FACULTY OF ENGINEERING AND ARCHITECTURE

DEPARTMENT OF ELECTROMECHANICAL, SYSTEMS AND METAL ENGINEERING
MATERIALS SCIENCE AND TECHNOLOGY GROUP

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PROCESSING, TEXTURE AND GRAIN SIZE IN TI-MICROALLOYED NON-ORIENTED ELECTRICAL STEELS

Dissemination Day 2024| Alexey Gervasyev | 25 Nov 2024

OUTLINE

- Processing overview
- Effect of the Ti-microalloying on grain size and texture
- Concluding comments

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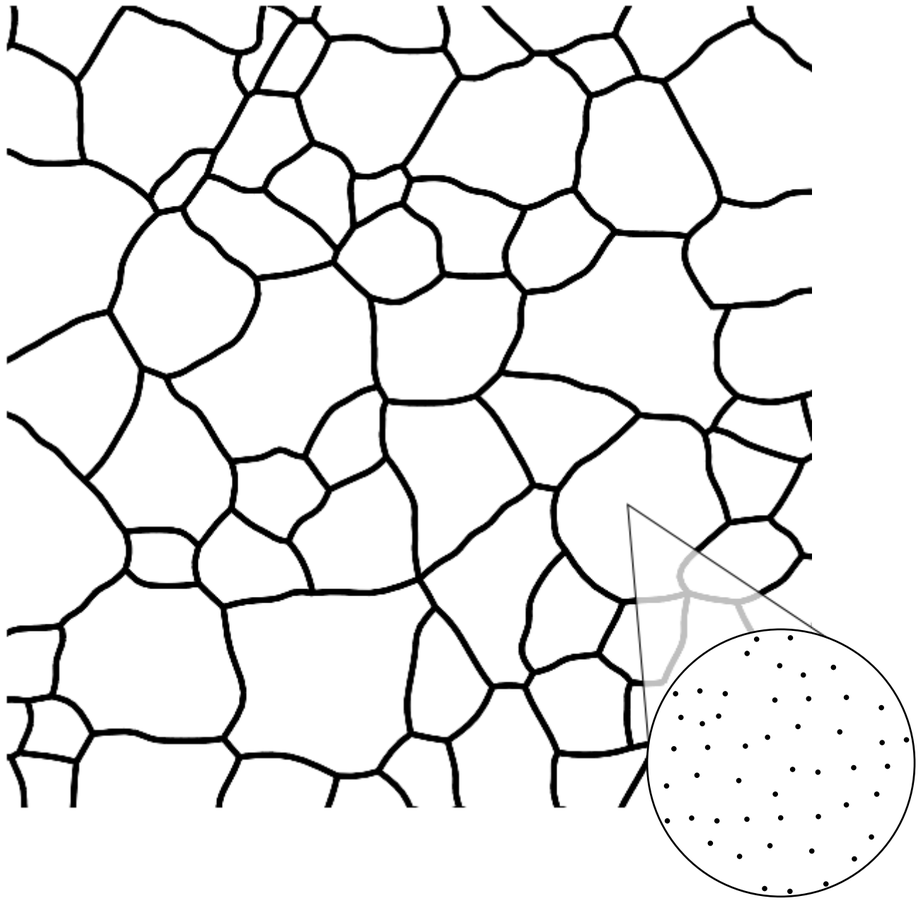
CONCEPT



Fine precipitates increase the hysteresis loss as they interact with magnetic domain walls hindering the alignment of ferromagnetic moments during magnetization cycle

