INTERPLAY OF ION BOMBARDMENT, SURFACE ORIENTATION AND DIFFUSION DURING NITRIDING OF ALUMINIUM

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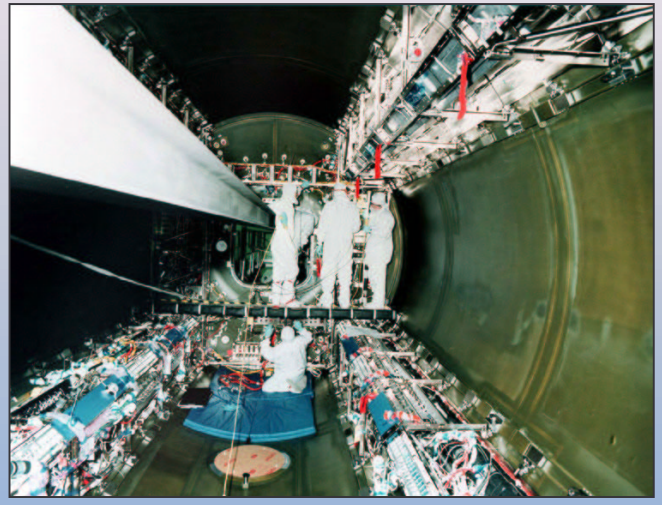
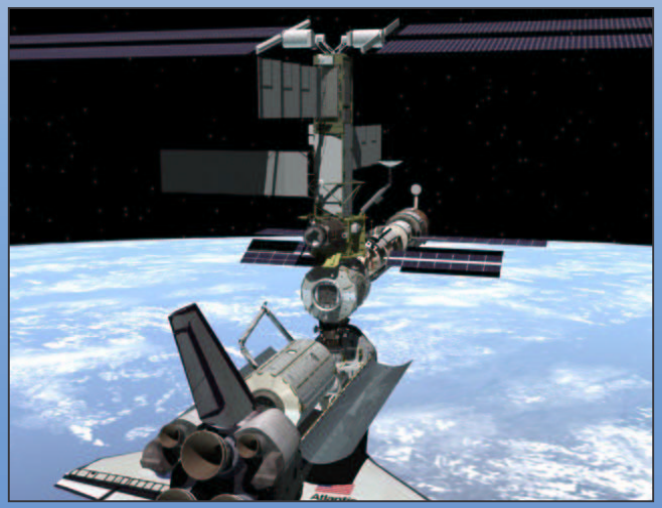
Motivation





