



# Texture and grain size in Ti-microalloyed non-oriented electrical steel

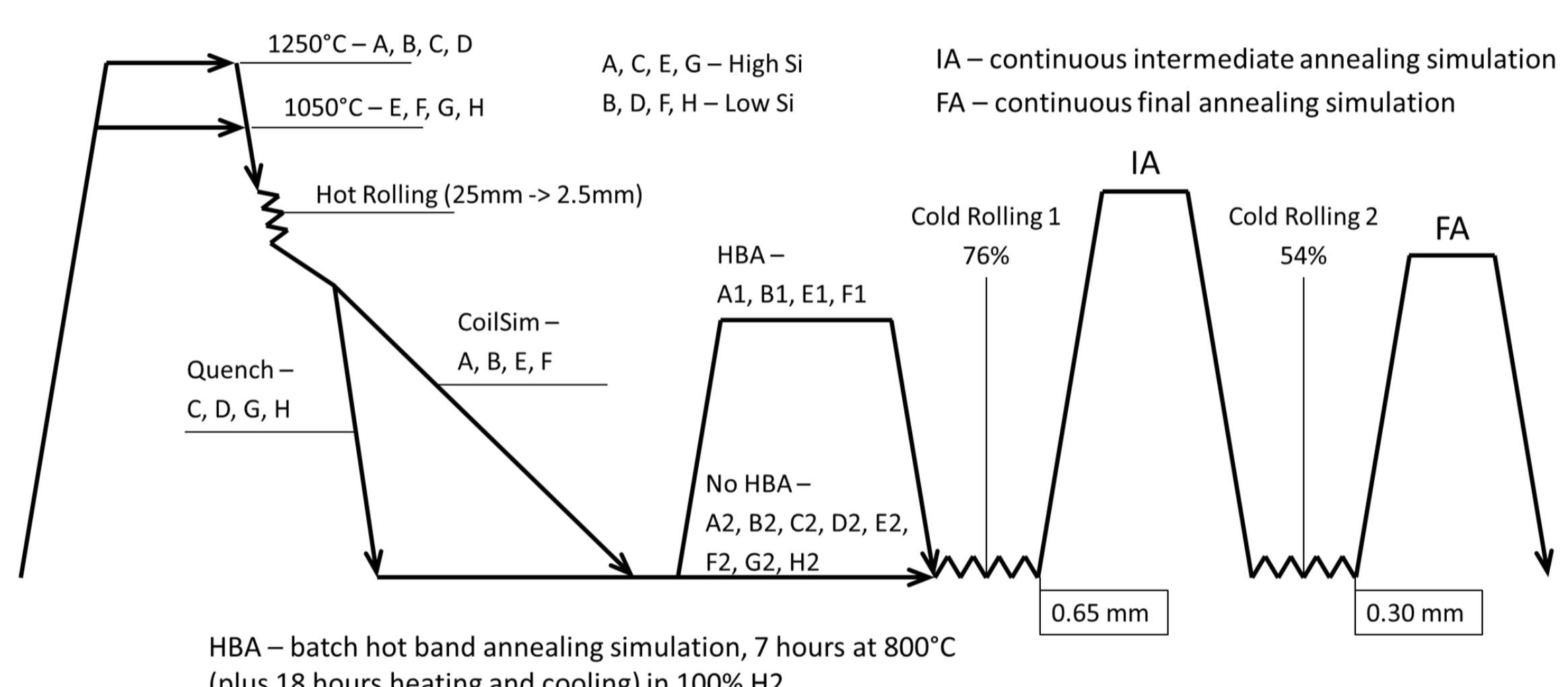
Alexey Gervasyev<sup>1</sup>, Leo A.I. Kestens<sup>1</sup>, Nikolas Mavrikakis<sup>2</sup>, Herbert Kreuzer<sup>3</sup>, Stefano Cicale<sup>4</sup>

<sup>1</sup>Ghent University, <sup>2</sup>OCAS NV, <sup>3</sup>Voestalpine Stahl GmbH, <sup>4</sup>RINA Consulting – Centro Sviluppo Materiali