Precipitate size ≈ 0.1 µm ≈ domain wall thickness

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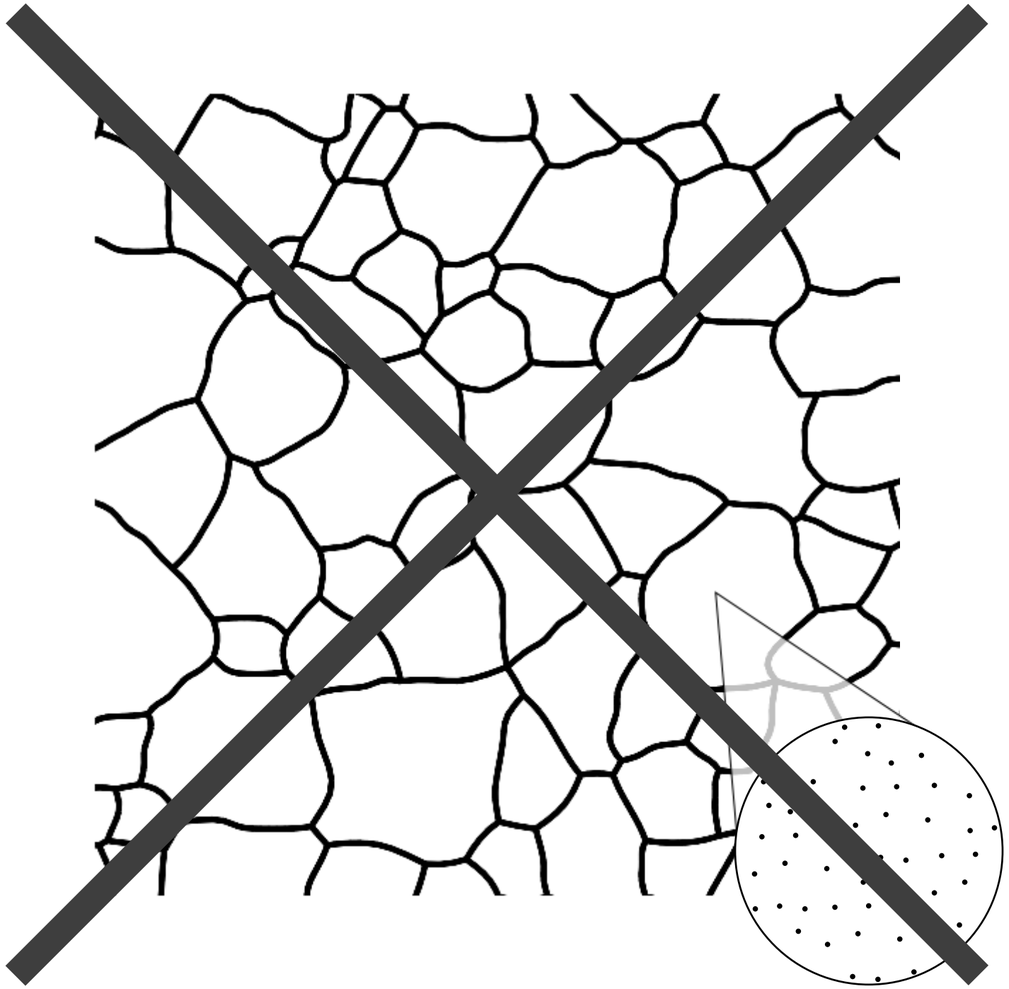
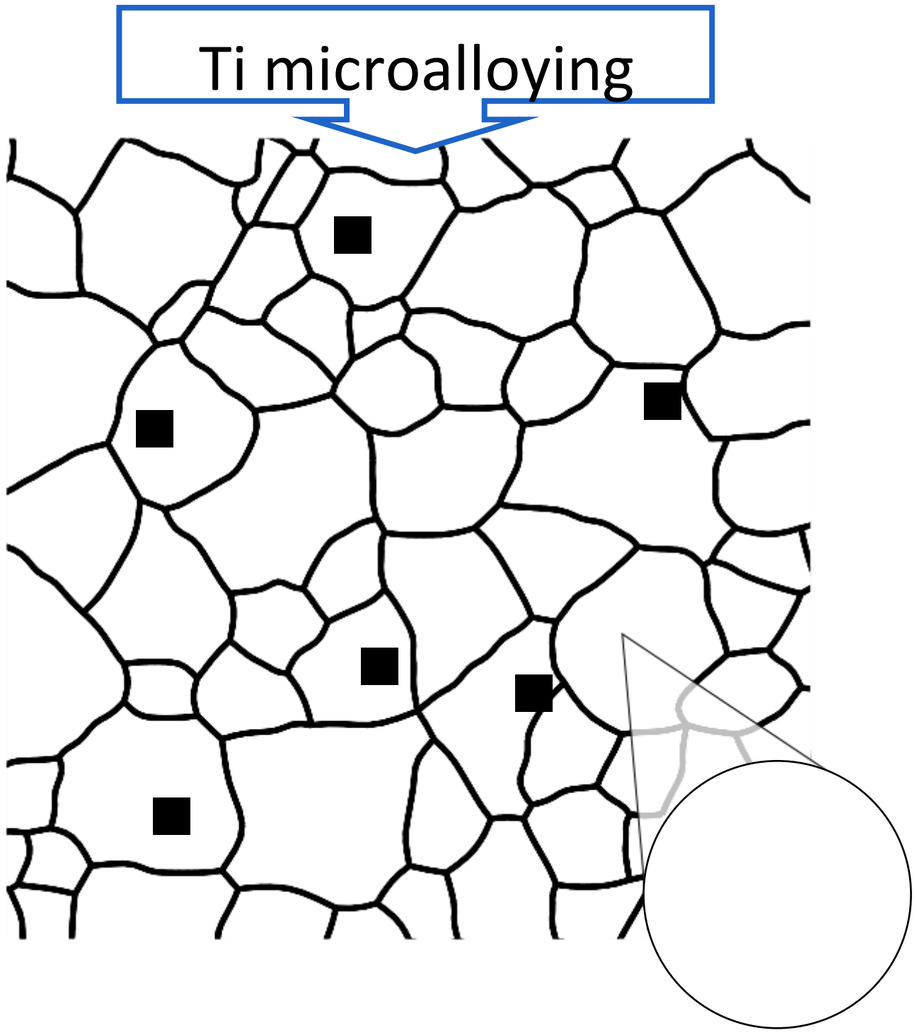
CONCEPT



