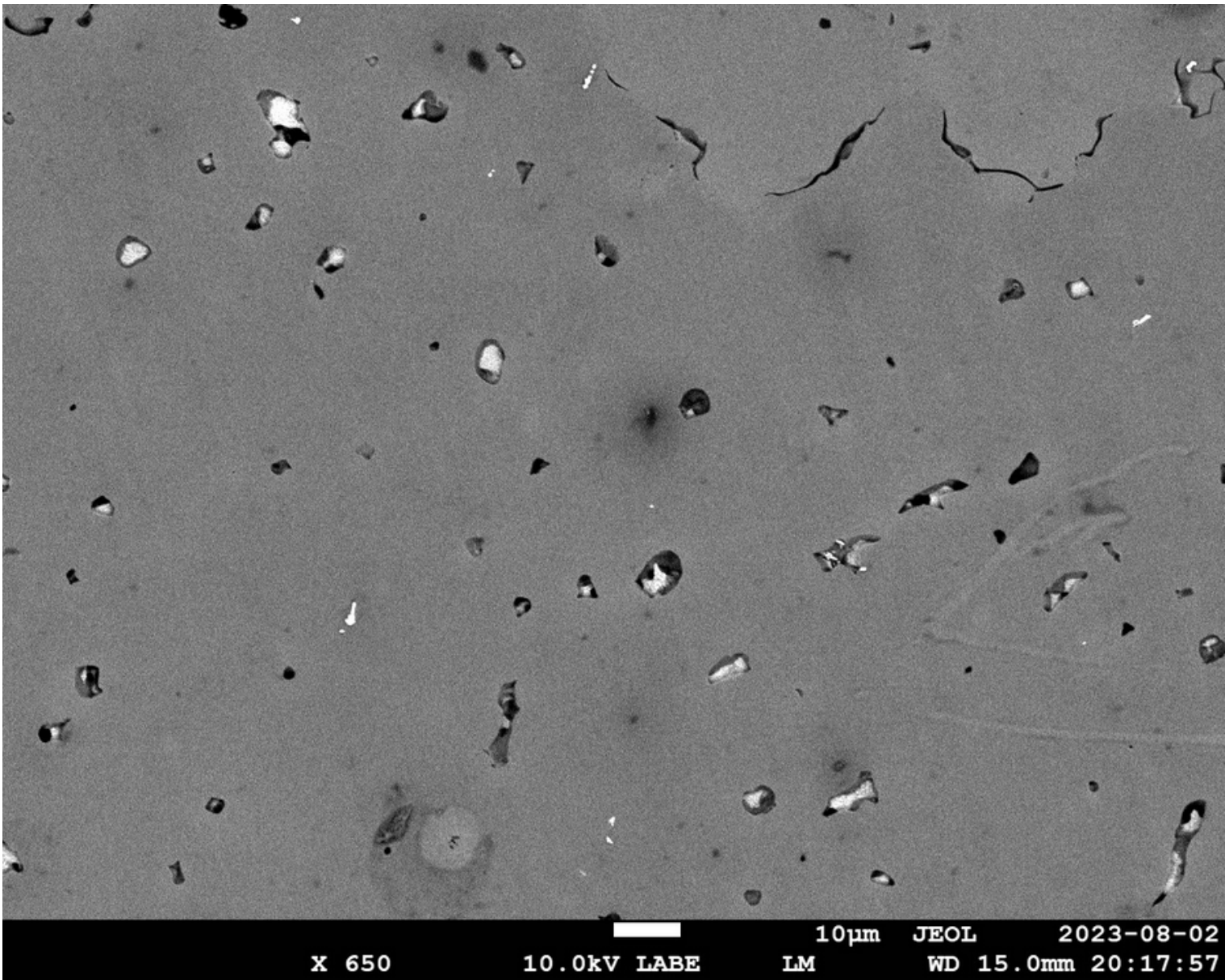
THE OUTWARD TRANSPORT OF RE IONS



FESEM Images of NiAl-Hf

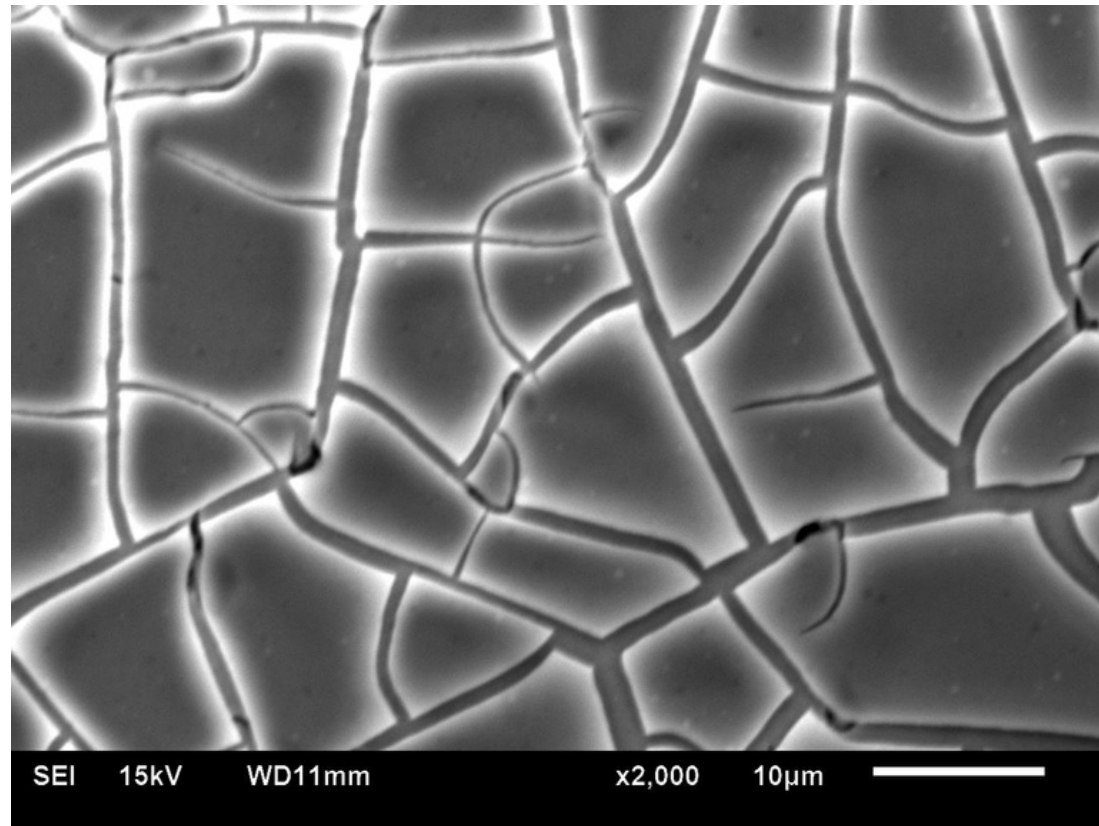


