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INSTITUTE OF METALLURGY
AND MATERIALS SCIENCE
POLISH ACADAMY OF SCIENCES

European Union
European Social Fund

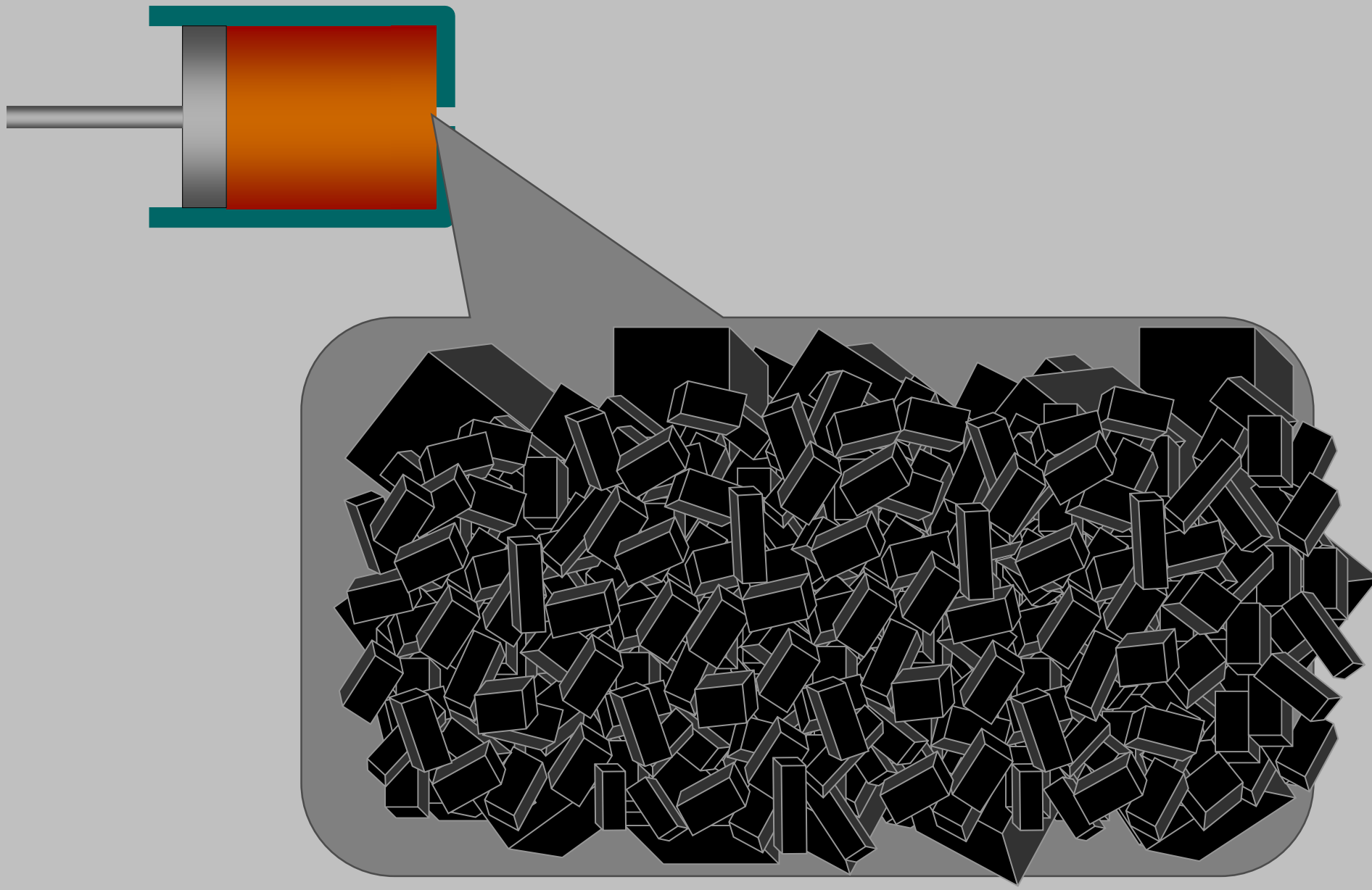
Texture analysis in materials engineering

Project WND-POWR.03.02.00-00-I043/16

International interdisciplinary PhD Studies in Materials Science with English as the language of instruction

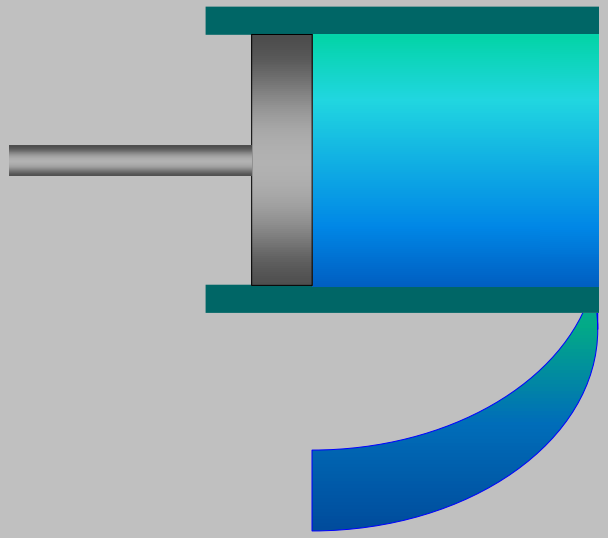
Project co-financed by the European Union within the European Social Funds

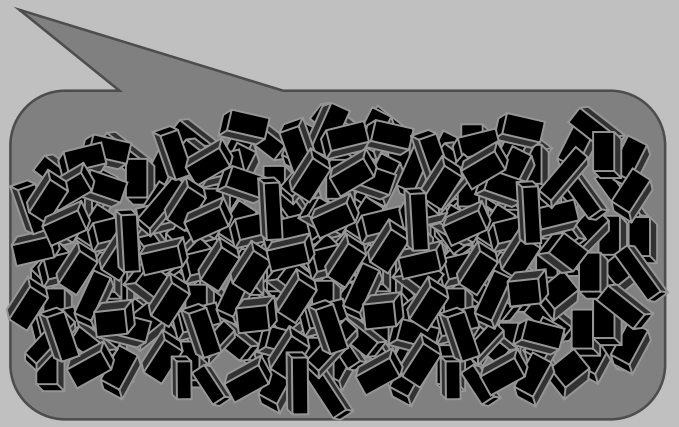
Extrusion process (forming the crystallographic texture)