- A European RFCS project, STabilized ELectrical Steels for Electric Mobility (STeELS-EM) is being conducted to explore the possibility to optimize the precipitation in NOES by microalloying. Ti microalloying was chosen, as Ti carbides and nitrides are expected to form at high temperatures and therefore to exceed the unfavourable size. This communication presents intermediate results related exclusively to the effect of Ti addition on the evolution of crystallographic texture and grain size through the NOES processing. The precipitation analysis results are to be published in a separate contribution.
- Reference materials without Ti addition and Ti-microalloyed materials were manufactured according to the typical industrial practices of NOES production using state-of-the-art laboratory materials processing equipment. The grain size and texture were measured by means of EBSD analysis on 2x4 mm areas in the RD-TD plane at 1/4th thickness of sheets.
- The chosen two-stage cold rolling and annealing schedule allows to avoid extensive sharpening of the  $\gamma$ -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.

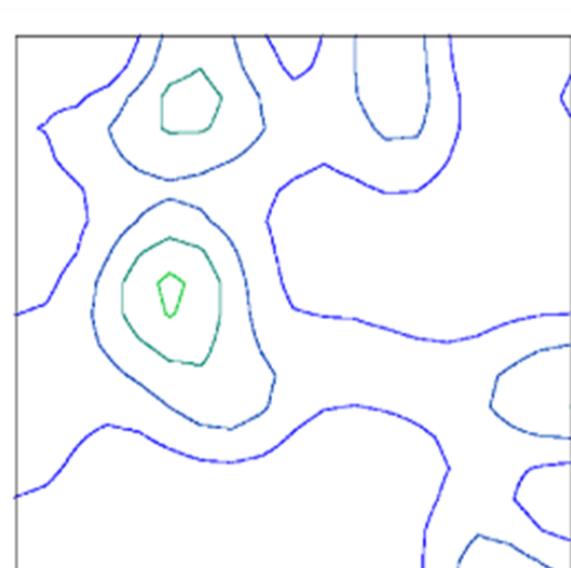
Content of main alloying elements in the laboratory heats, wt.%

	Si	C	N	Al	Mn	S	Ti	Cu	P
Ref Low Si	1.02	0.0060	0.0047	0.51	0.30	0.002	-	0.014	0.014
Ref High Si	2.92	0.0060	0.0037	0.98	0.30	0.002	-	0.015	0.014
Ti Low Si	1.53	0.0053	0.0032	0.51	0.27	0.002	0.20	<0.015	0.011
Ti High Si	2.97	0.0061	0.0036	0.99	0.32	0.002	0.20	<0.015	0.012