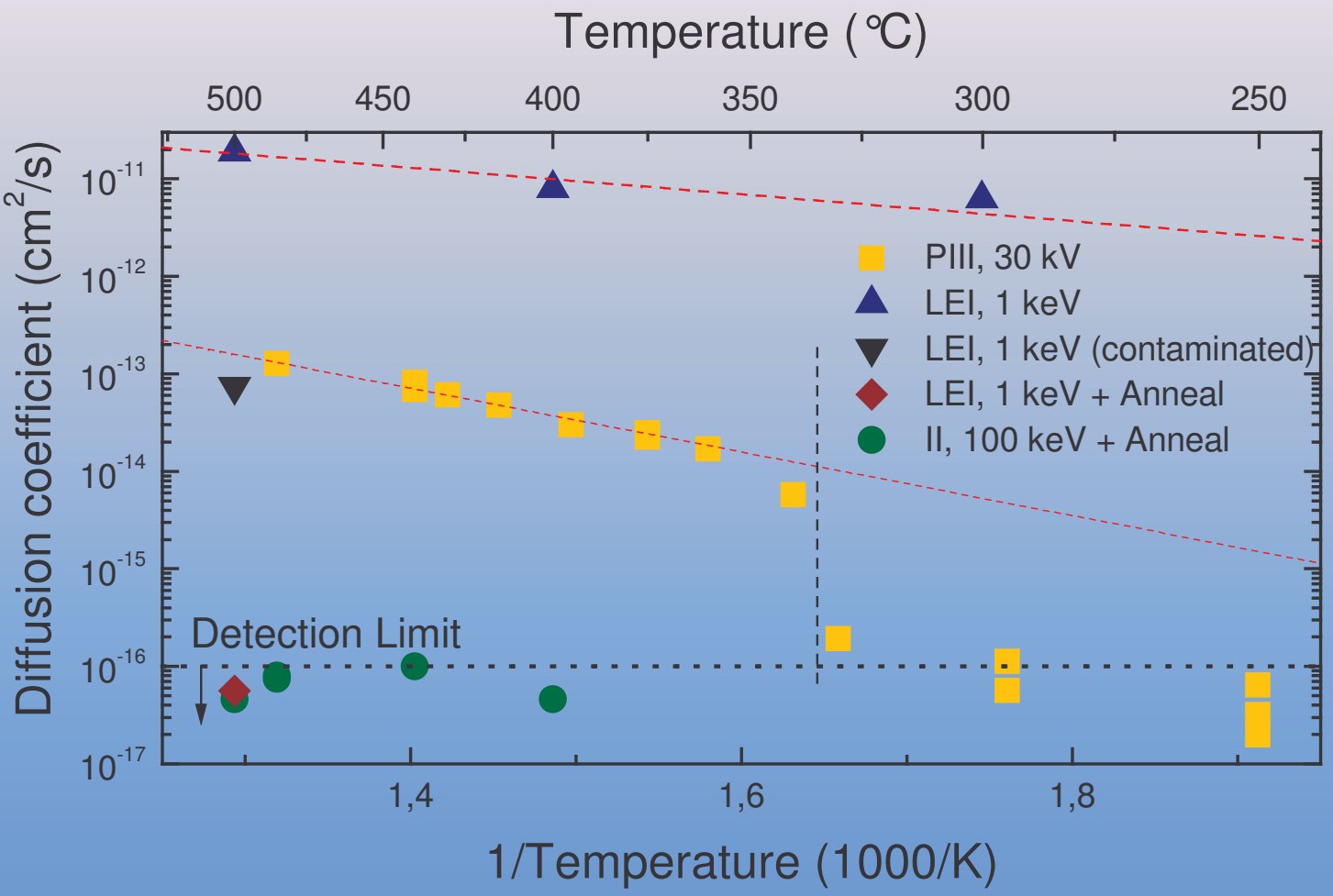
- Wide applications of Al and its alloys
- Low hardness, high wear, low chemical and thermal stability

⇒ *Surface modification is necessary*

Contents

- Motivation
- Formation of Aluminium Nitride
- Surface Orientation & Sputter Yield
- Diffusion & Temperature
- Conclusion