Extrusion process

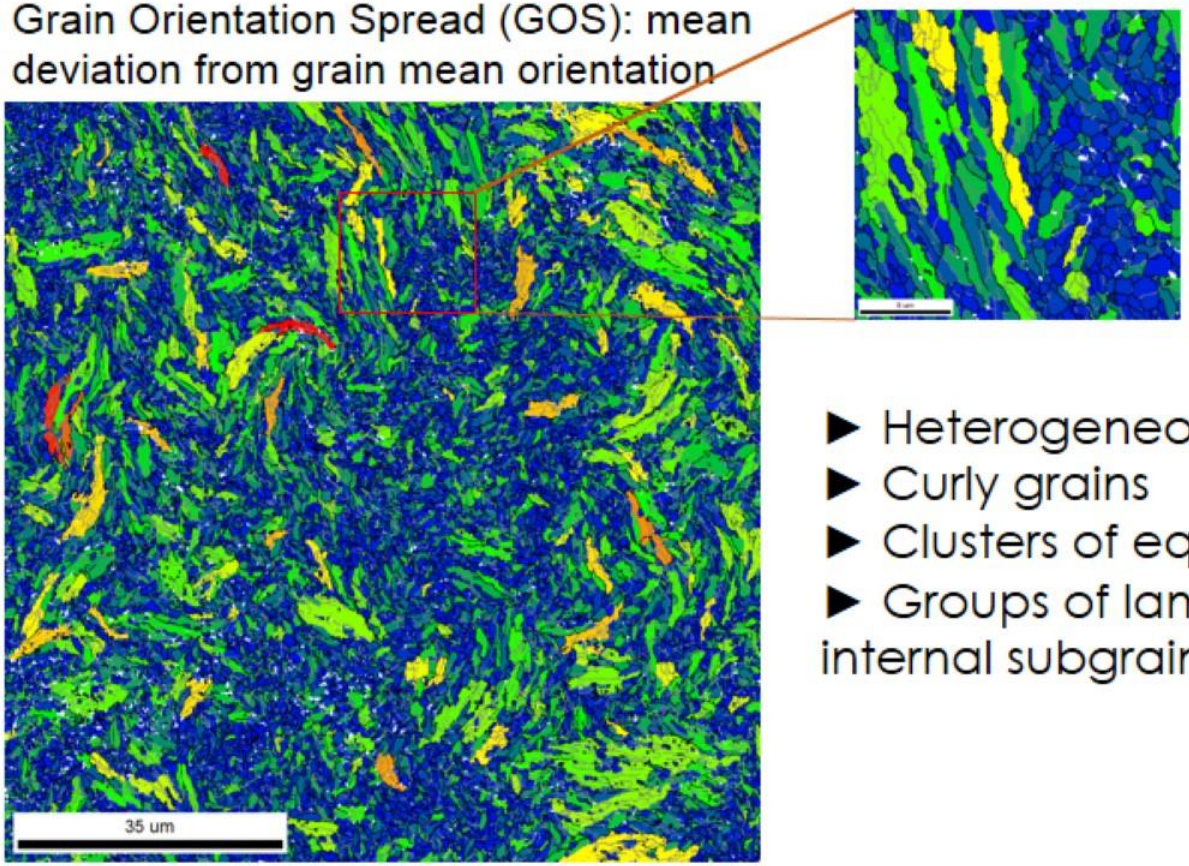
KoBo tchnology





CP titanium after KoBo deformation

Grain Orientation Spread (GOS): mean deviation from grain mean orientation



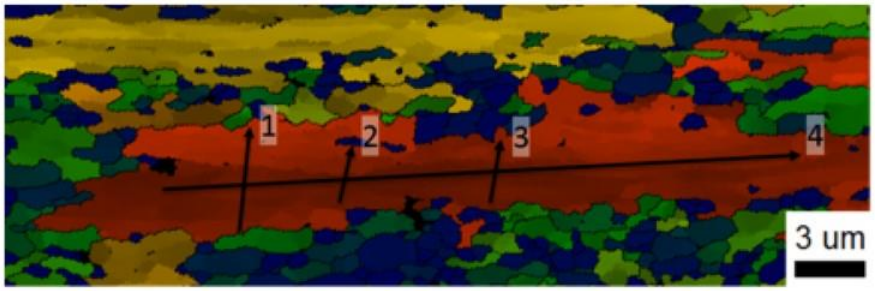
- Heterogeneous/bimodal structure
- Curly grains
- Clusters of equiaxed grains
- Groups of lamellar elongated grains with internal subgrain structure

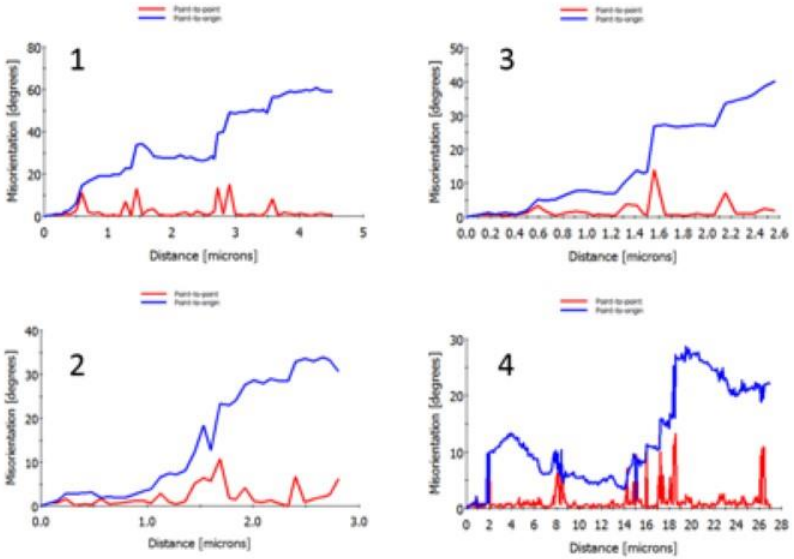
K Sztwiertnia, A Morawiec, M Bieda, J Kawałko, *Microstructure of titanium deformed by warm extrusion with forward-backward rotating die (KoBo),* IOP Conf. Series: Mater. Sci. Eng. **63** (2014) 012012.

K. Kowalczyk-Gajewska, K.Sztwiertnia, J.Kawałko, K.Wierzbanowski, M.Wronski, K. Frydrych, S.Stupkiewicz, H.Petryk, *Texture evolution in titanium on complex deformation paths: Experiment and modelling*, Mater. Sci. Eng. A , 637(2015)251–263

CP titanium after KoBo deformation

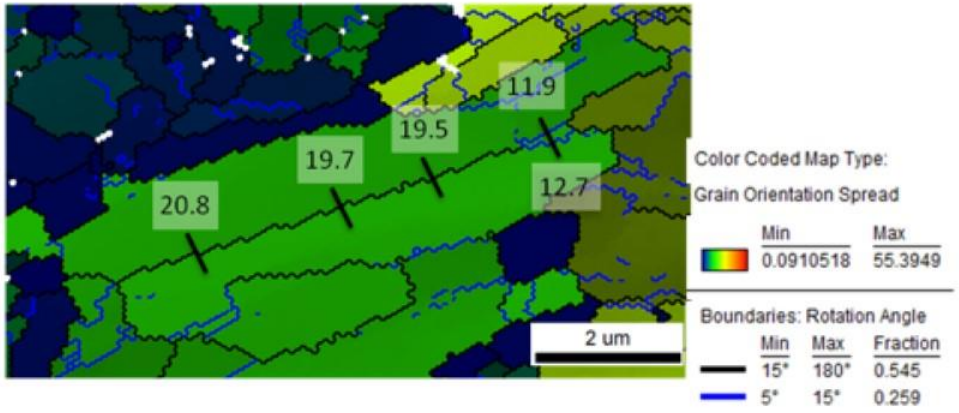
Grain orientation spread (GOS) yellow and red – high spread; green and blue – low spread





Orientation gradients observed in elongated grains,
-large gradients in minor axis direction
-relatively low gradients in major axis direction (ED)

Incomplete HAGBs or boundaries that are changing misorientation, leading to overestimation of grain sizes based on EBSD measurements

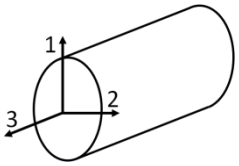


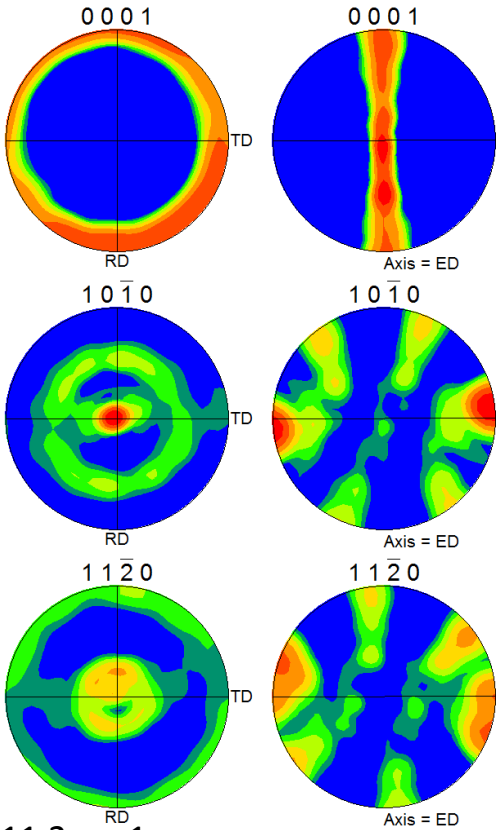
Deformed texture

KoBo I
Reduction R: 19.1

KoBo II
Reduction R: 26.2

HE I
Reduction R: 69.4





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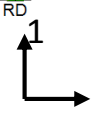

