Effect of Hot and Cold Rolling on Grain Size and Texture in Fe-Si Strips with Si-Content Larger than 2 wt%

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Outline

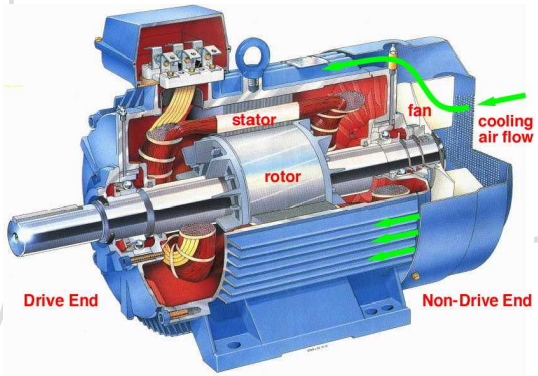
Application

Eletrical steel

Ferromagnetic material largely used as core in electrical machines.

Examples (basically):

- Electrical motors
- Transformers

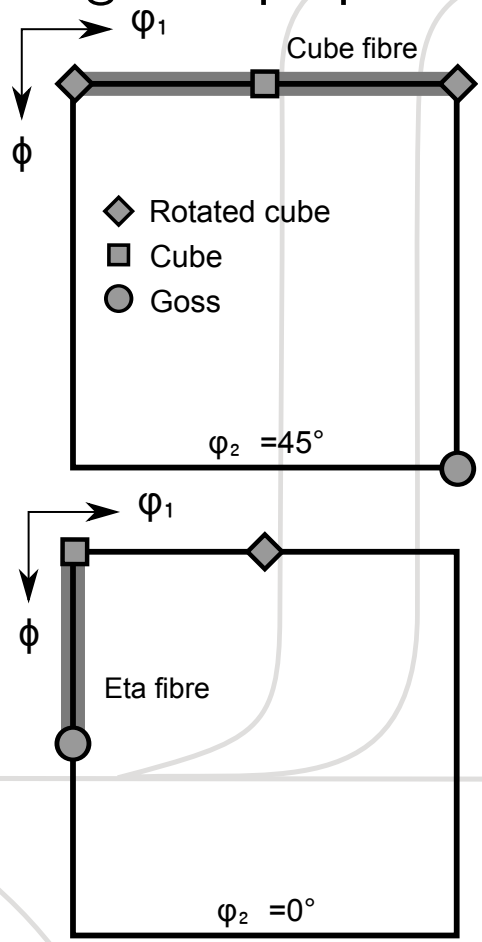


Grain size and Texture

The magnetic properties are affected by:

- Grain size
- Grain size distribution
- Grain morphology
- Crystallographic texture

For magnetic properties:



Current knowledge

- The hot band annealing, especially for Fe-Si alloys with phase transformation, leads to an enhanced intensity of the Goss and cube texture as well as of the eta-fibre (higher coiling temperatures after hot rolling).
- A coarse grained hot band structure gives a higher intensity of Goss texture.
- A final hot rolling in the two phase region and ferritic region may also result in better magnetization behaviour of the materials[1].

[1] work at TU Bergakademie Freiberg and TKS

Work motivation

With respect to Fe-Si alloys without phase transformation:

- Little or no literature data are available on the effect of different hot rolling parameters.
- Even more regarding the effect of whole processing conditions(hot rolling, cold rolling and annealing).