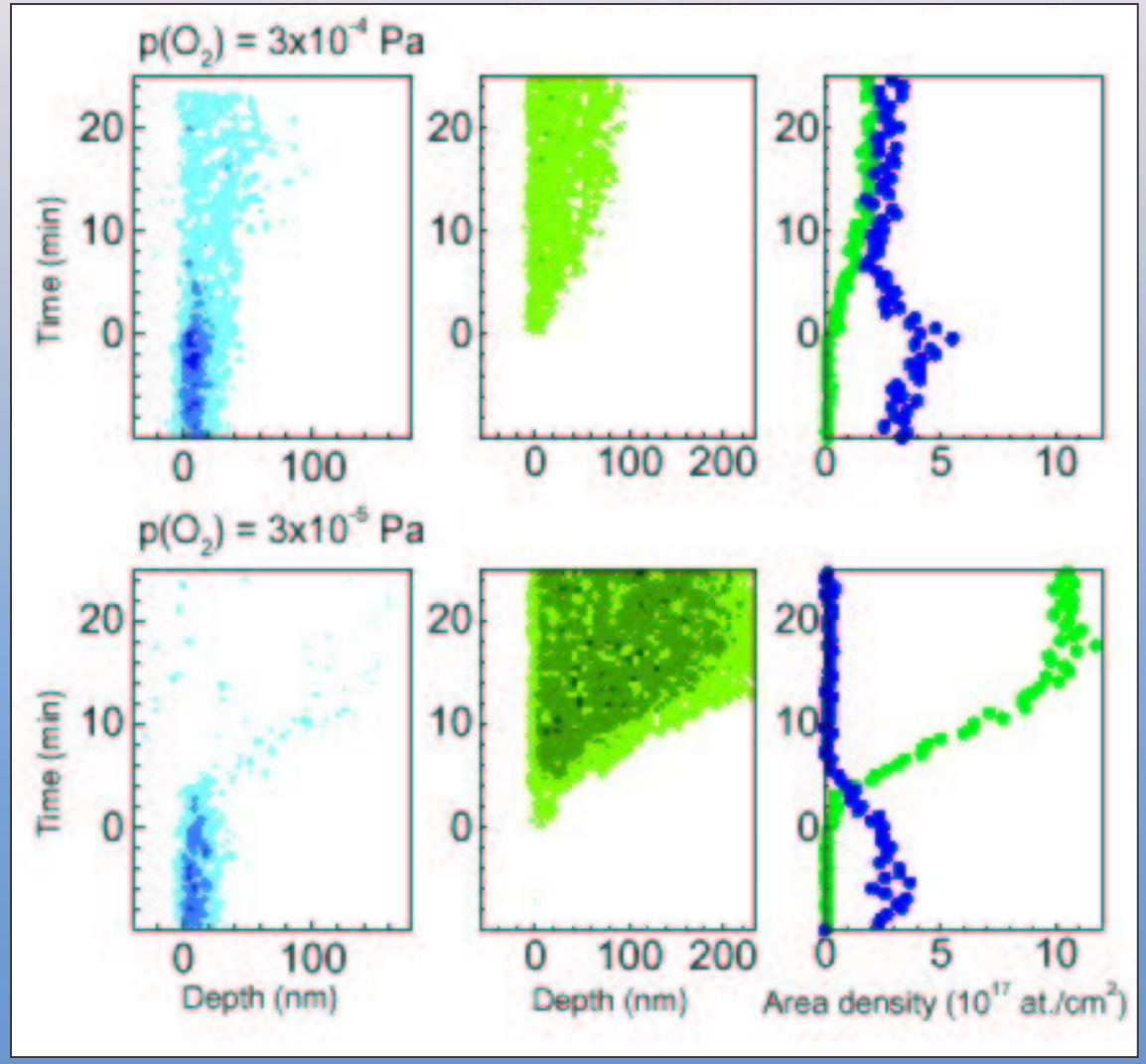
Bulk Diffusion



- **Methods**: ion implantation, plasma nitriding, low energy implantation, plasma immersion ion implantation, ...