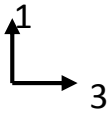

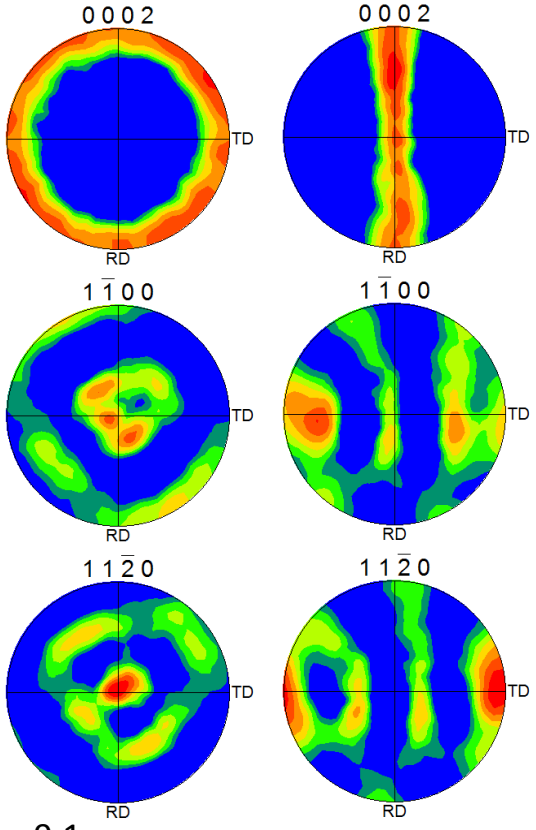

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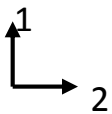

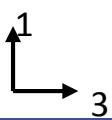

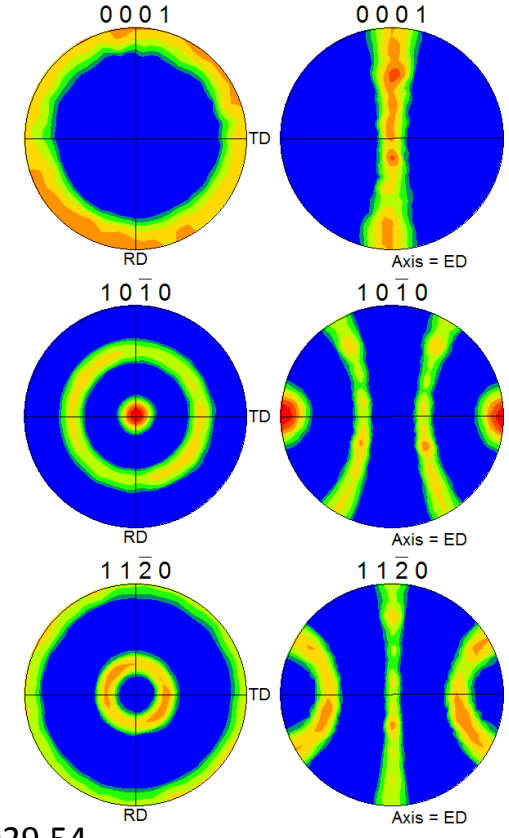

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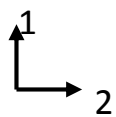
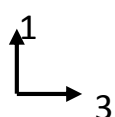
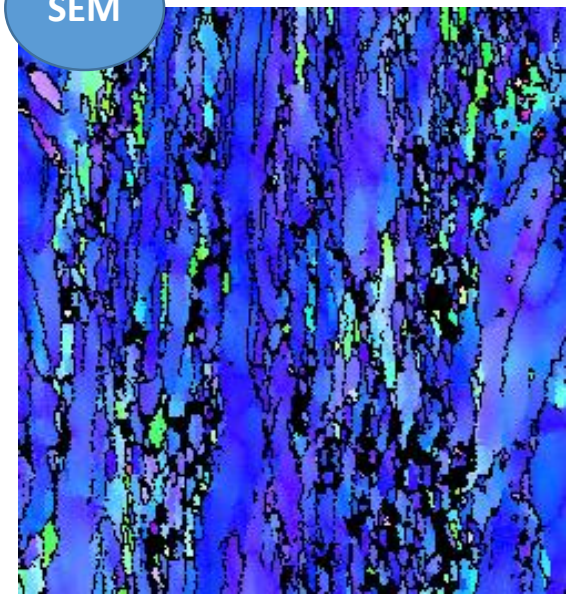
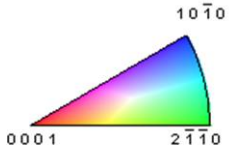