Precipitate size ≈ 0.1 µm ≈ domain wall thickness



Precipitate size >> 0.1 µm

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CHEMICAL COMPOSITION OF THE MATERIALS (WT.%)

		Si	Al	Ti	C	N	Mn	Cu	S	P
Wave 1 - reference	Low Si	1.02	0.51	-	0.0060	0.0047	0.30	0.014	0.002	0.014
	High Si	2.92	0.98	-	0.0060	0.0037	0.30	0.015	0.002	0.014
Wave 2 – 0.2%Ti	Low Si	1.53	0.51	0.20	0.0053	0.0032	0.27	<0.015	0.002	0.011
	High Si	2.97	0.99	0.20	0.0061	0.0036	0.32	<0.015	0.002	0.012
Wave 3 – 0.5%Ti	Low Si	0.98	0.49	0.49	0.0050	0.0033	0.30	0.015	0.003	0.008
	High Si	2.98	1.01	0.49	0.0046	0.0023	0.29	0.015	0.003	0.008

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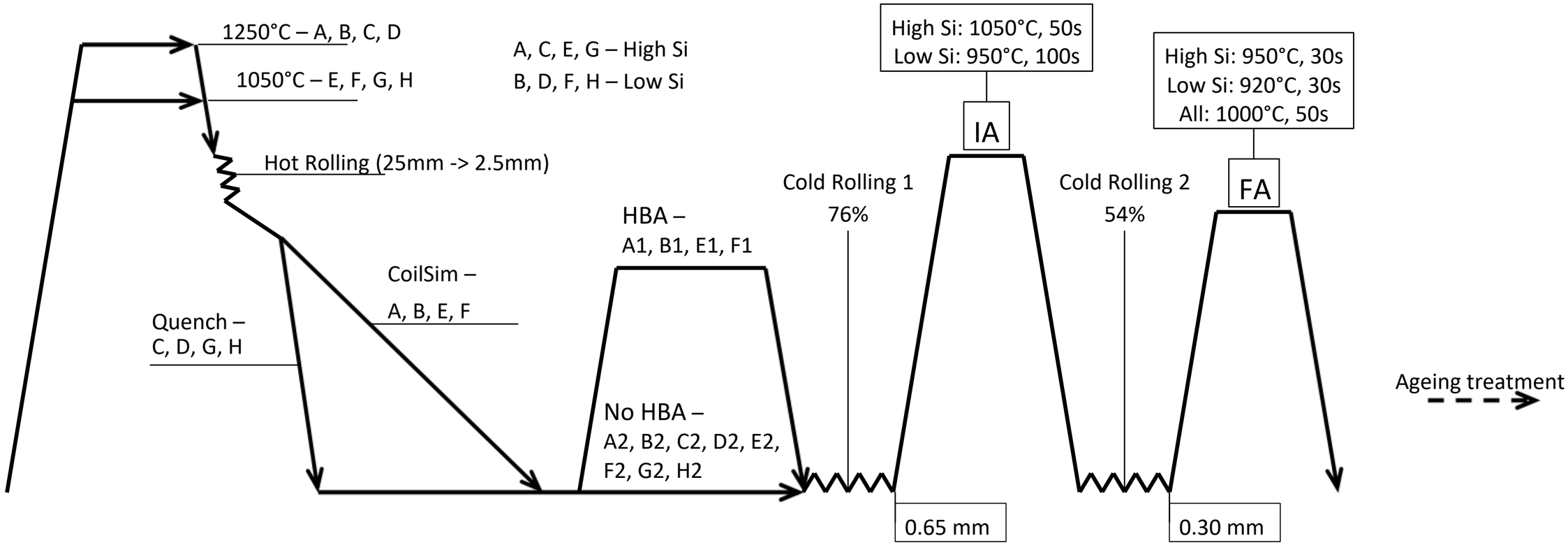
1ST WAVE (REFERENCE) MATERIALS PROCESSING



HBA – batch hot band annealing simulation, 7 hours at 800°C (plus 18 hours heating and cooling) in 100% H_2

IA – continuous intermediate annealing simulation
FA – continuous final annealing simulation