- Large scatter in diffusivity

Surface Effects



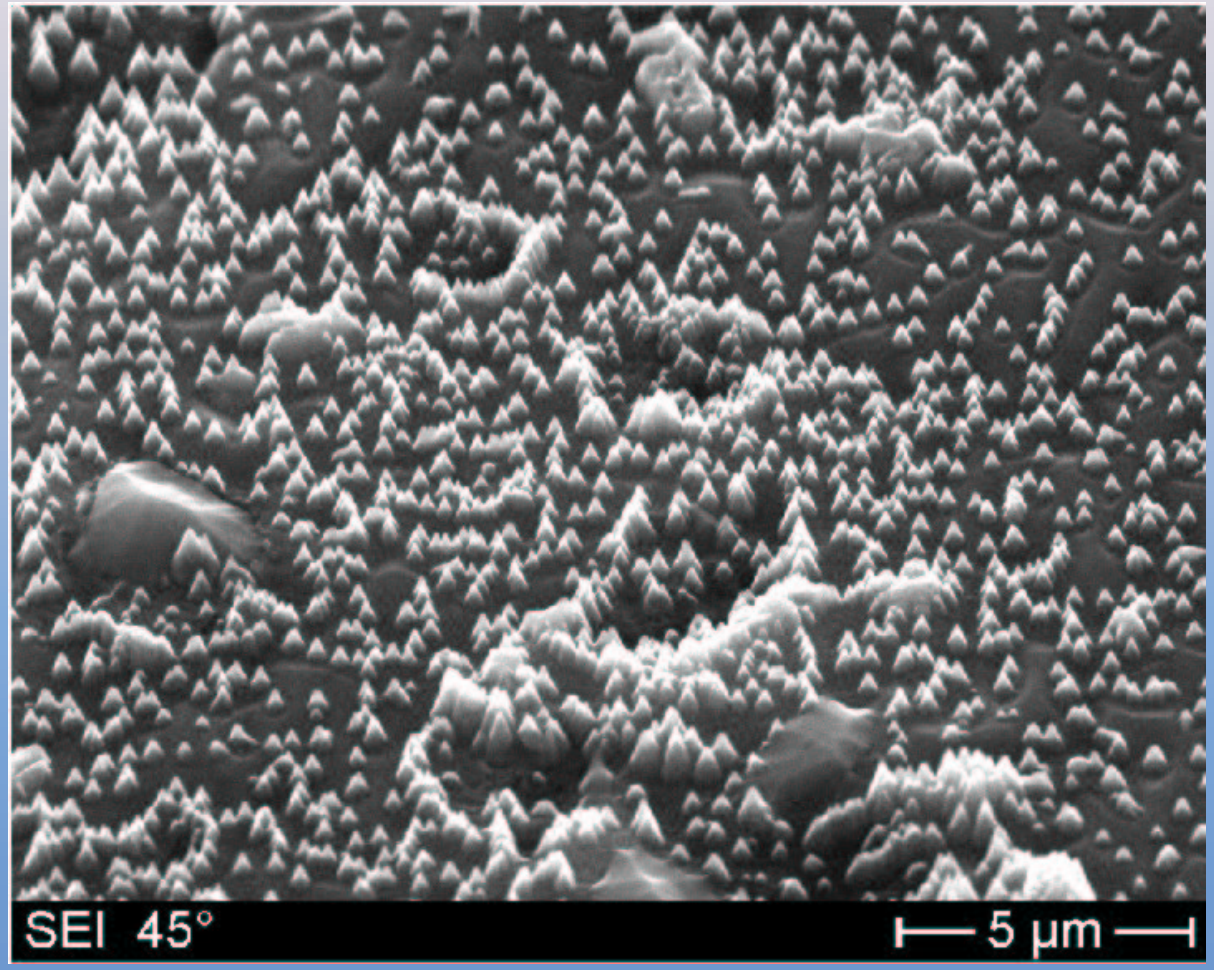
- Native oxide layer as barrier against nitrogen insertion
- Sufficient oxygen partial pressure blocks nitrogen supply
- Competition of surface adsorption and sputter removal

AlN ≡ Nitriding of Steel??