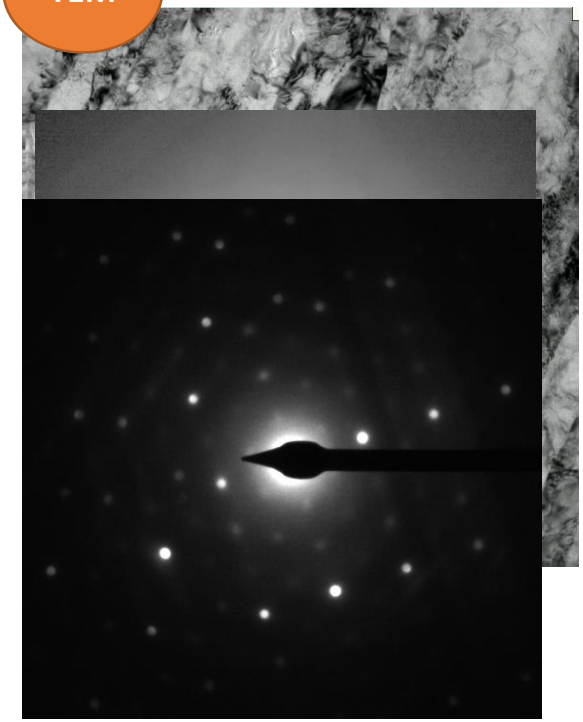
Pure Titanium after HE - TEM

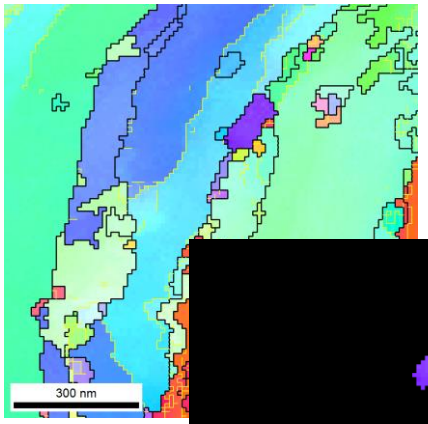
SEM

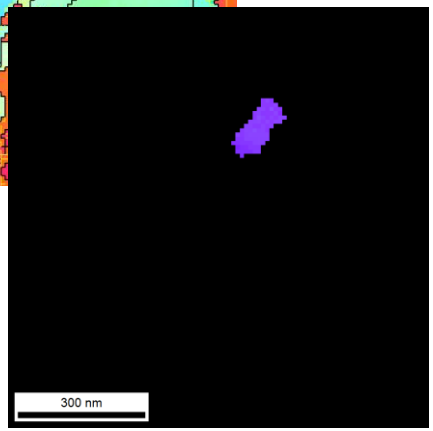




TEM







100 nm grain size

http://crystorient.com

Ridging phenomenon

K. Sztwiertnia, J. Pospiech, T. Rostek, M. Faryna: Arch. Metall, **47** (2002) 197-204.

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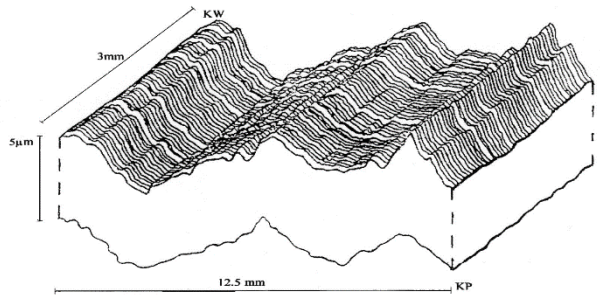
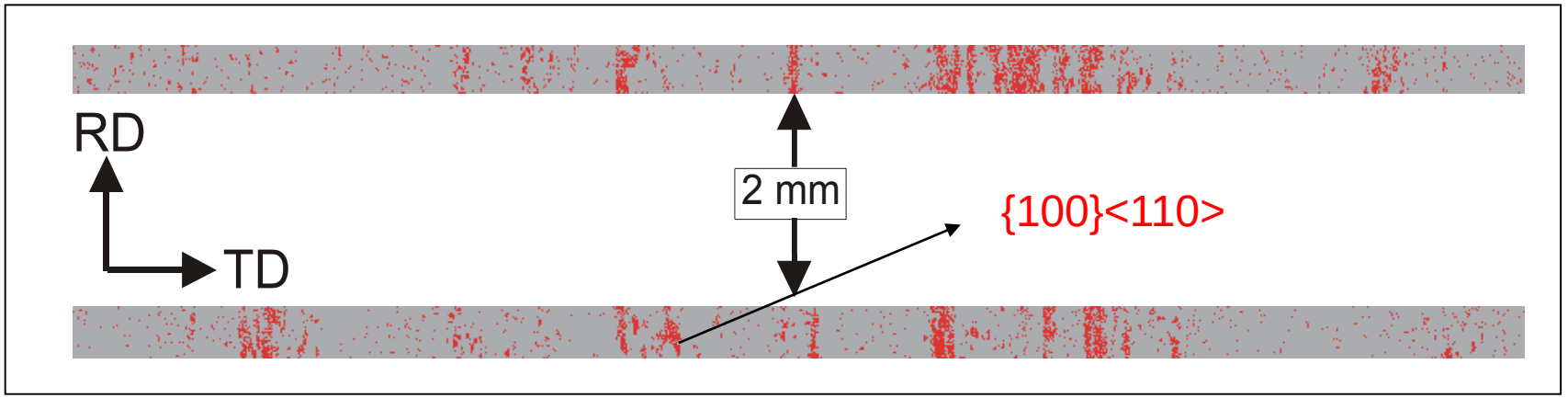
The ridging phenomenon in ferritic stainless steel



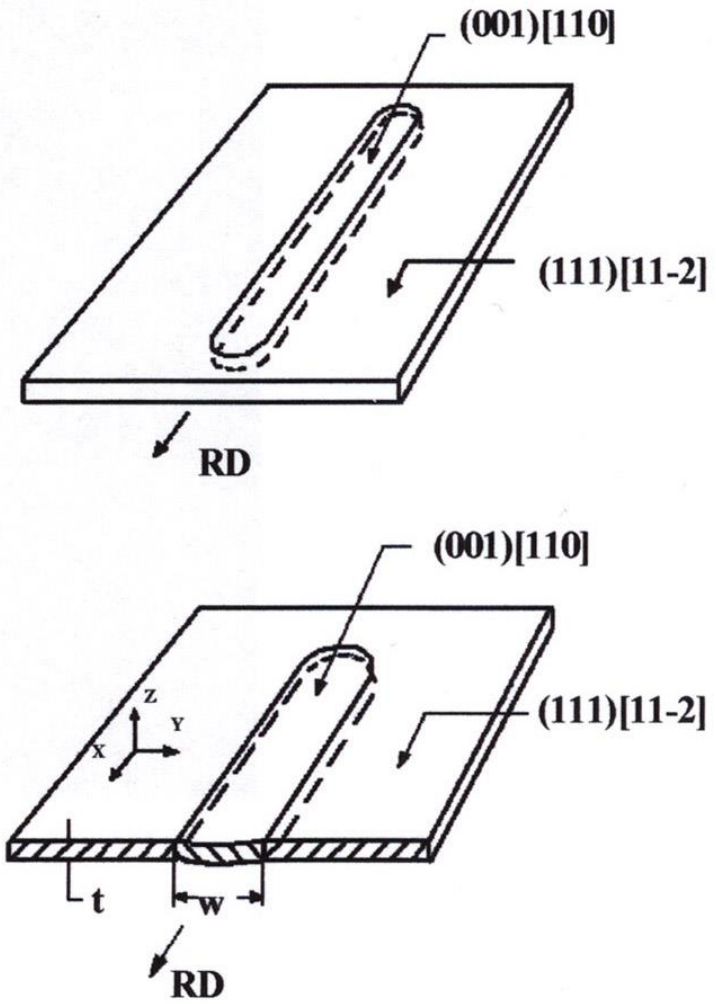
Two macroelements can be distinguished in the sheet microstructure: thin bands with the orientation {100}<110> lying parallel to the rolling direction, surrounded by a matrix with a different orientation (and anisotropy).

distance between ribs - 1-5 mm, height of ribs - 20 µm

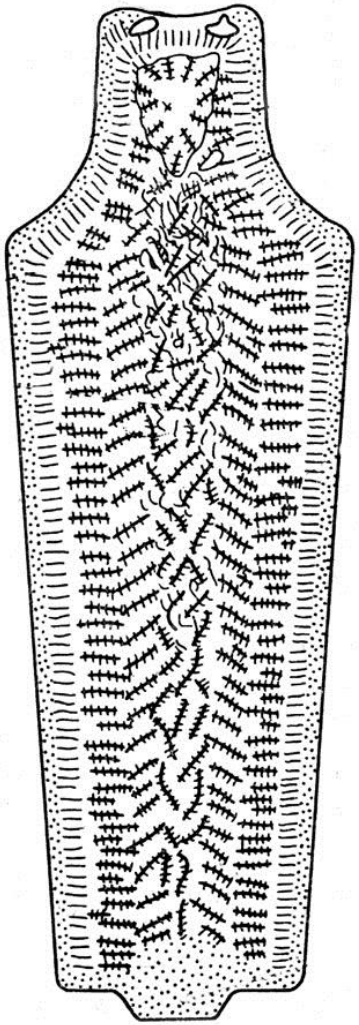


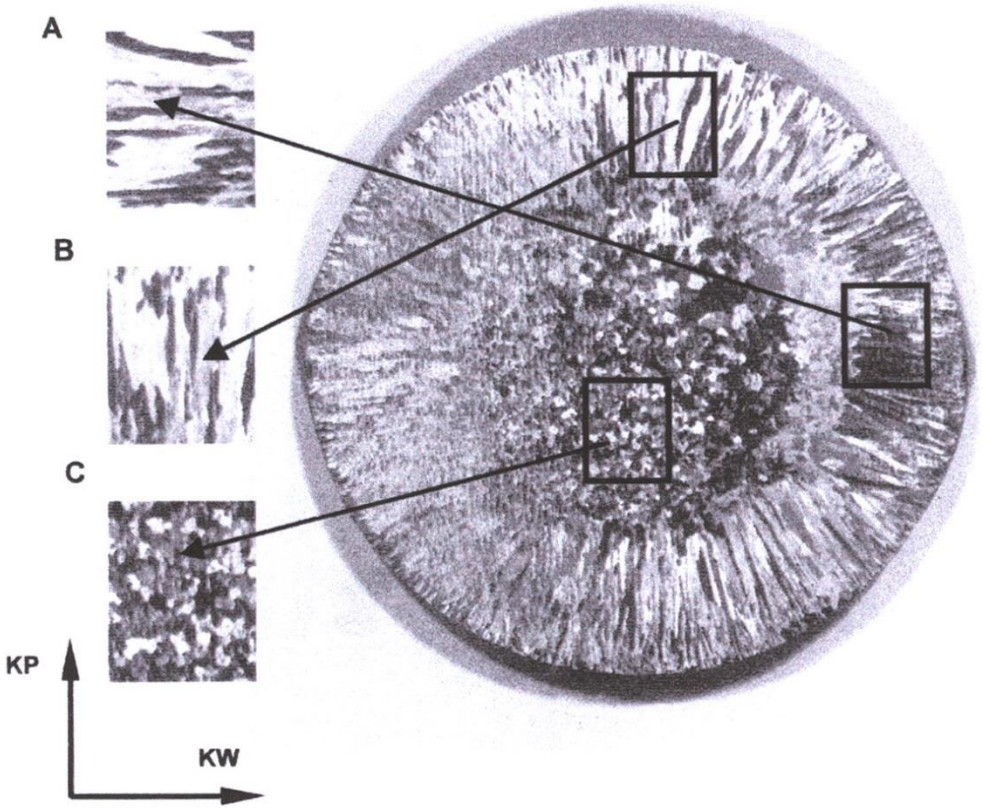
Wright model

The reasons for the rib effect are related to the plastic anisotropy of specific heterogeneities occurring in the material, and the observed effect is a result of differences in the plastic anisotropy of deformation between, formed in bands, grain colonies with orientations close to {001}<110> and the matrix of a different texture.