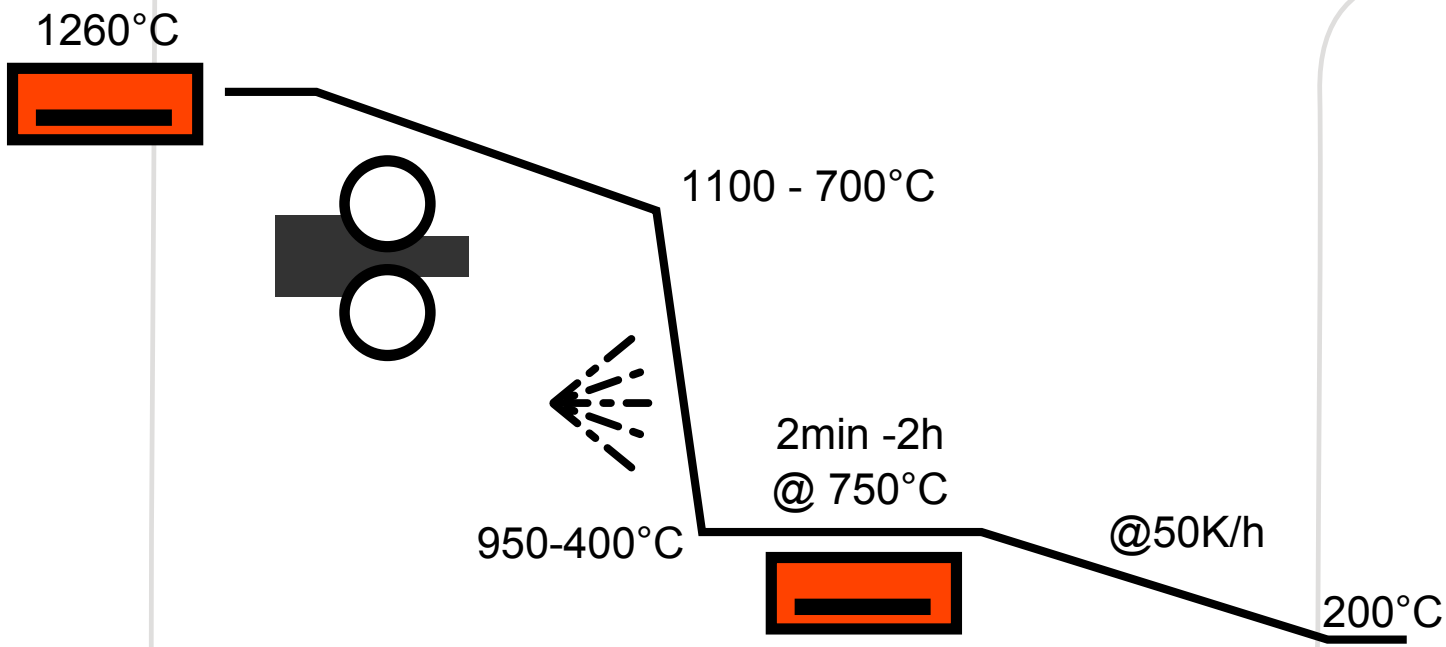
Outline

Samples

- Samples with 2.4wt%Si and 3.0wt% of Si $\rightarrow$ no phase transformation
- Width of 80mm and a thickness of 2mm (after hot rolling[2])
- Fabricated using the four stand high speed hot rolling mill at TU Freiberg

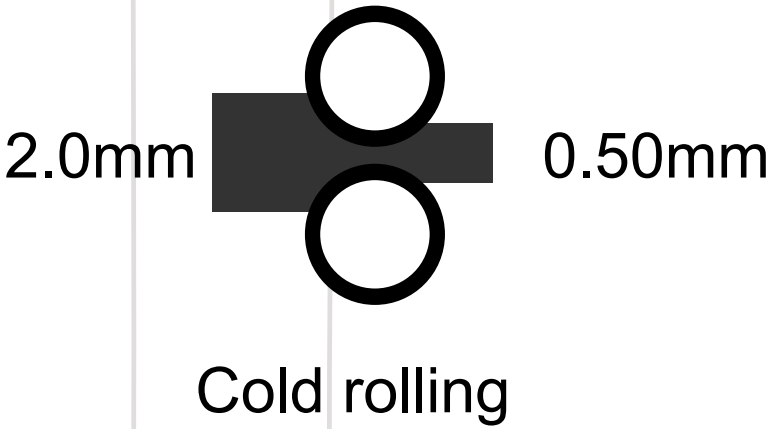
[2]The final thickness was reached after six passes. The reduction was larger than 40% in the first five passes.

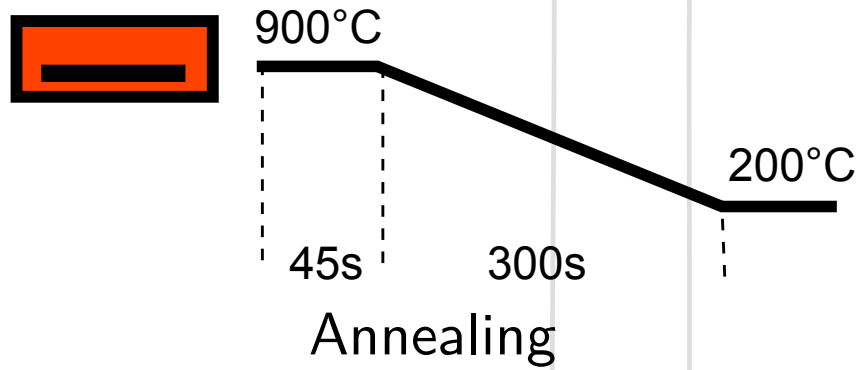
Hot rolling



Sample Name	Si Content	Finishing Temperature	Rapid Cooling To	Holding Temperature (Time)	Slow Cooling To
A	2.4%	860°C	800°C	750°C (20min)	200°C
B	2.4%	1010°C	950°C	750°C (2h)	200°C
C	3.0%	820°C	400°C	-	200°C
D	3.0%	860°C	800°C	750°C (2min)	200°C

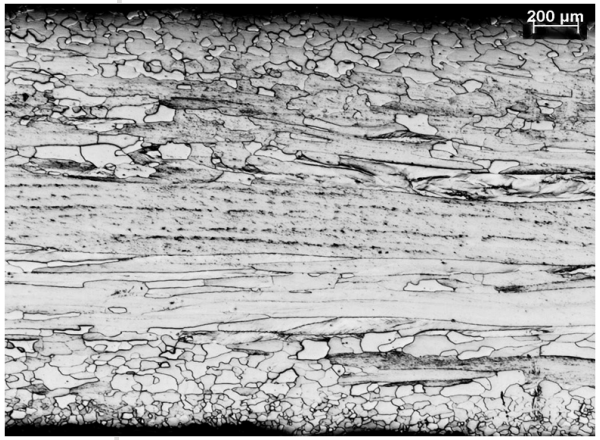
Cold rolling and Annealing



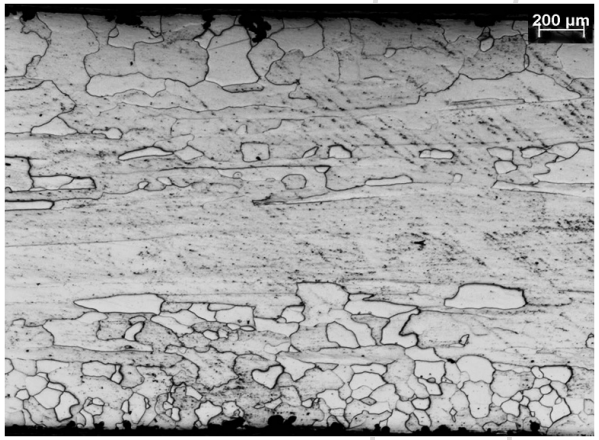


Outline

Optical micrograph (samples with 2,4% Si)