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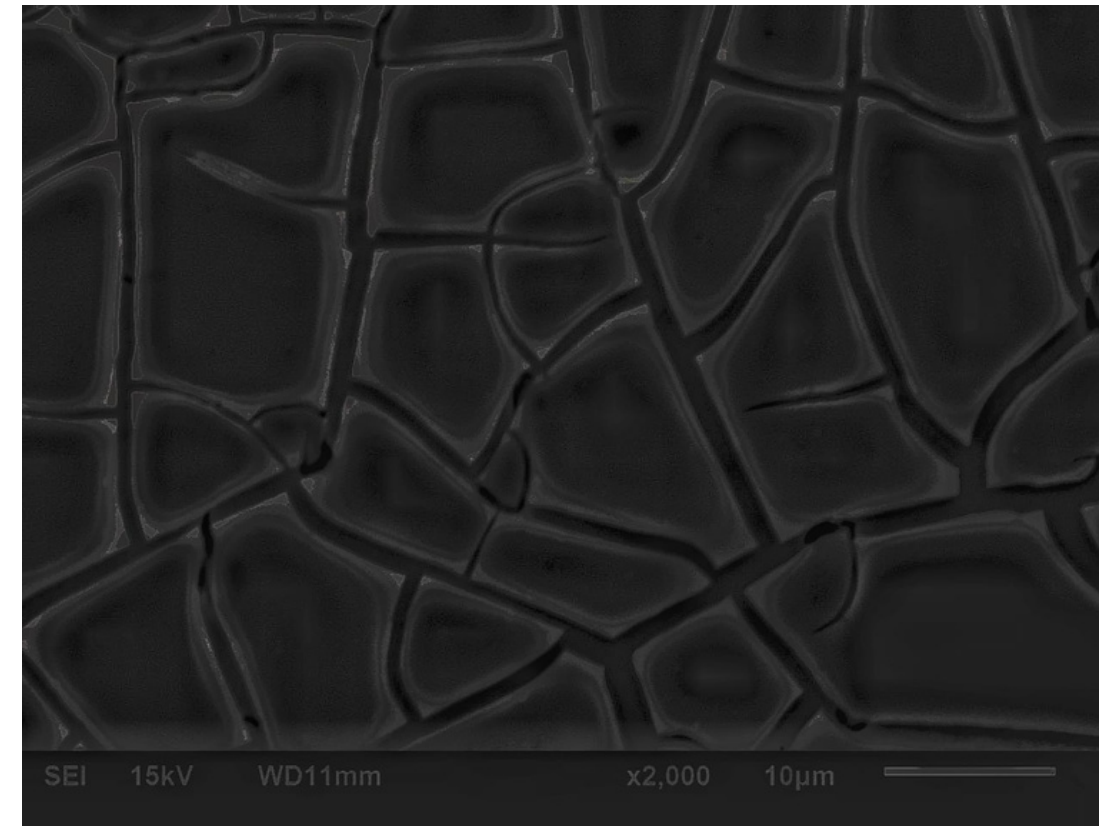
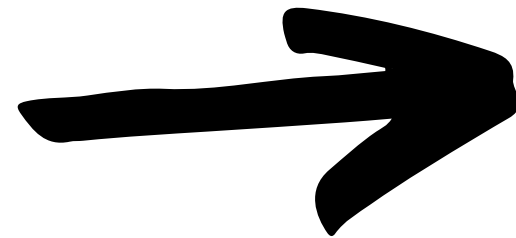