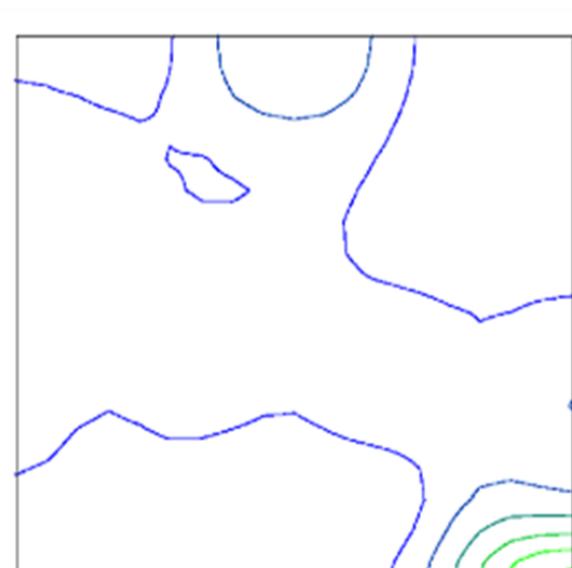


Schematic of the material processing followed within STeELS-EM project

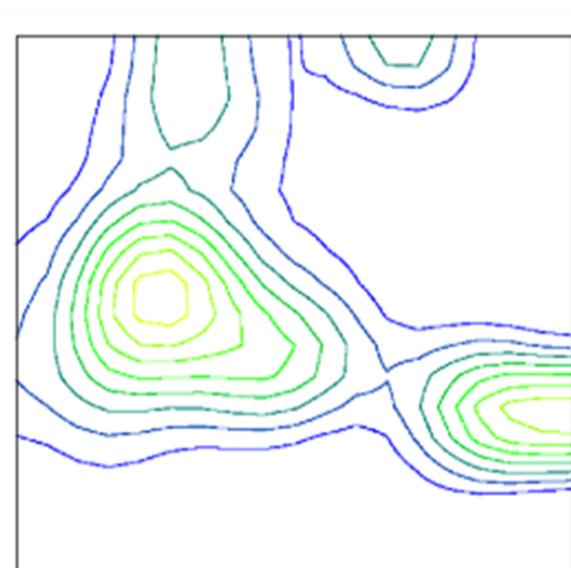
Ref – intermediate annealing



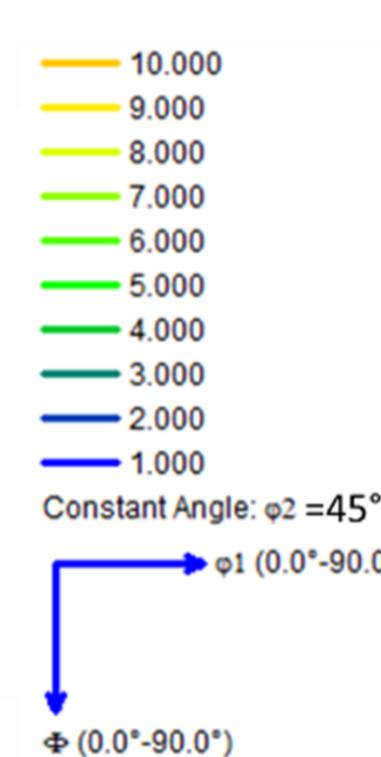
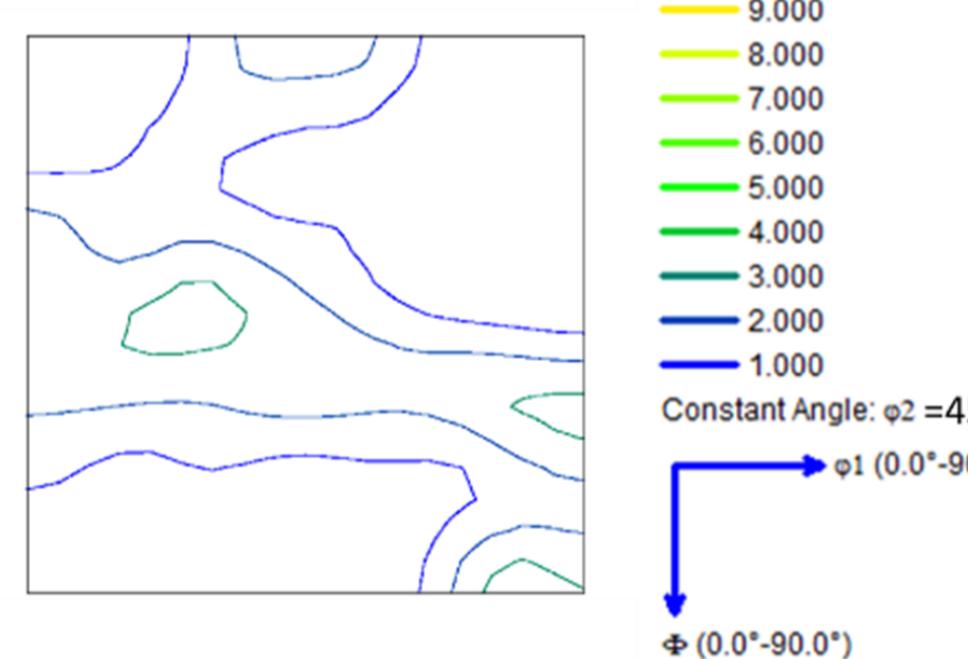
Ref – final annealing