A (FT=860°C, AN→20min@750°C)

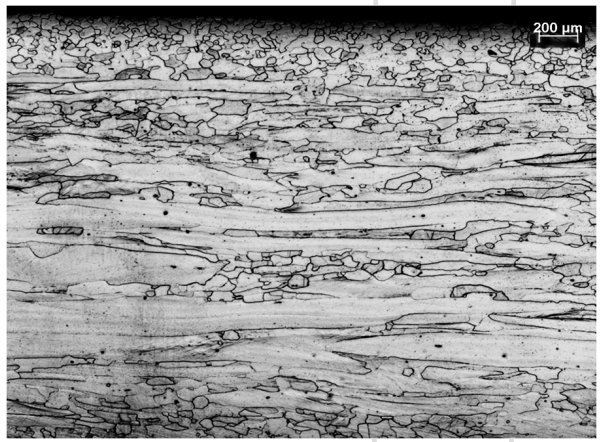


B (FT=1010°C, AN→2h@750°C)
higher finishing temp and longer annealing time

Optical micrograph (samples with 3,0% Si)

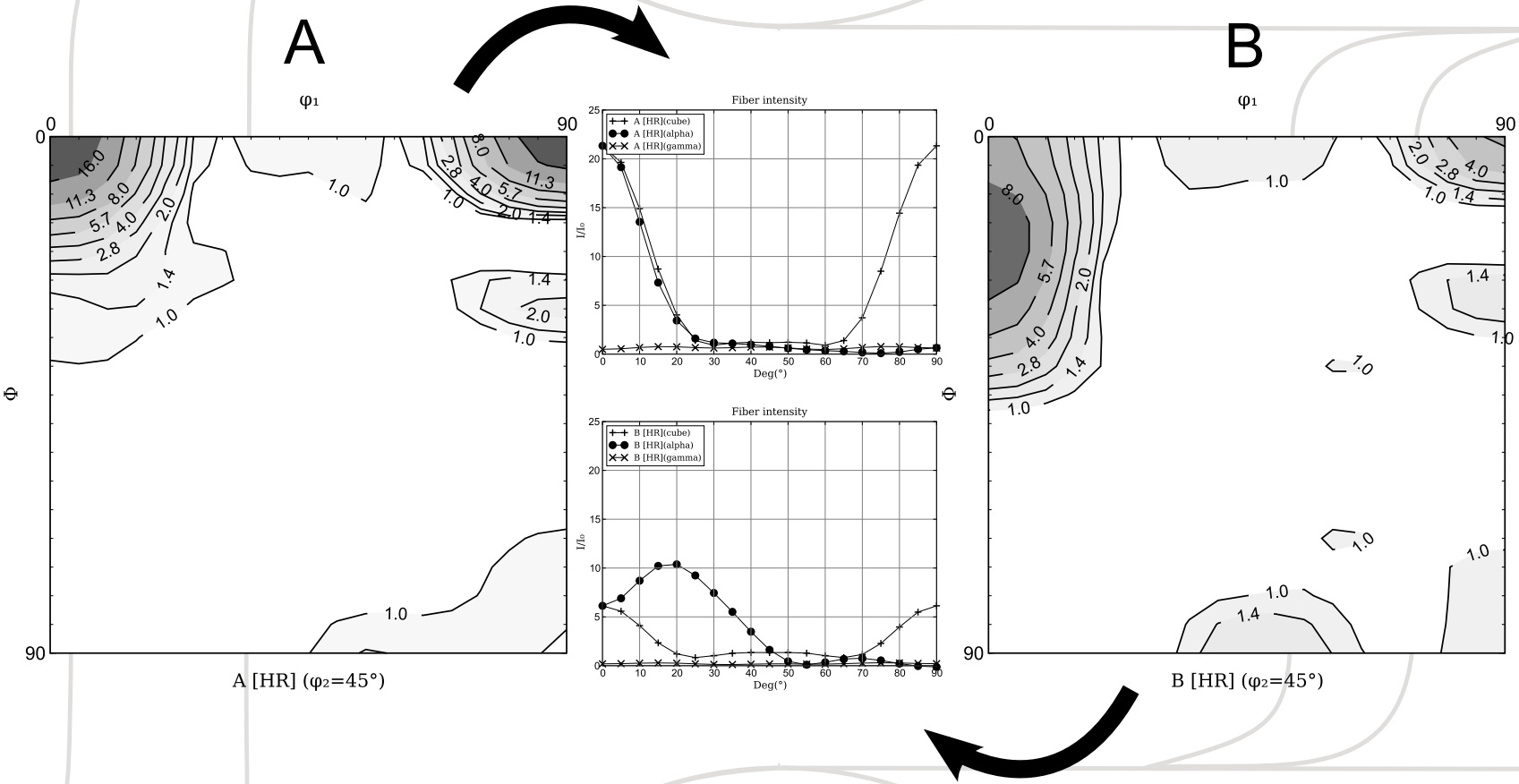
C (RC to 400°C)

rapid colling after HR and no annealing



D (RC to 800°C, AN→2min@750°C)

Texture (samples with 2,4% Si)