Data from T.Fitz, PhD Thesis

Surface Effects

M.Quast et al., Surf. Coat. Technol. (2001),



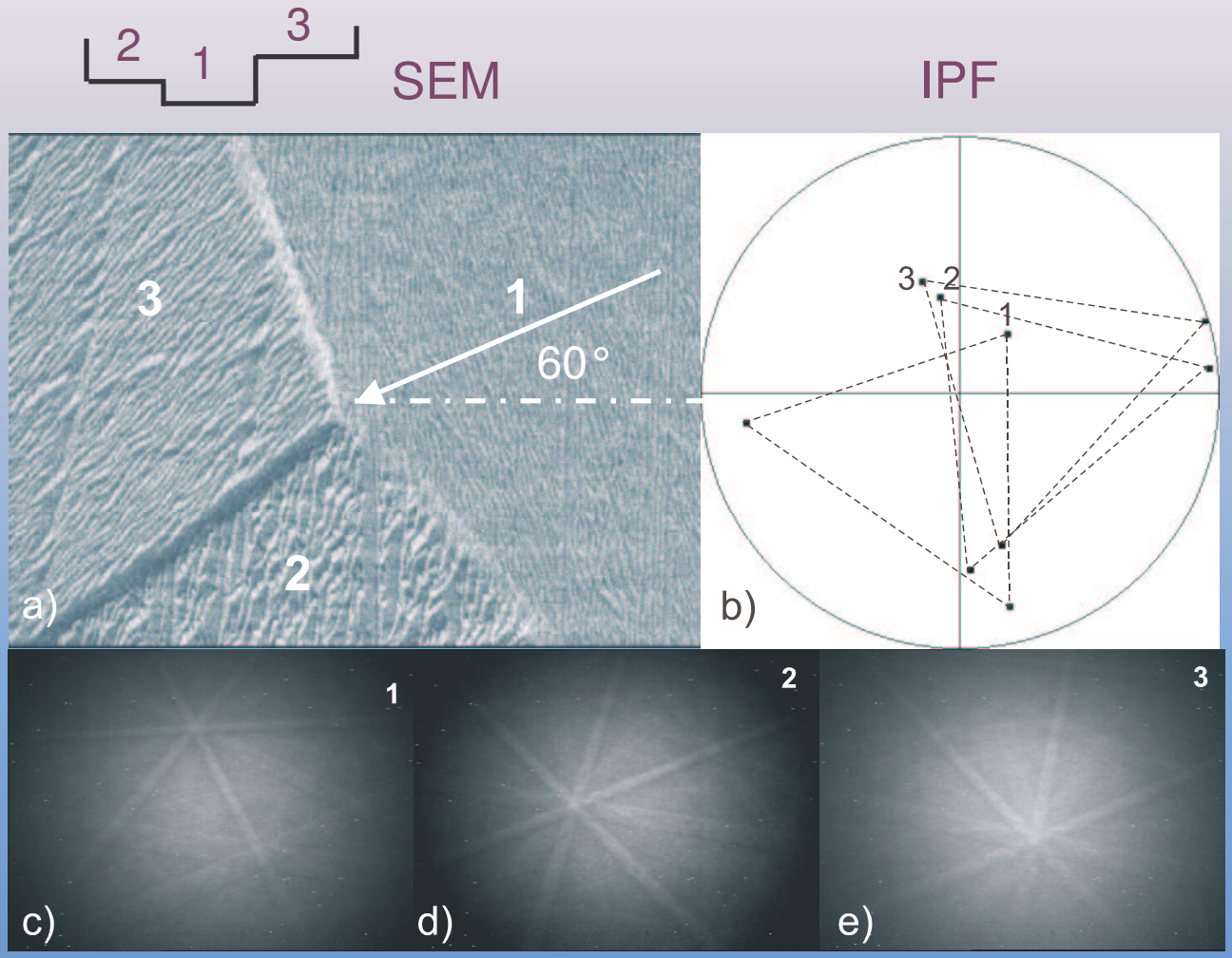
- Sputtering in Ar/H_2 mixture, 410 °C
- Almost uniform surface with regularly arranged features
- Possible explanations:

  i) self organisation

  ii) selective redeposition of sputtered oxide layer

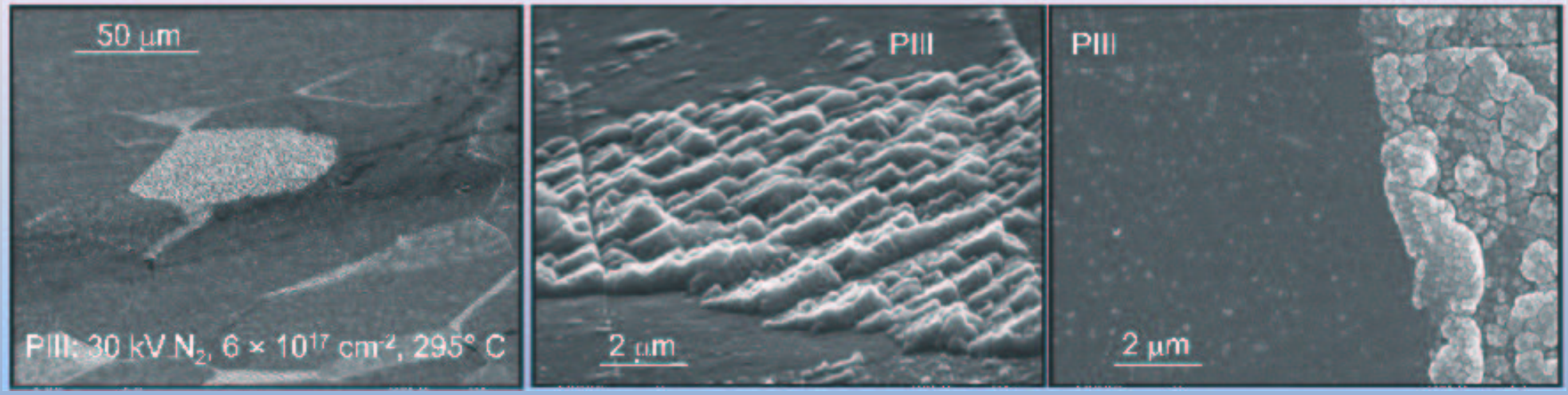
But: polycrystalline substrate: orientation dependence?