Ingots of ferritic steel





Sampling scheme for ingots

h_j

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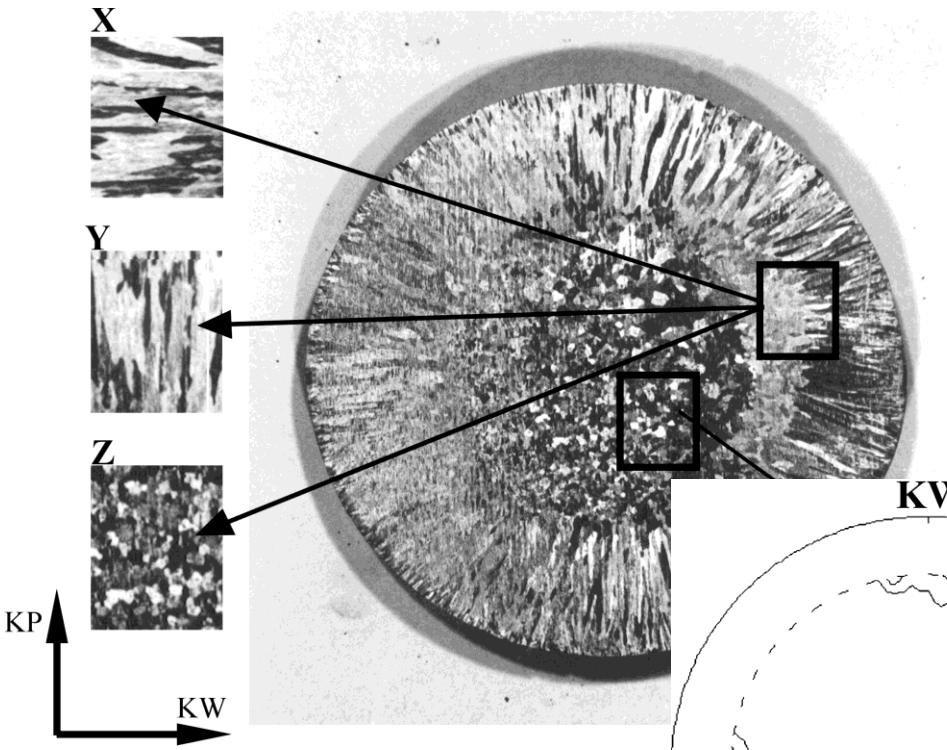
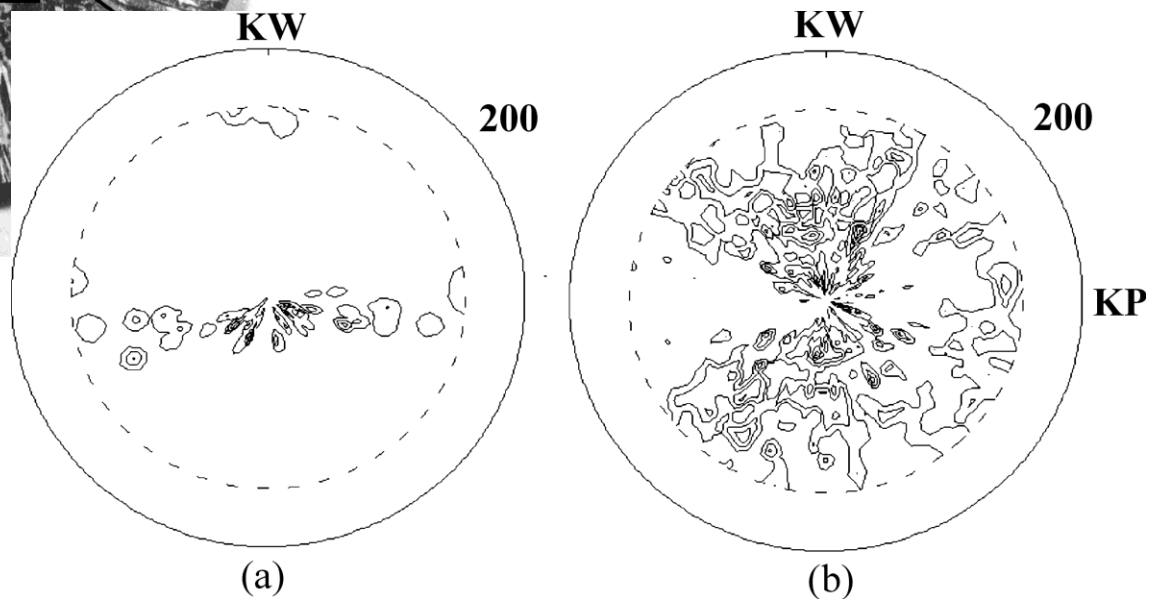
Physical simulation of hot rolling



X-samples – dendrites parallel to the rolling direction;
Y-samples – dendrites parallel to the transverse direction;
Z – samples- dendrites parallel to the normal direction;
R-samples - equiaxial grains.