BACK-SCATTERED

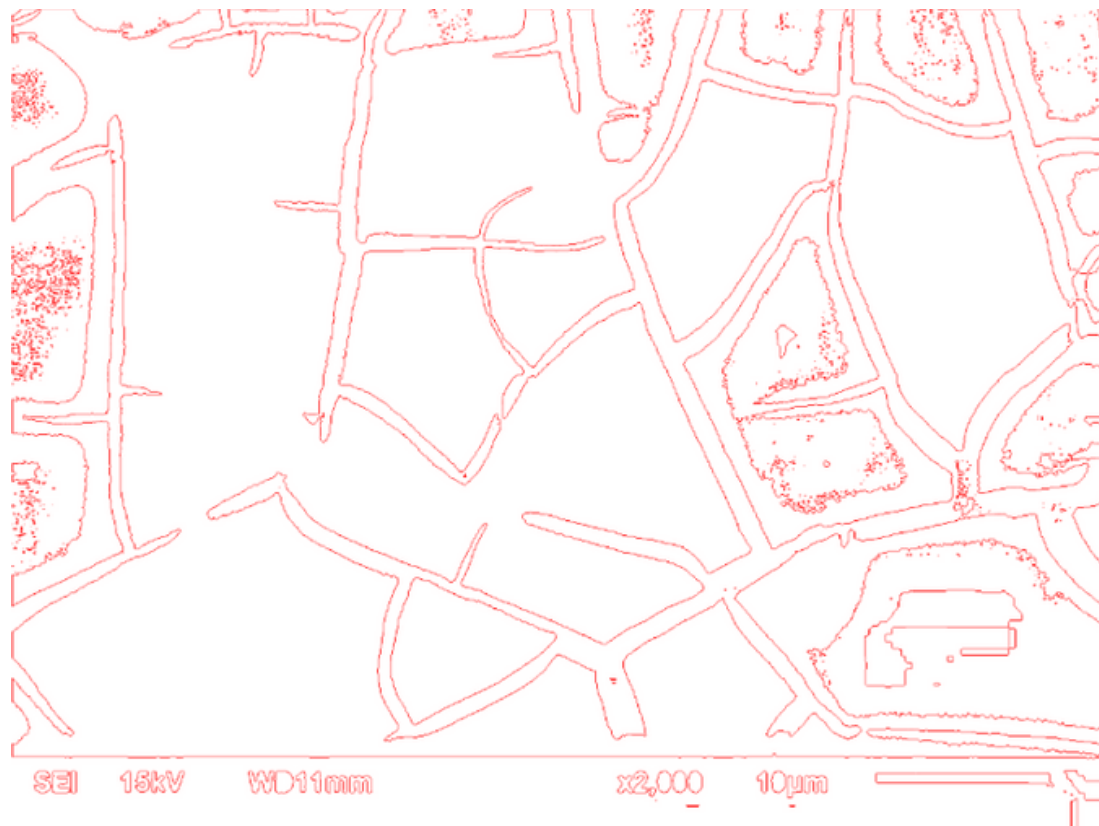
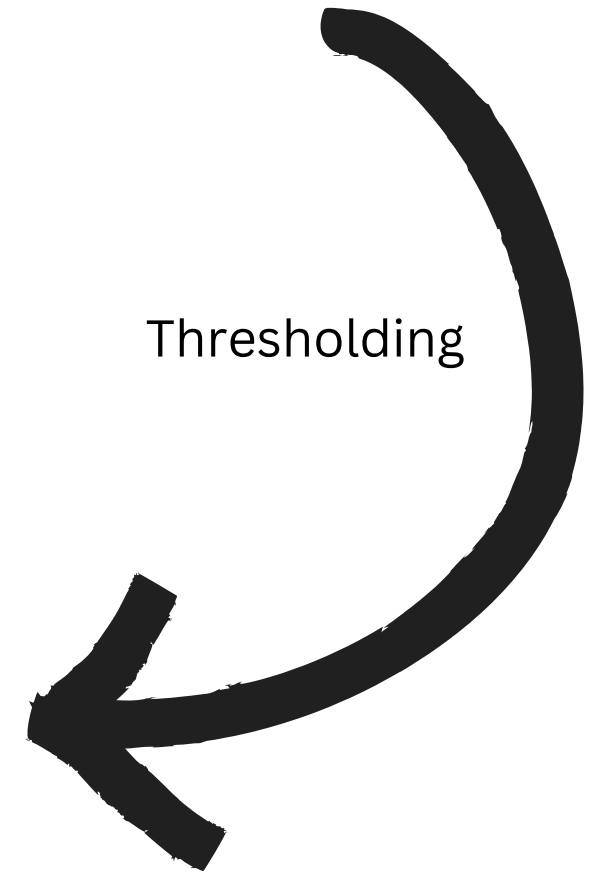
IMAGE PROCESSING