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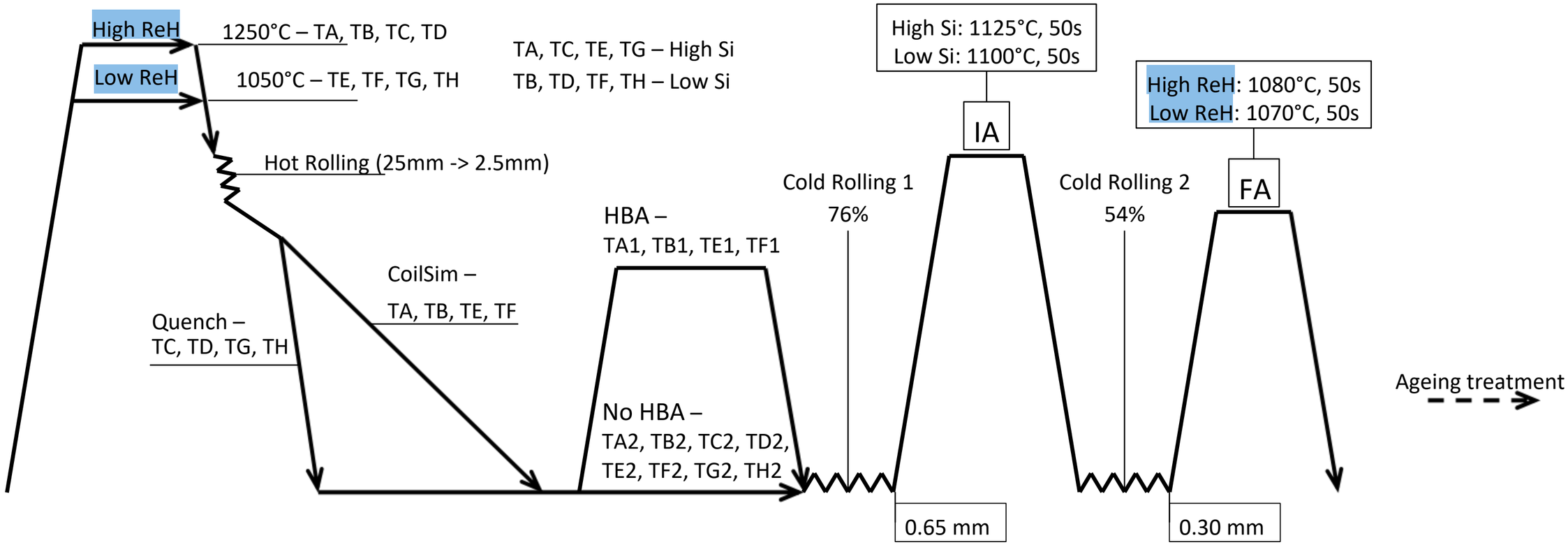
2ND WAVE (0.2%Ti) MATERIALS PROCESSING



HBA – batch hot band annealing simulation, 7 hours at 800°C (plus 18 hours heating and cooling) in 100% H_2

IA – continuous intermediate annealing simulation
FA – continuous final annealing simulation

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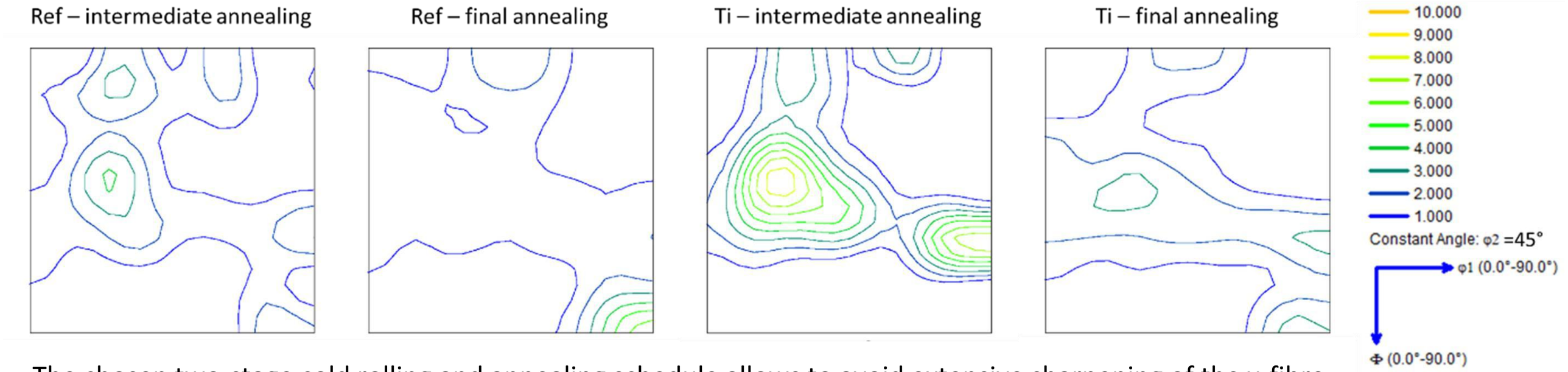
CRYSTALLOGRAPHIC TEXTURE IN WAVES 1 AND 2



The chosen two-stage cold rolling and annealing schedule allows to avoid extensive sharpening of the γ-fibre texture in the final condition despite the increased susceptibility to form this fibre in the Ti-added materials due to the reduced interstitials content. The pronounced Goss component in the final texture is possibly related to the large content of shear bands formed by the cold rolling step within large grains that were present after the intermediate annealing.