Ti – intermediate annealing



Ti – final annealing

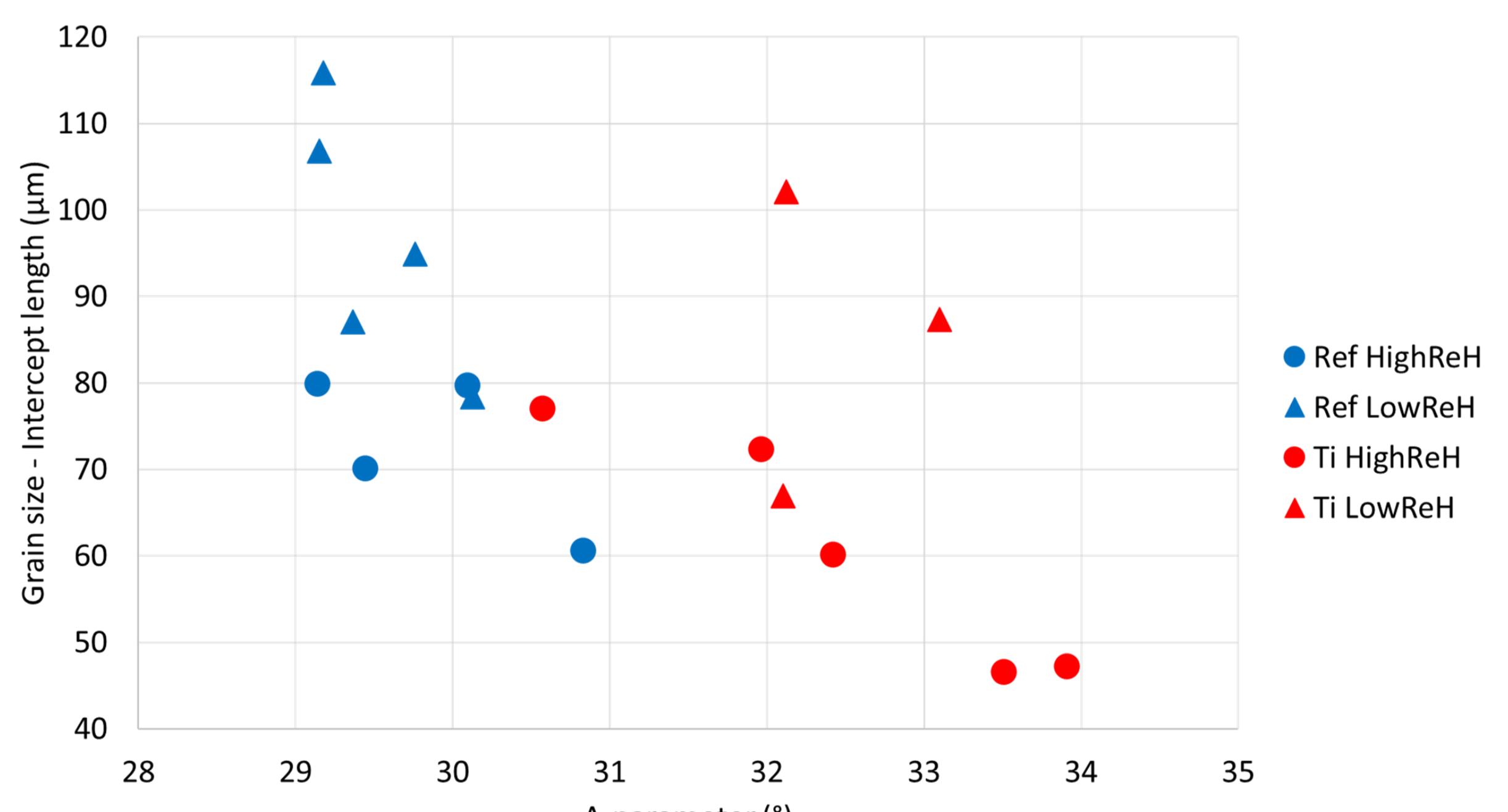


It is suggested that the main factors contributing to grain growth suppression are the Ti addition and the initial reheating temperature (prior hot rolling). Ti addition and higher reheating temperature result in a stronger suppression of grain growth.

Typical crystallographic texture after annealing steps of processing with and without Ti addition.  
 $\Phi = 45^\circ$  ODF sections

## Intermediate conclusions

- Overall, the Ti-materials have a less favourable combination of grain size and texture compared to the reference materials. While the texture deterioration (A-parameter increase) was expected and can probably be tolerated, the grain growth inhibition implies that the Ti precipitates did not reach the desired size, and this should be addressed in the next processing trials. A somewhat negative effect of Ti microalloying on texture can be compensated by an improved resistance to the magnetic ageing, which is the main objective of the project.



Grain size and A-parameter values for the final condition of the materials studied