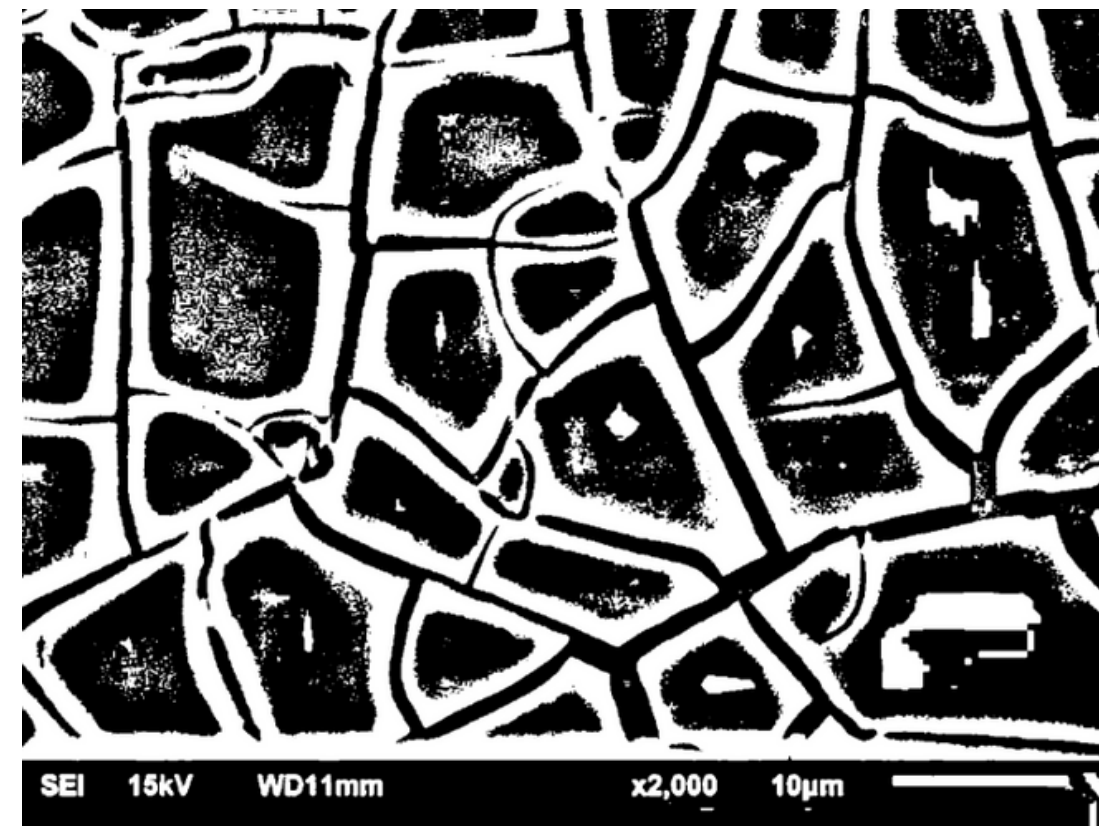
Contrast adjustments,
noise reduction



Thresholding



Marking paths
between grains



TIMELINE

SEMESTER-I

- LITERATURE REVIEW
- EXPERIMENTAL ANALYSIS
- IMAGE PROCESSING
- GATHERING DATA

SEMESTER-II

- MATHEMATICAL MODELLING
- WRITING ALGORITHM
- TESTING AND IMPROVING
- ANALYSING RESULTS
- DRAWING CONCLUSIONS

REFERENCE

Pint, B. A.
1996/02/01

Experimental observations in support of the dynamic-segregation theory to explain the reactive-element effect

Pint1996