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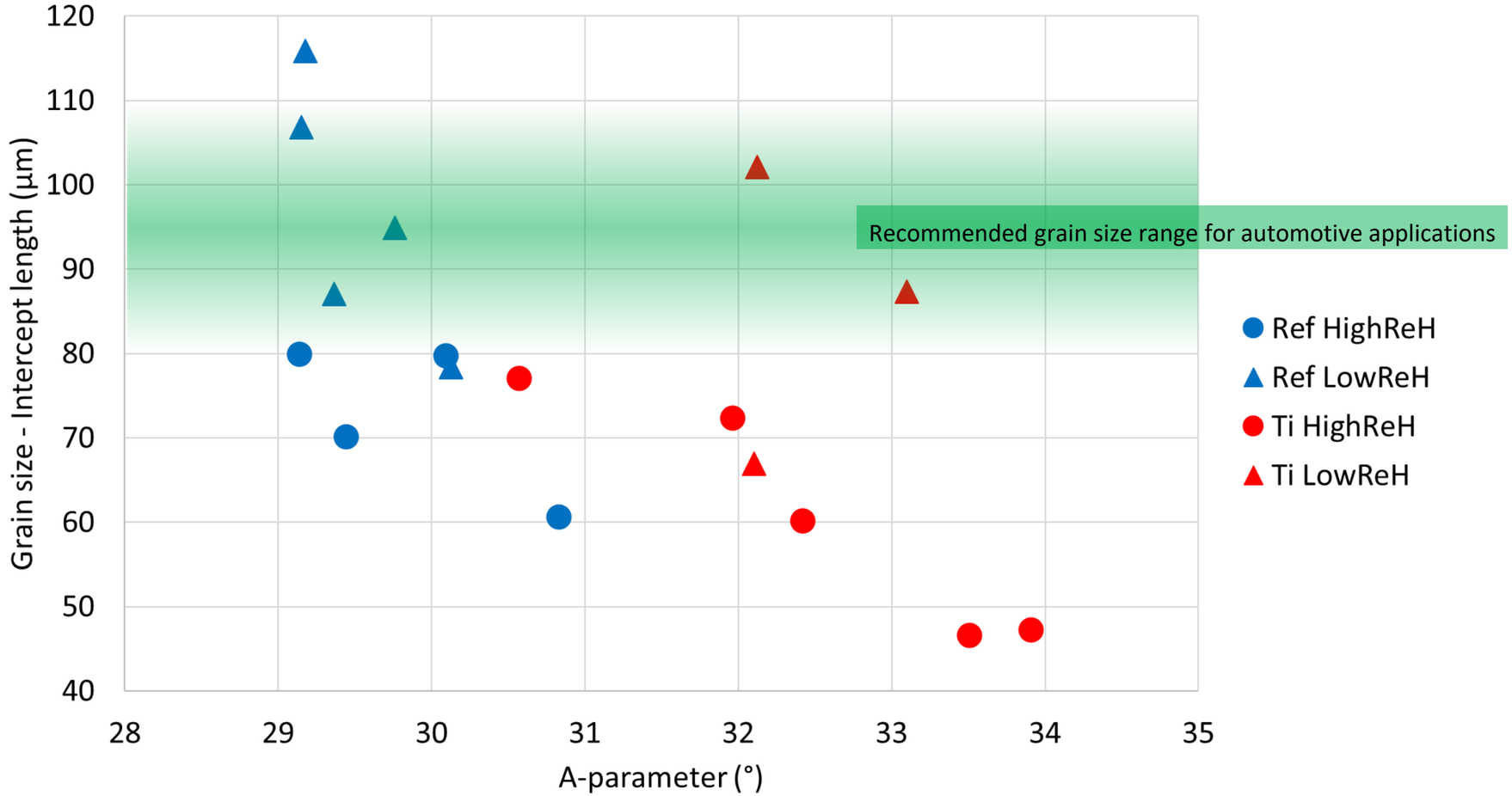
GRAIN SIZE AND TEXTURE IN WAVES 1 AND 2



It is suggested that the main factors contributing to grain growth suppression are the Ti addition and the **initial reheating temperature (prior hot rolling)**. Ti addition and higher reheating temperature result in a stronger suppression of grain growth