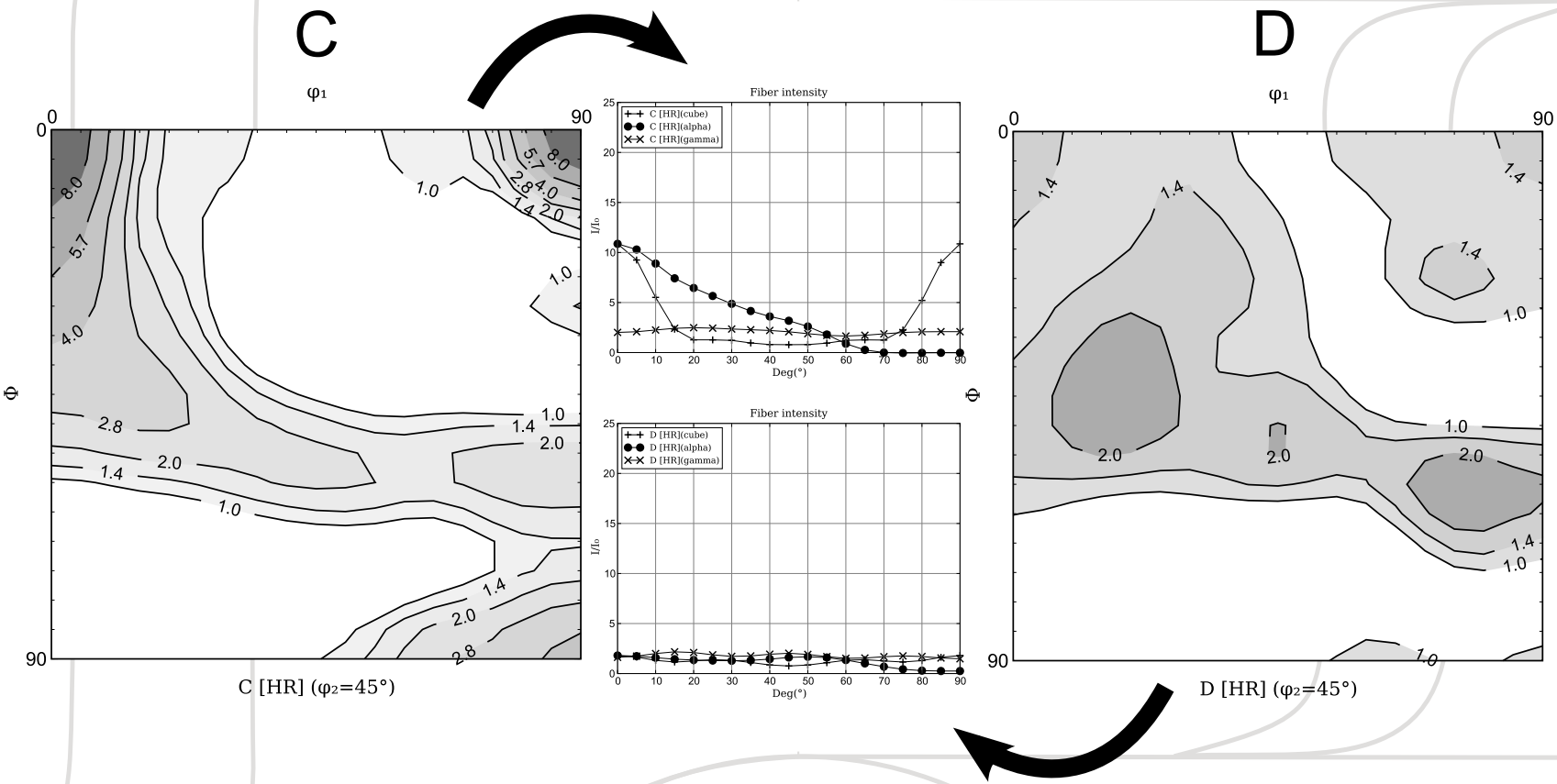


FT=860°C, AN→20min@750°C

FT=1010°C, AN→2h@750°C

higher finishing temp and longer AN time

Texture (samples with 3,0% Si)