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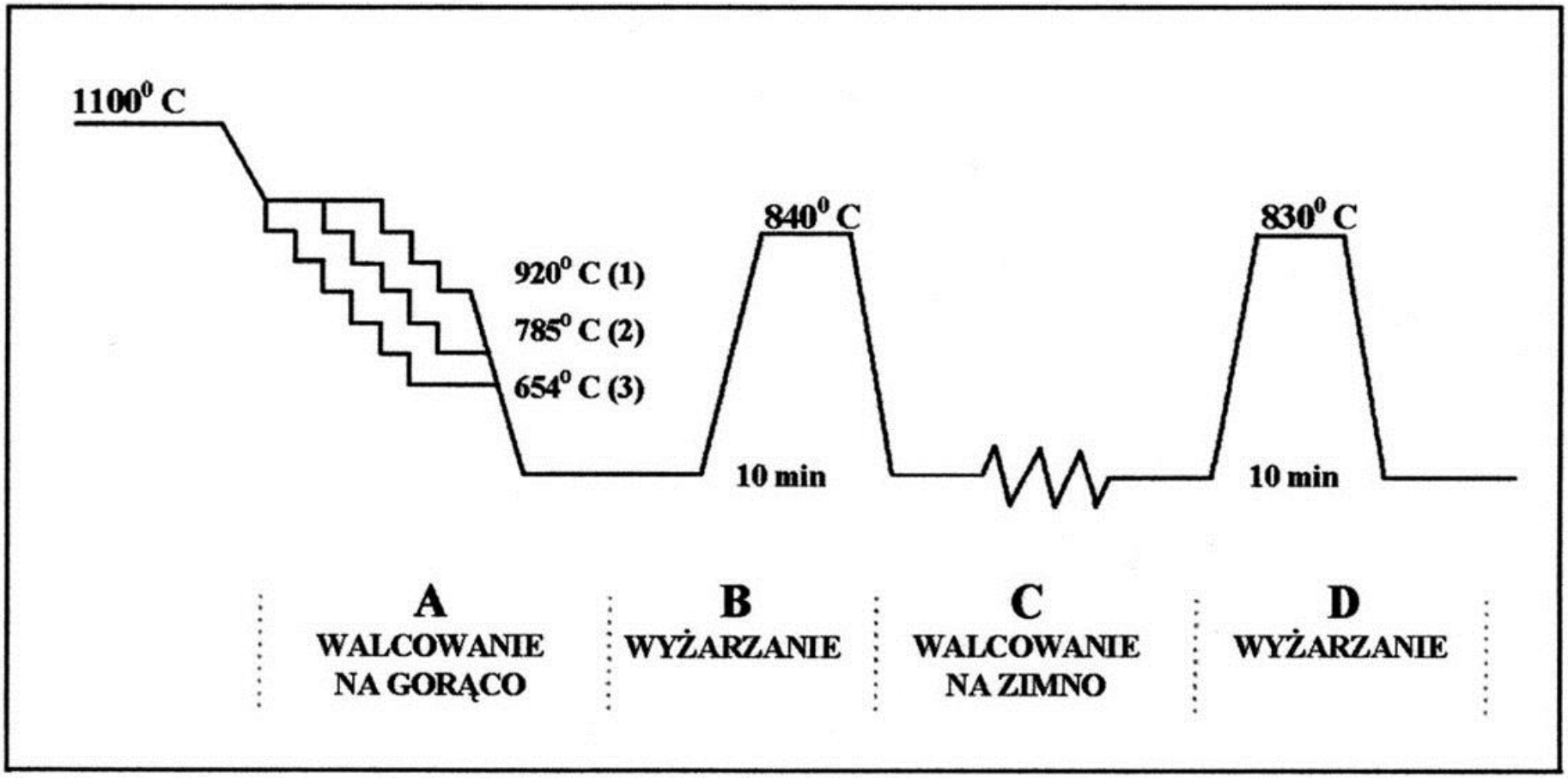
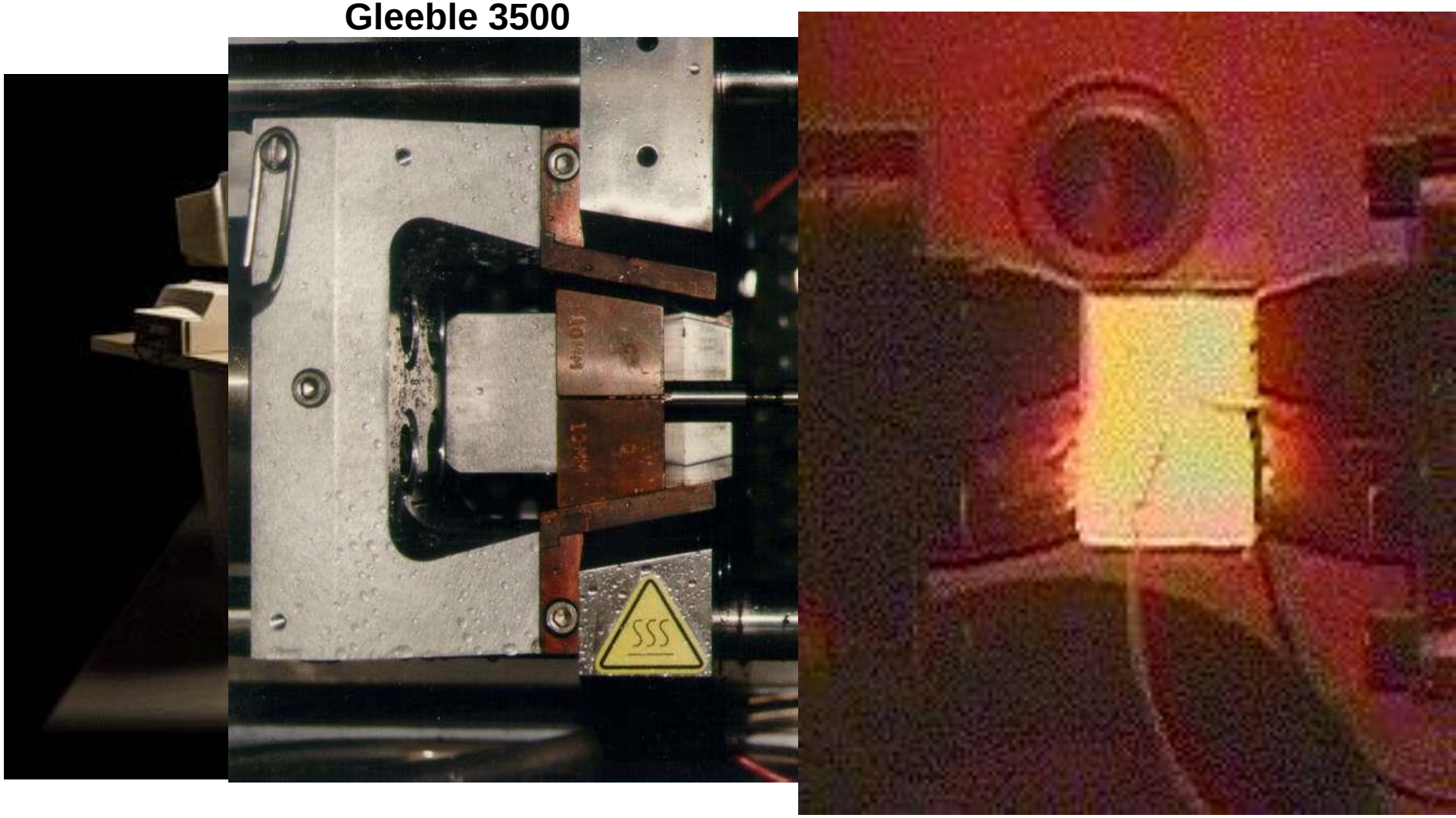


Schemat obróbki cieplno-mechanicznej badanych próbek

Physical simulation of hot rolling

Gleeble 3500



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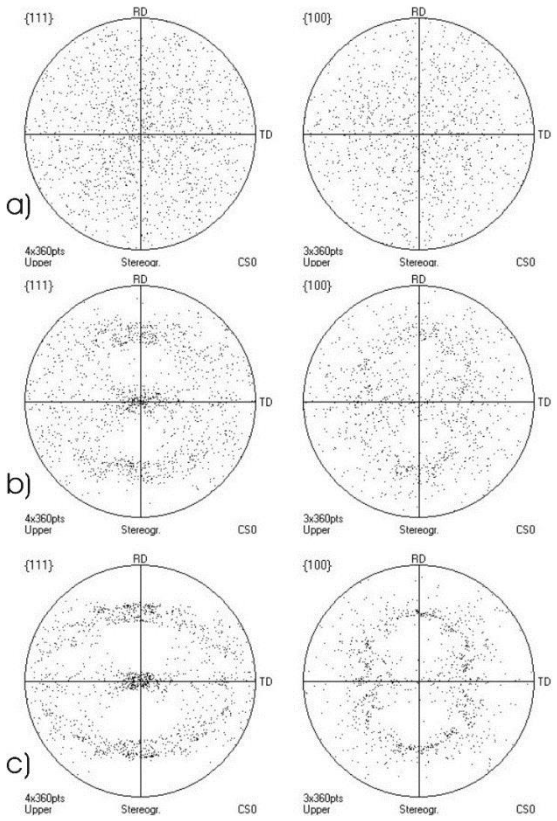
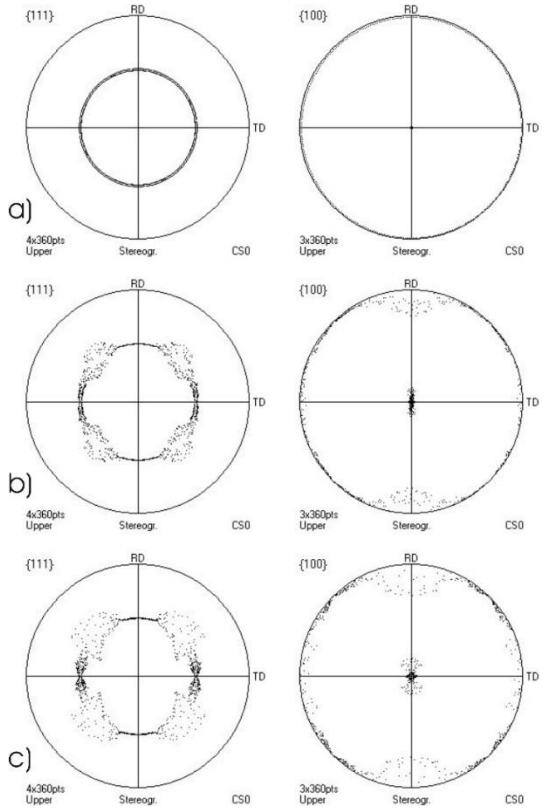
Computer simulation of the deformation texture