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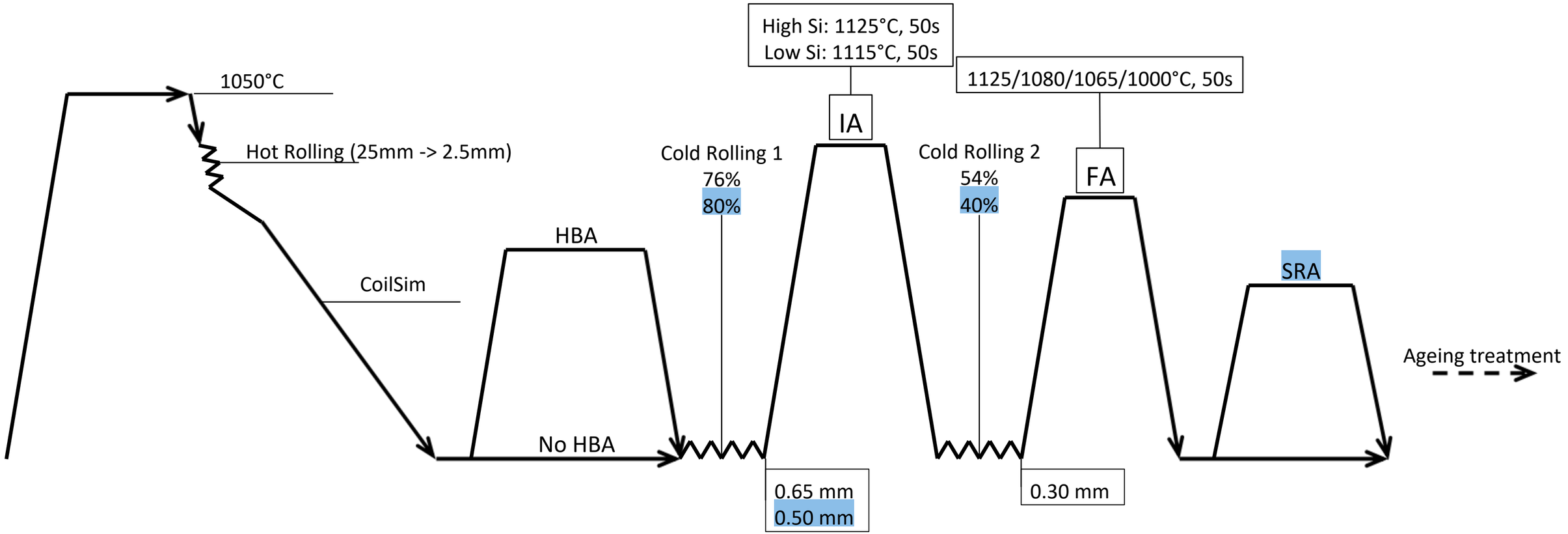
3RD WAVE (0.5%Ti) MATERIALS PROCESSING



HBA – batch hot band annealing simulation, 7 hours at 800°C (plus 18 hours heating and cooling) in 100% H_2

IA – continuous intermediate annealing simulation
FA – continuous final annealing simulation

SRA – batch stress relief annealing simulation, 1 hour at 750°C (plus approx. 23 hours heating and cooling) in 100% H_2

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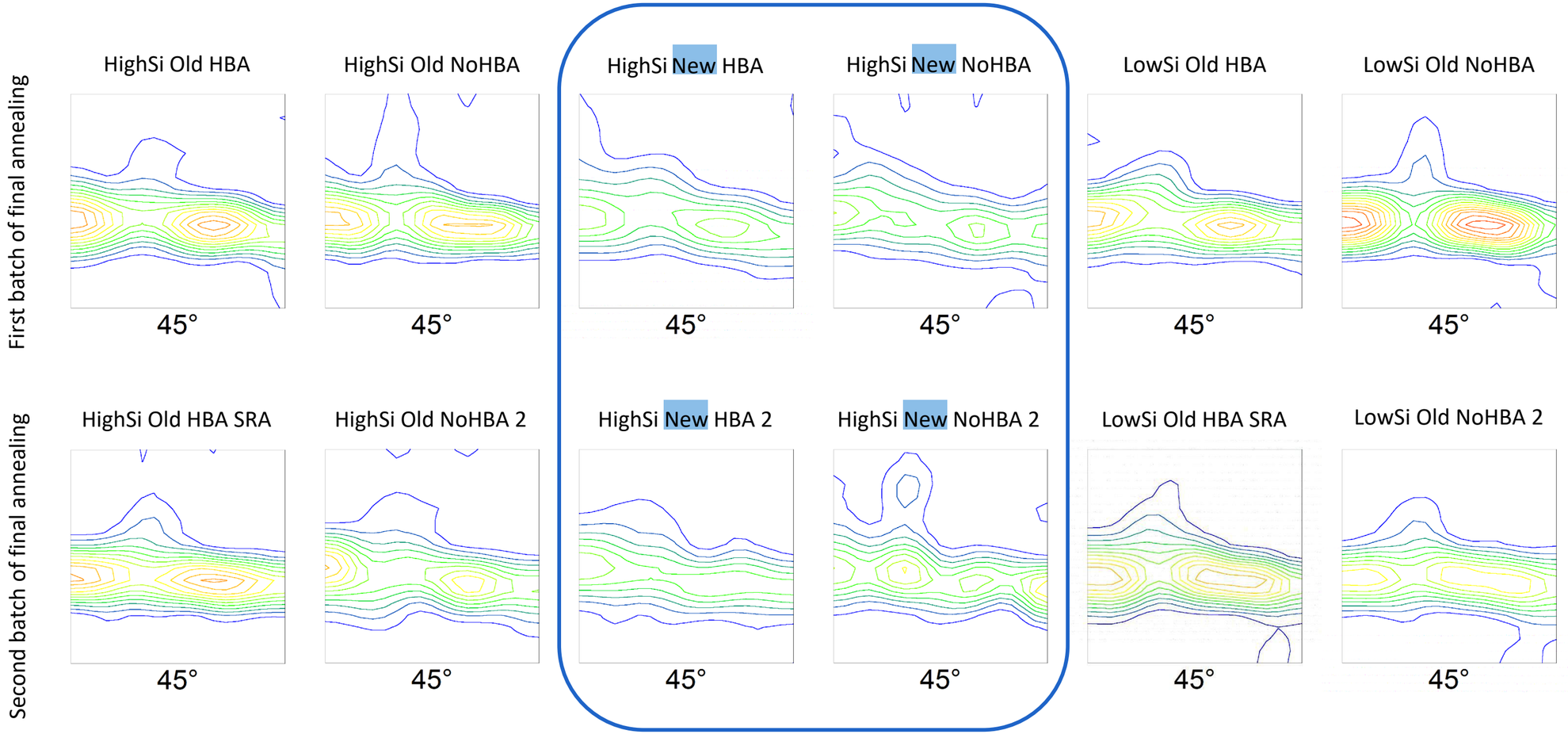
CRYSTALLOGRAPHIC TEXTURE IN WAVE 3