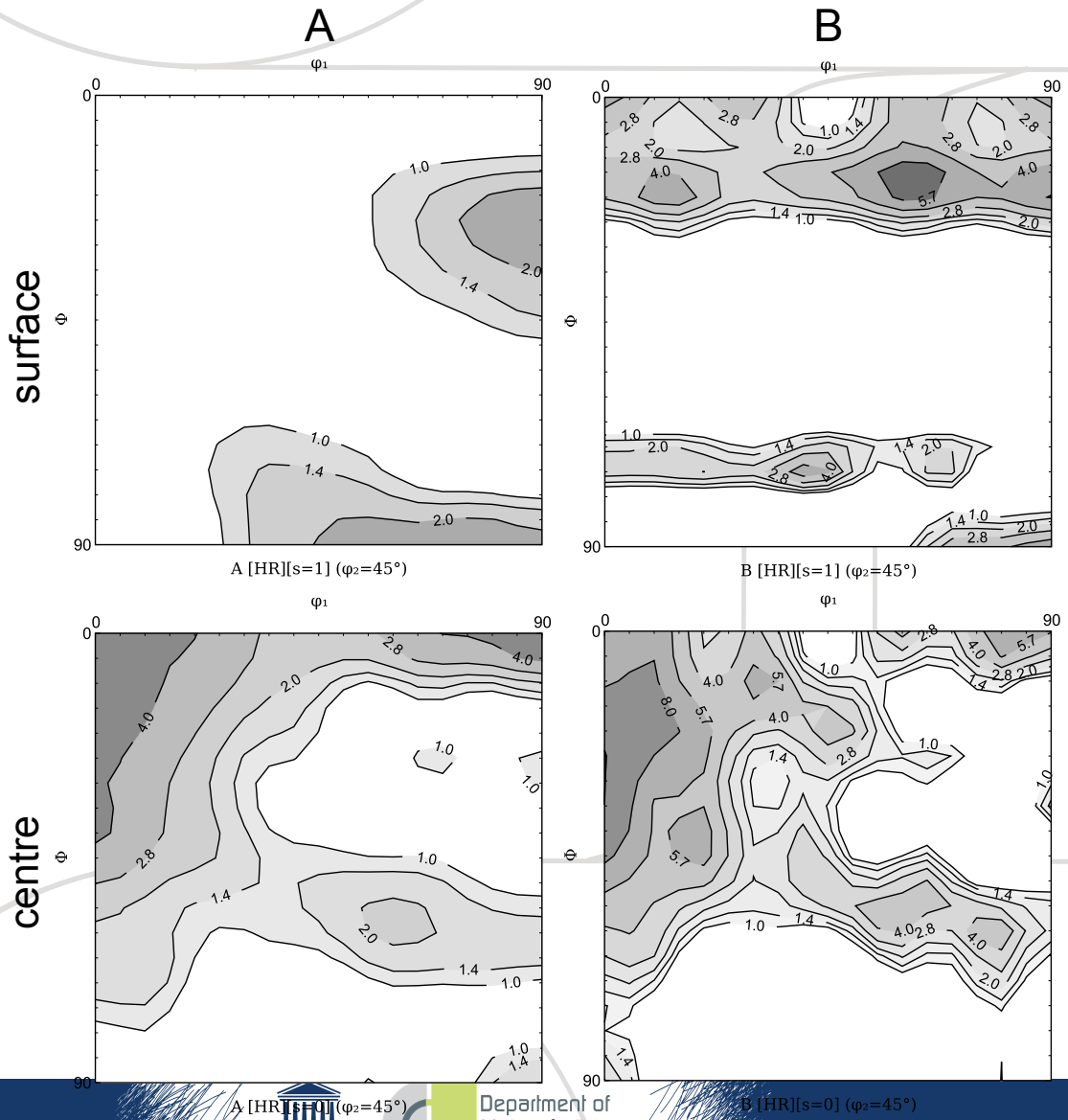


RC to 400°C, no annealing

RC to 800°C, AN→2min@750°C

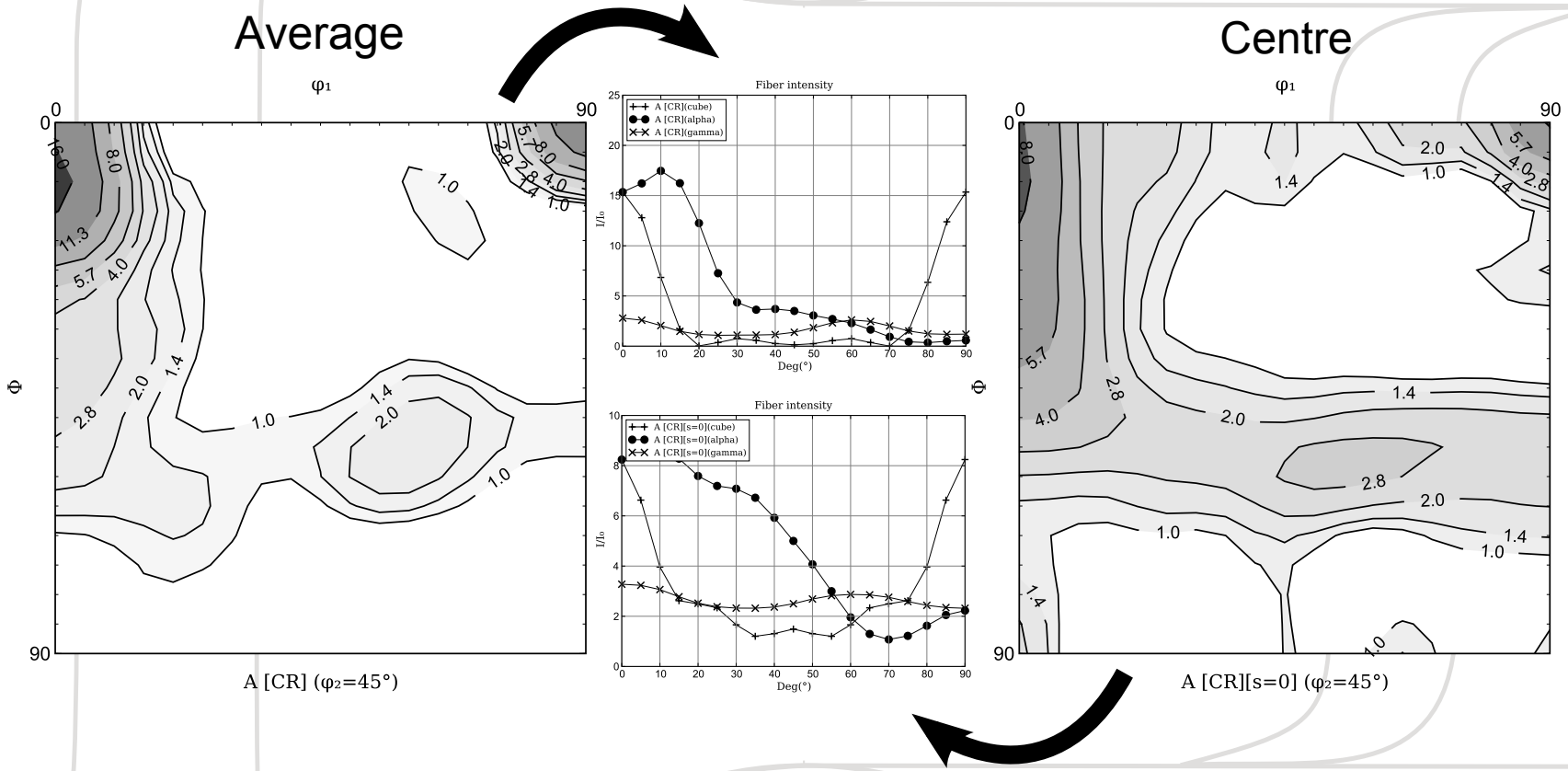
Texture heterogeneity (samples with 2,4% Si)