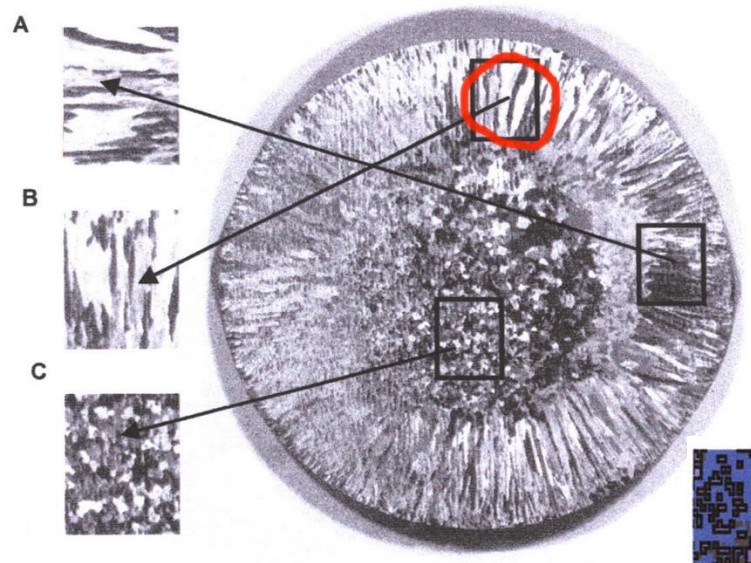


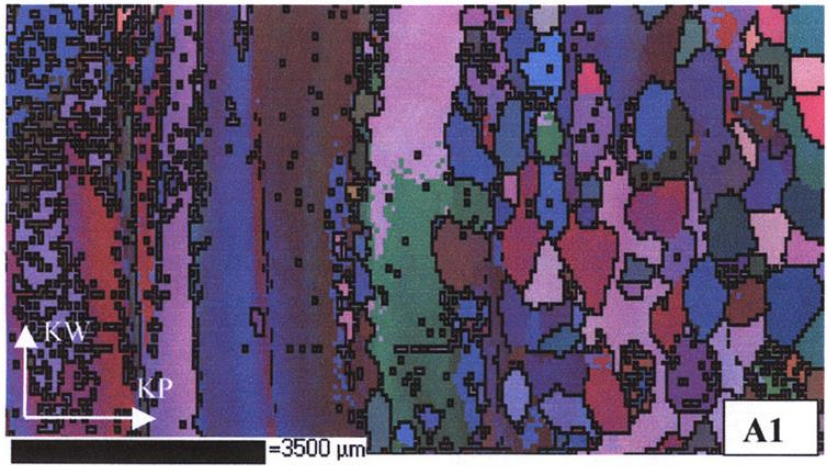
Initial orientation distribution: random

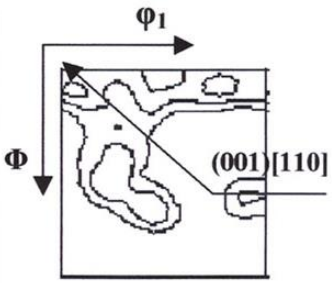
Initial orientation distribution: axis<100>IIKN.

K. Sztwiertnia, J. Pospiech, T. Rostek, M. Faryna: Arch. Metall, **47** (2002) 197-204.

Physical simulation of hot rolling







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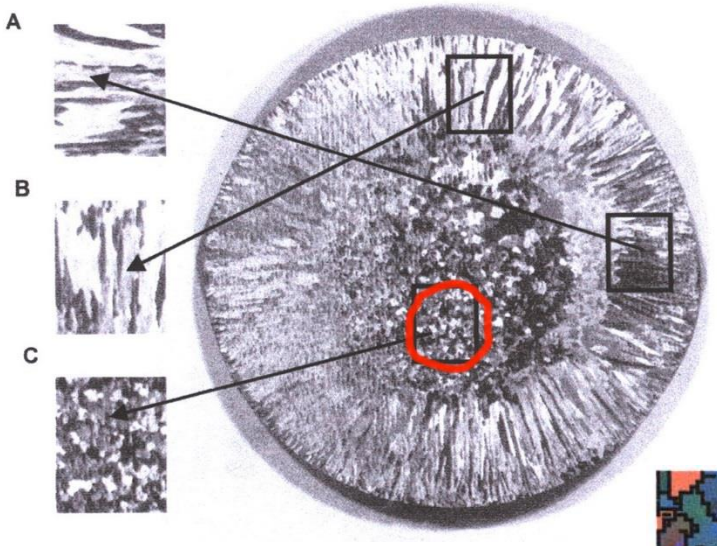
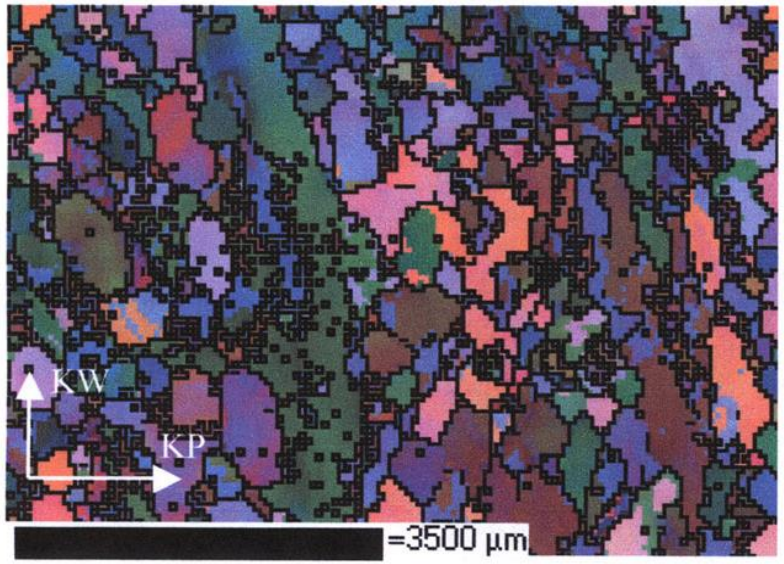
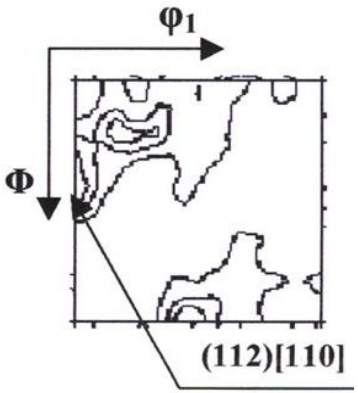
Physical simulation of hot rolling







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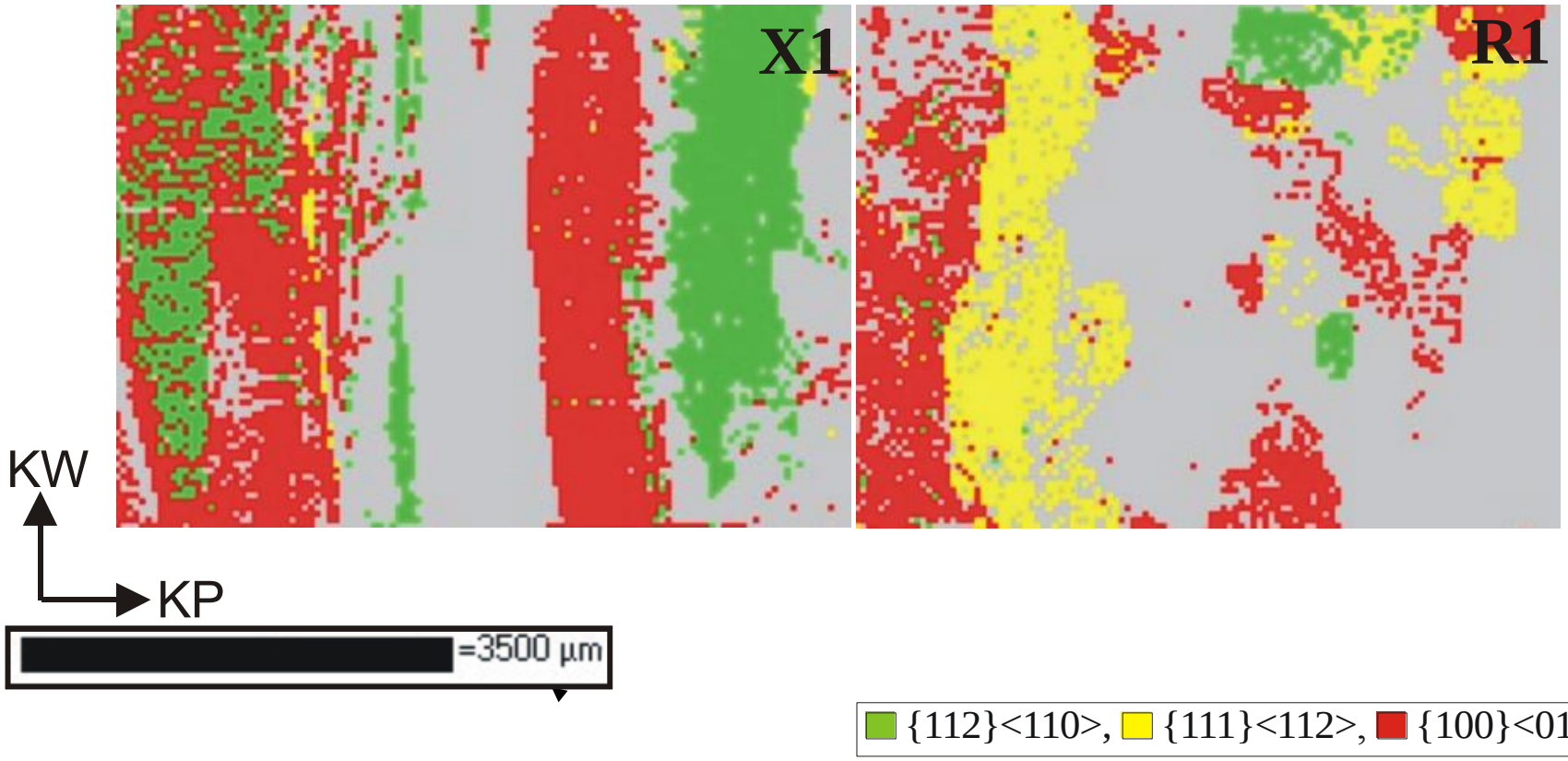
Physical simulation of hot rolling