The new cold rolling reductions (80% + 40% instead of 76% + 54%) resulted in a less sharp γ-fibre.

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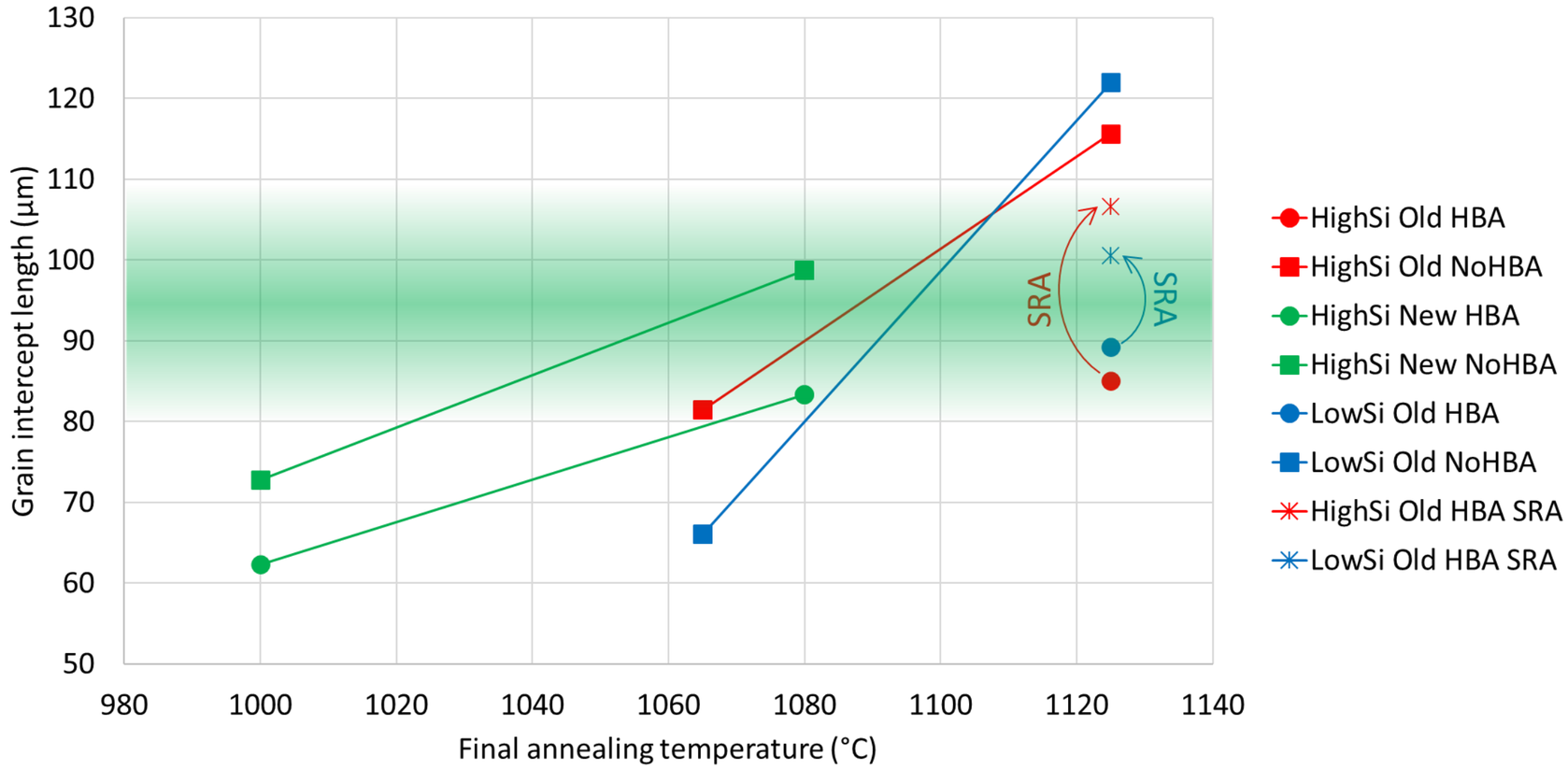
GRAIN SIZE IN WAVE 3