- Gradient of texture
- Shear stress components on surface
- Planar compression in the center



Outline

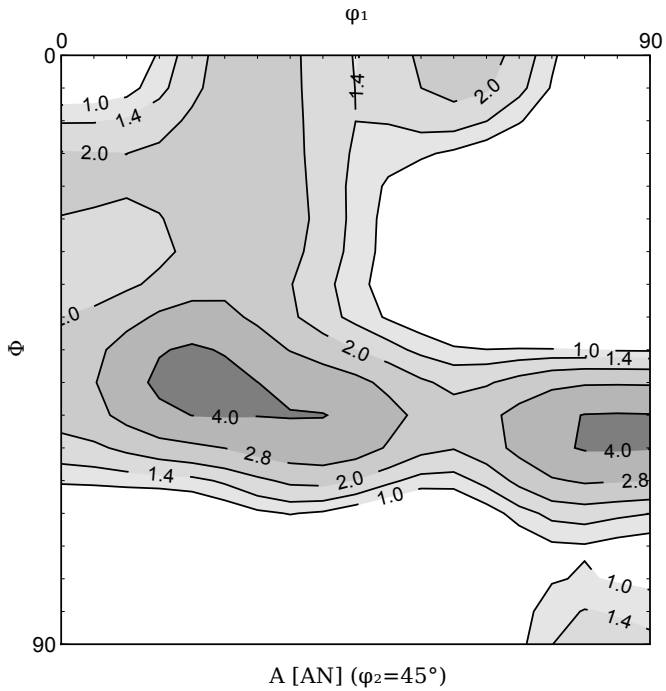
Cold rolling texture

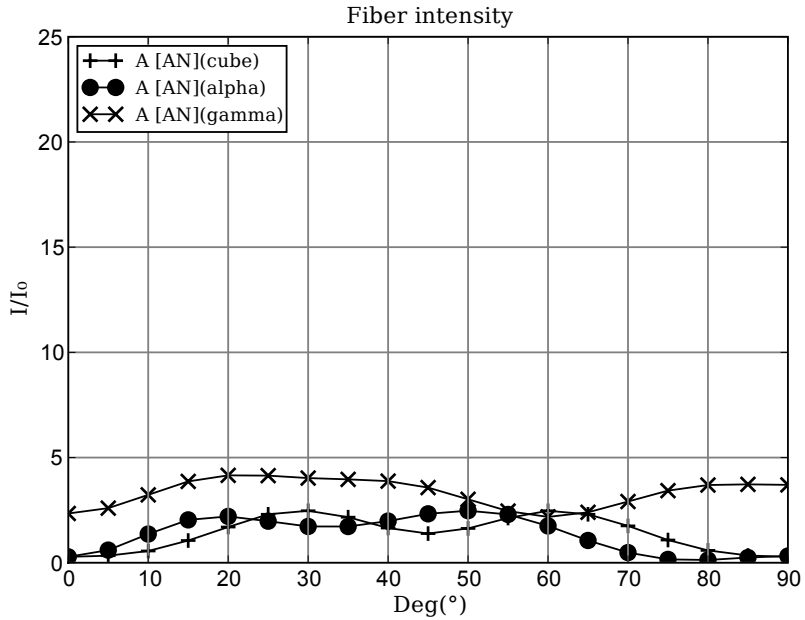


Sample A (FT=860°C, AN→20min@750°C)