Basic deformation scheme, time between roll passes 10 s, rolling reduction per pass ~15%, after completion of deformation 10 min. at temp. 820^{0}C.



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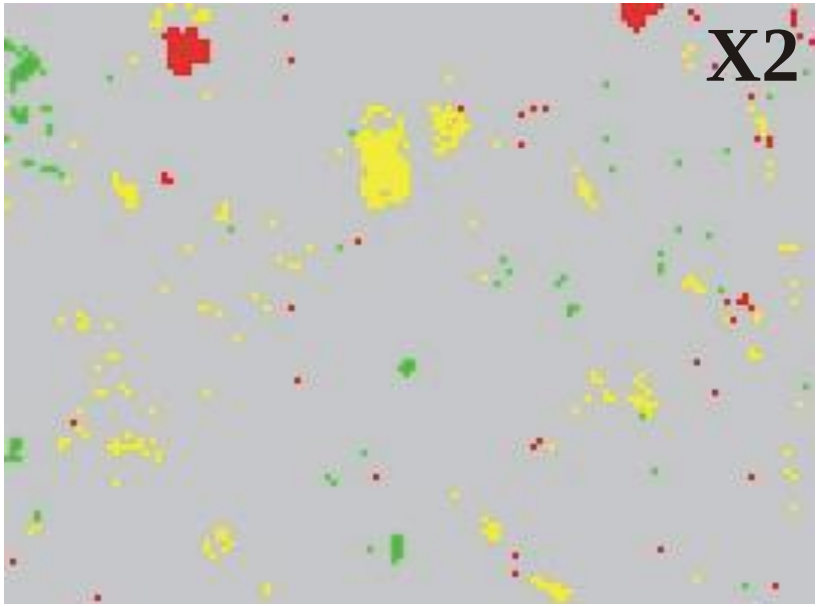
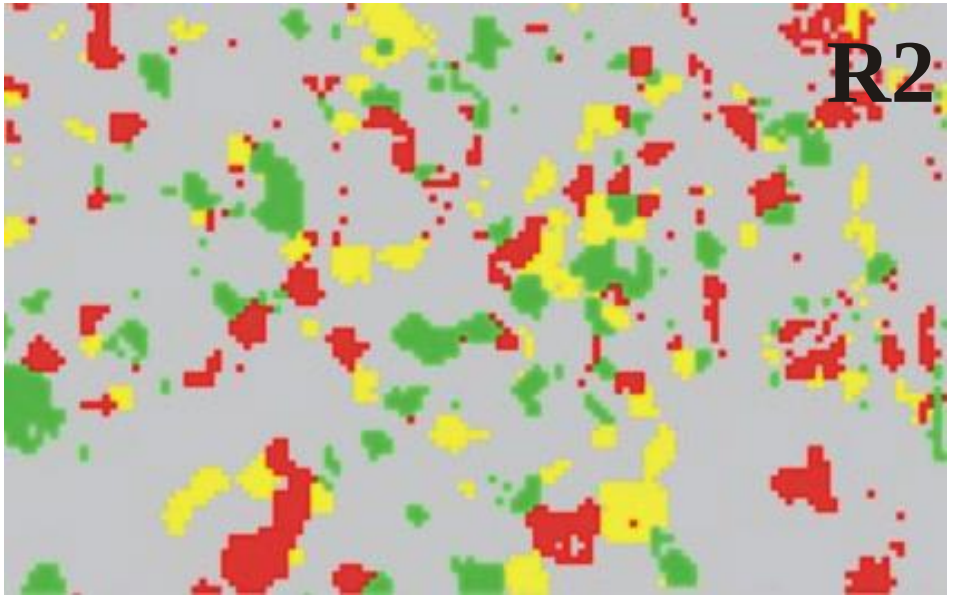
Physical simulation of hot rolling

Modified deformation scheme, time between roll passes 30 s, rolling reduction per pass ~30%, after completion of deformation 10 min. at temp. 820^{0}C.





{112}<110>, {111}<112>, {100}<011>.

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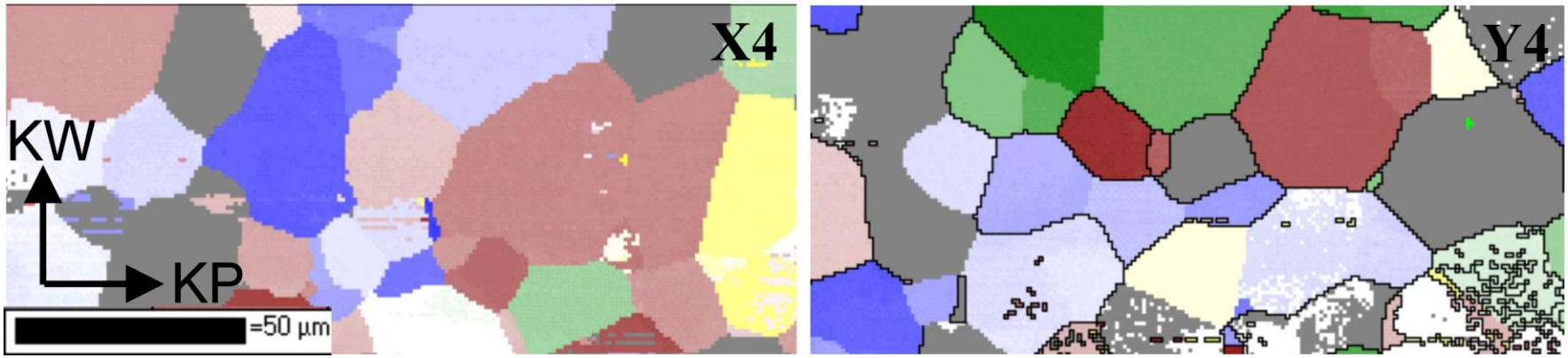
Physical simulation of hot rolling

High speed deformation.



Orientation topographies of specimen after physical simulation of hot rolling at high strain rate (~400 s-1) - X4, Y4 specimens (X-samples – dendrites parallel to the rolling direction, Y-samples – dendrites parallel to the transverse direction).

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Conclusions.

The ridging effect is caused by the plastic anisotropy of the components of the heterogeneous material structure.

The specific grain band structure of the orientation {001}<110> appears after the hot rolling stage and must be modified at the latest at this stage to eliminate the ridging effect.

The microstructure and texture of the finished product, and thus the intensity of the ridging effect, are significantly influenced by the original microstructure of the ingot. The structure with bar-crystals approximately perpendicular to the rolling plane is the least favourable, while the microstructure with equiaxial grains is the most.

Thank you

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