Sputtering with Cs^+: EBSD



- Sputtering of Al with 5 keV Cs^+ ions
- For different grains- different sputter yield and different patterns
- Structure related with grain orientation and not with plane of incident ions
- Relation supported by EBSD patterns and inverse pole figure

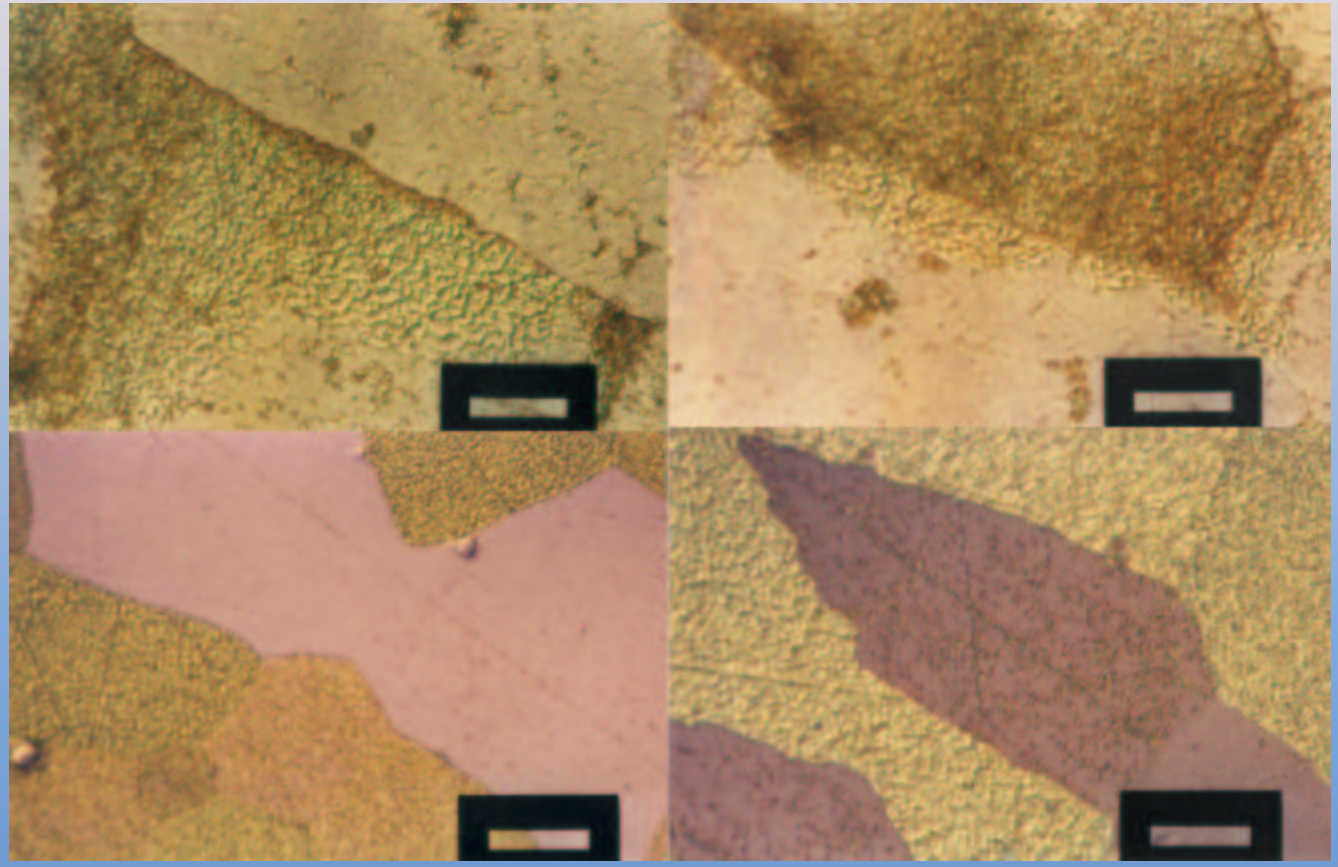
Surface Structure: PIII



- Sputtering independent of process (SIMS, PIII)
- Different surface morphology for different grain orientation after sputtering
- Competing processes: sputtering + adsorption + diffusion