Outline

Annealing texture

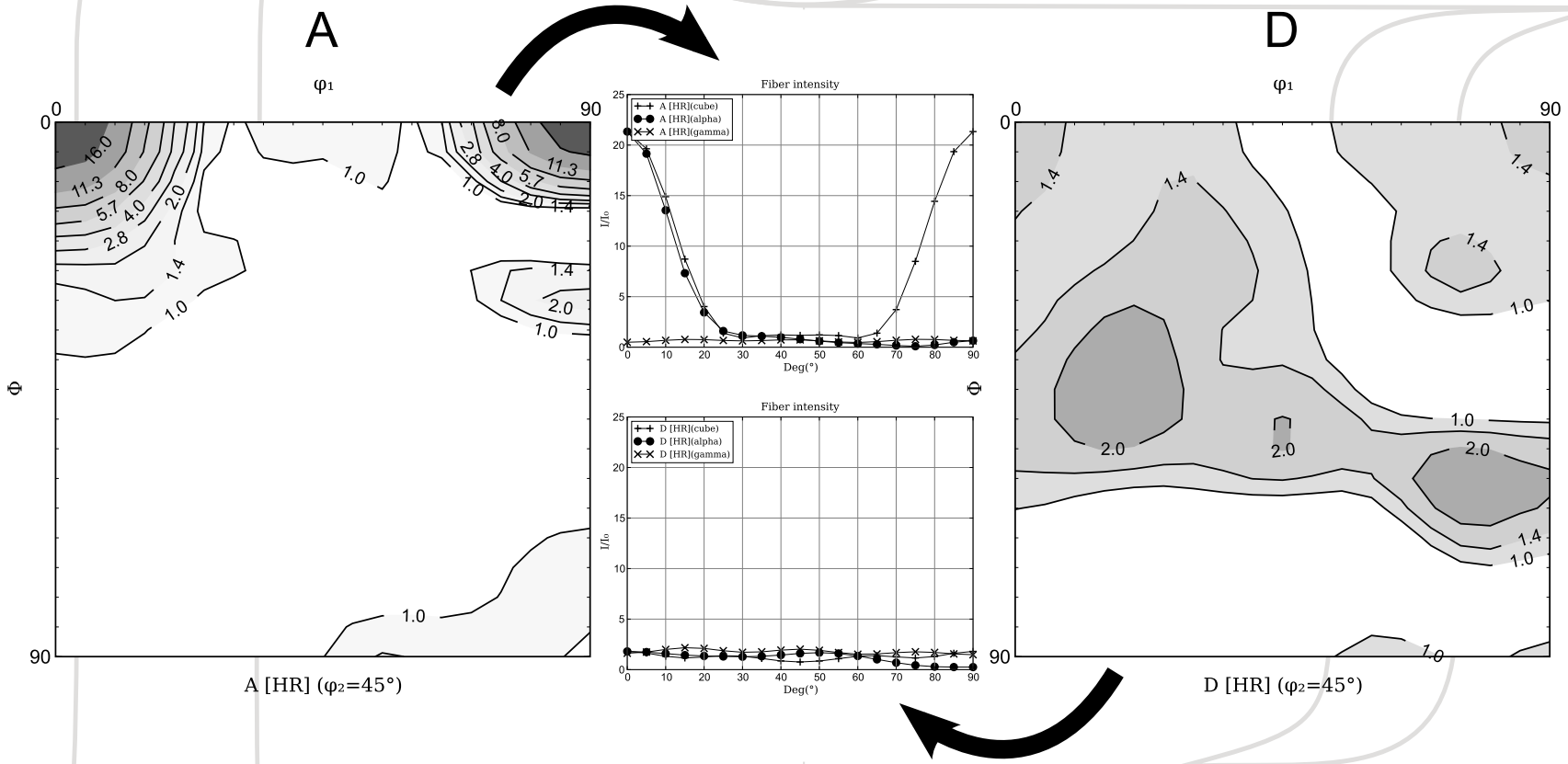




Sample A (FT=860°C, AN→20min@750°C)

Outline

Same hot rolling process, different Si



FT=860°C, AN→20min@750°C

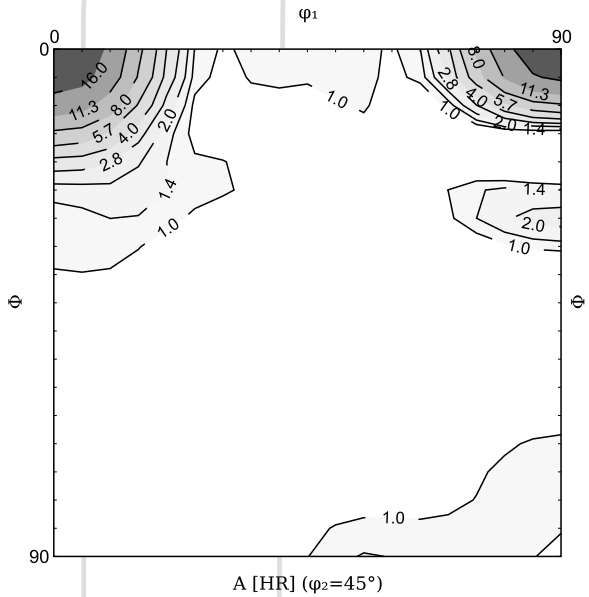
2,4% Si

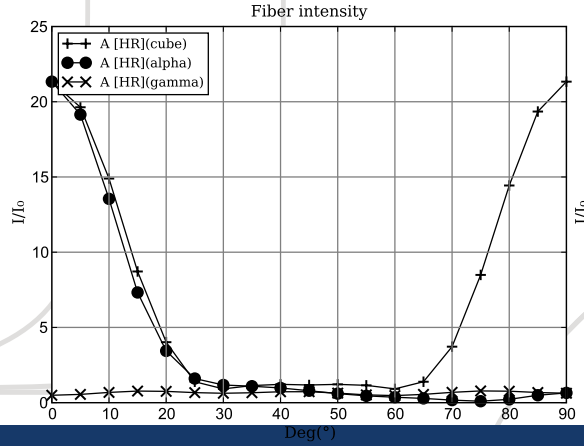
RC to 800°C, AN→2min@750°C

3,0% Si

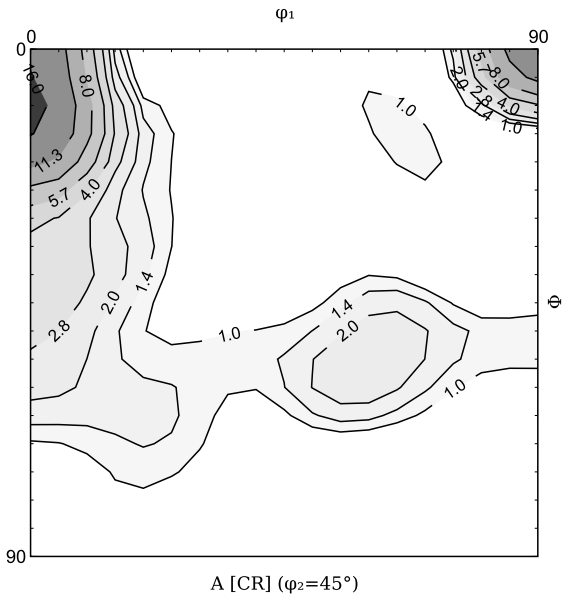
Texture evolution (sample A with 2,4% Si)