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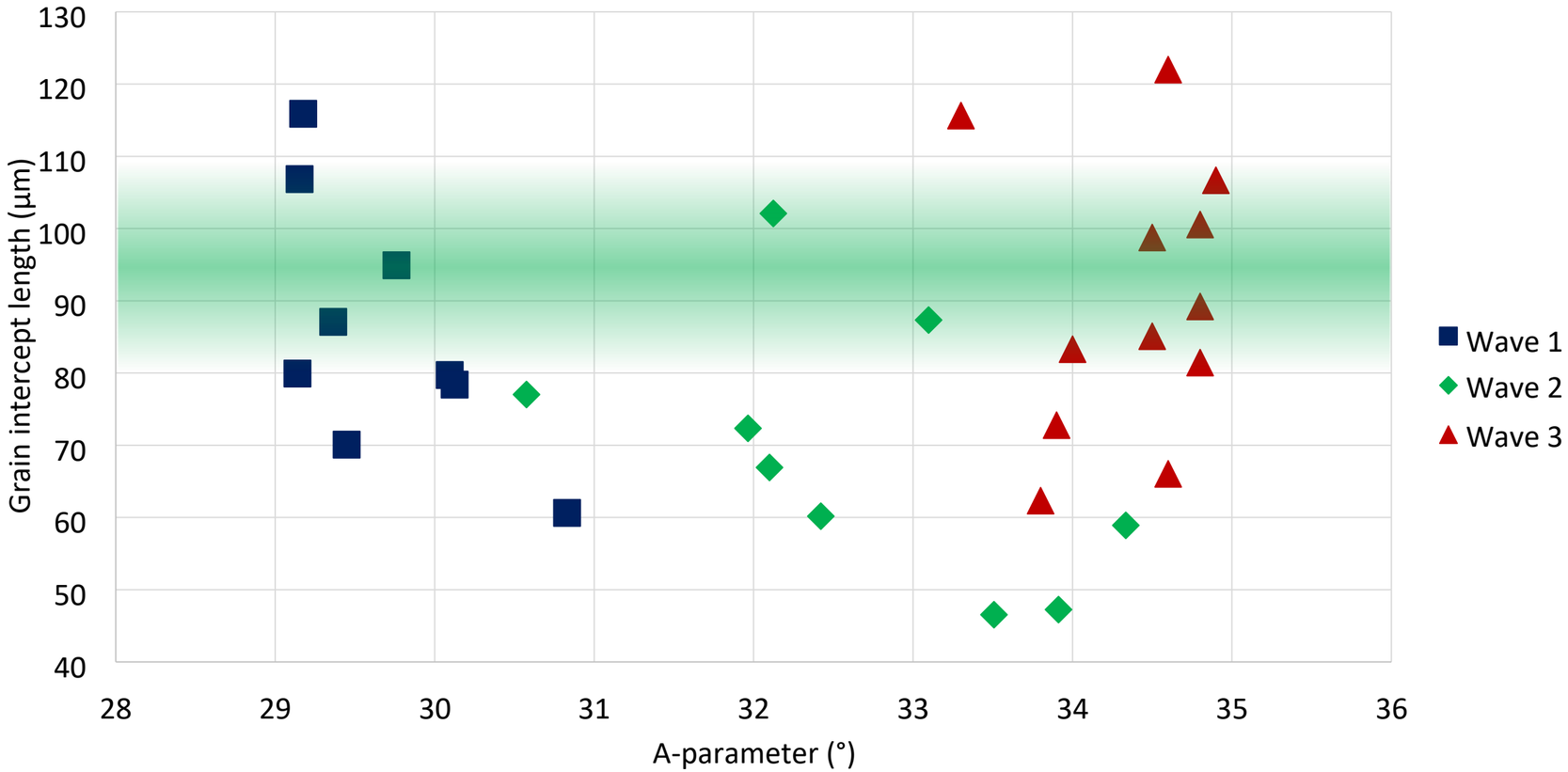
GRAIN SIZE AND TEXTURE IN WAVE 3



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CONCLUDING COMMENTS

- Ti addition inevitably leads to the development of the unfavourable γ-fibre texture due to the reduced interstitials content. This effect can be reduced by the adjustment of the two-stage cold rolling reduction schedule.
- The grain size can be controlled reasonably well despite the stronger grain growth inhibition in the Ti-microalloyed materials compared to the reference materials

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ACKNOWLEDGEMENT

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Thank you!