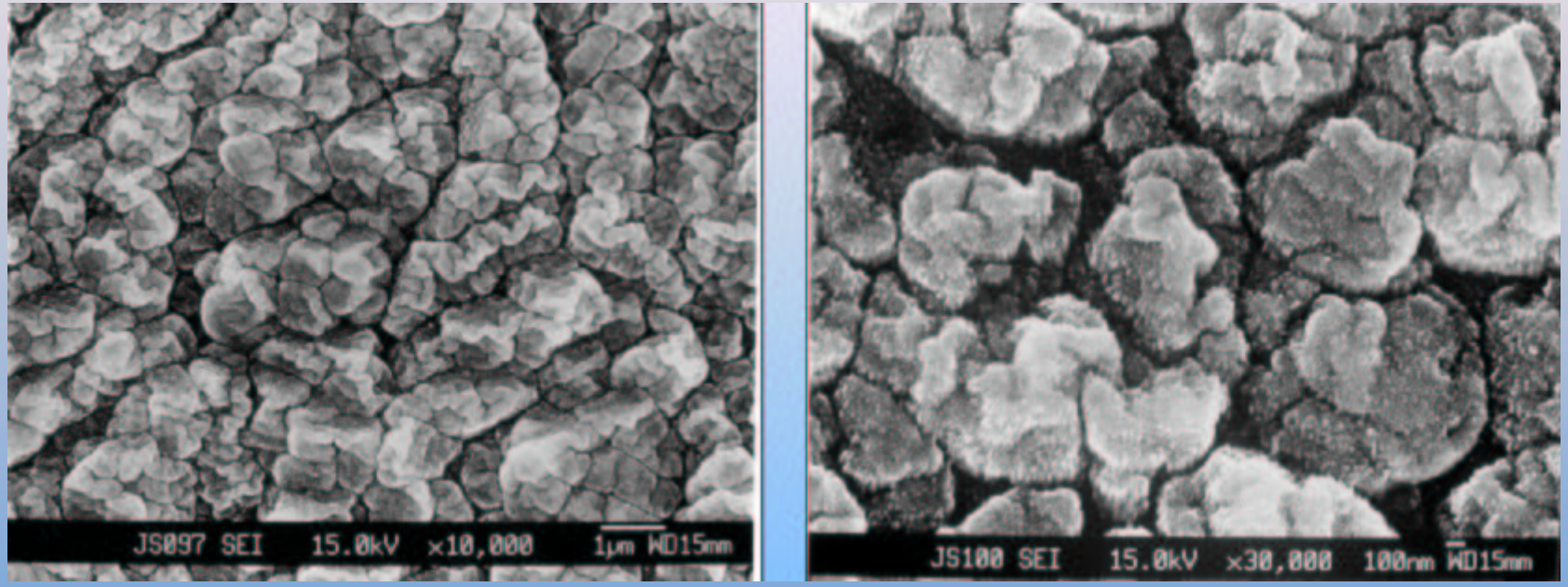
⇒ *Surface structure determined by orientation of base material*

Temperature and Surface Structure



- Nitrogen PII implantation in Al at medium temperature
- Strongly inhomogeneous surface
- Grain boundary diffusion dominates over bulk diffusion at medium temperatures
- Surface determined by grain boundary diffusion

High Temperature Diffusion



- Nitrogen PII implantation in Al at high temperatures
- Very rough surface as a result of competition between sputtering and diffusion
- Uniform surface morphology due to dominance of bulk diffusion

Summary & Conclusions

- Nitriding of Al different from nitriding of steel.

	AlN	Steel
mobile species	Al cations	N

- Important role of surface orientation
  – different sputter yield, diffusion rate, surface morphology
- Grain boundary diffusion starts to dominate over surface diffusion at medium temperatures.
- Bulk diffusion dominates at high temperatures, smoothing differences between grains. **But:** highly corrugated surface due to simultaneous sputtering.

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