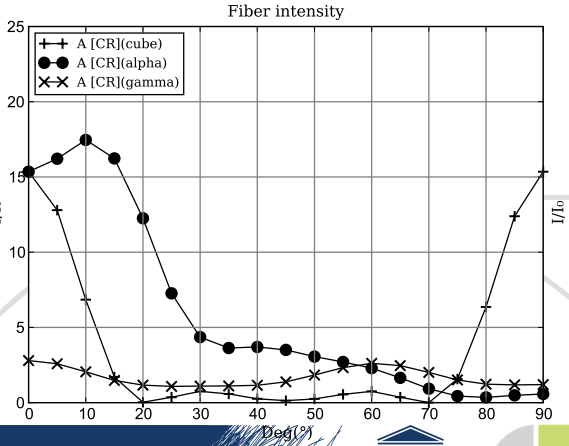
Hot band



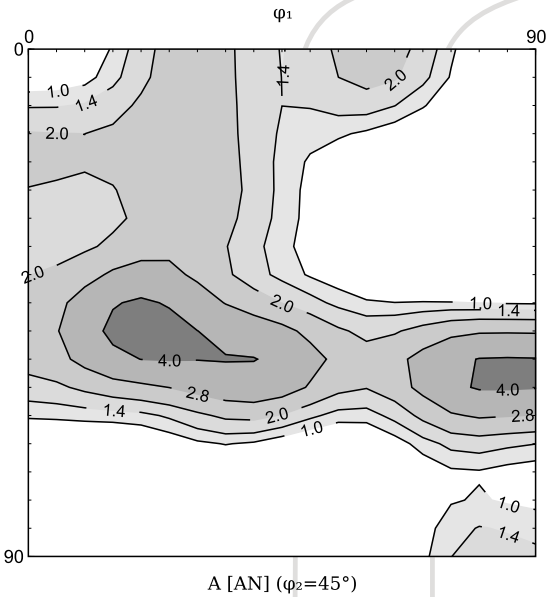


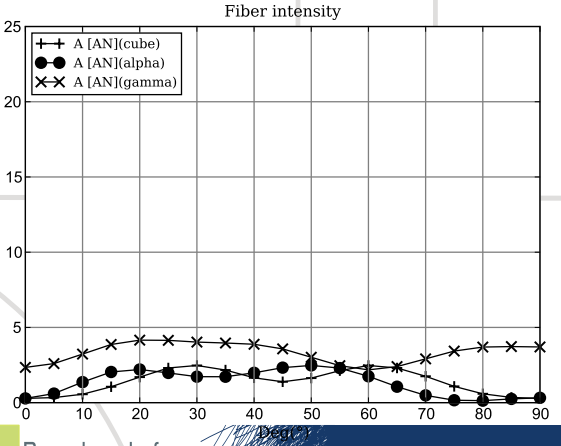
Cold Rolling





Annealing

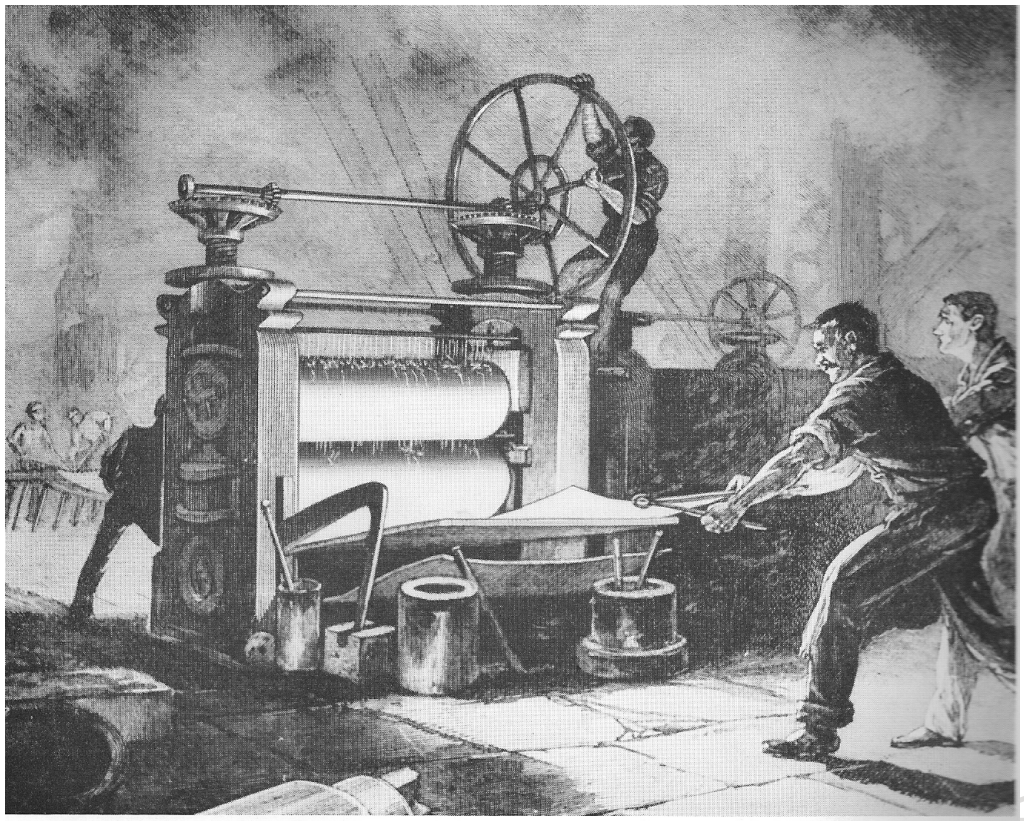




Summary

- Development of texture along the process route (HR, CR and annealing) depends sensitively on the processing parameters and the composition of the alloy.
- For the regarded Fe-Si materials without phase transformation a high intensity of cube texture is desired.
- The understanding of the different process steps on the evolution of cube texture is far from complete.

Thank for your attention !!!



Still a lot of work to do!