Grain Nucleation and Growth in Carbon Steel

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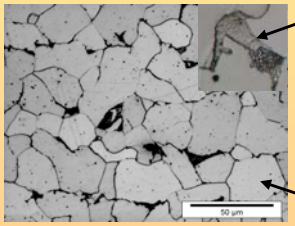
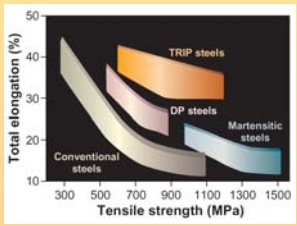
Aim:

Understanding the evolution of the microstructure during the production of steel, where the high temperature austenite (γ) phase transforms into ferrite (α) and cementite (θ).

Production

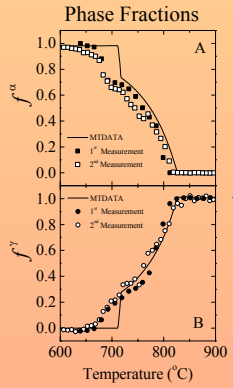


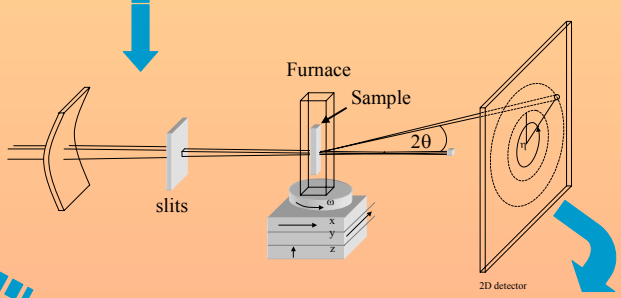
Microstructure



Mechanical Properties

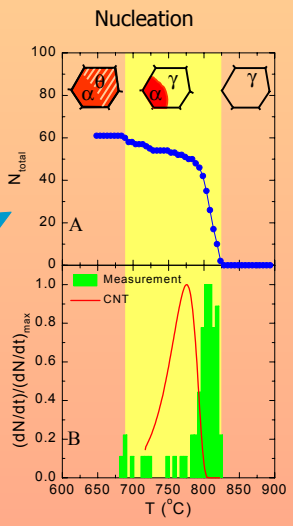
Three-dimensional x-ray diffraction microscope at the European Synchrotron Radiation Facility



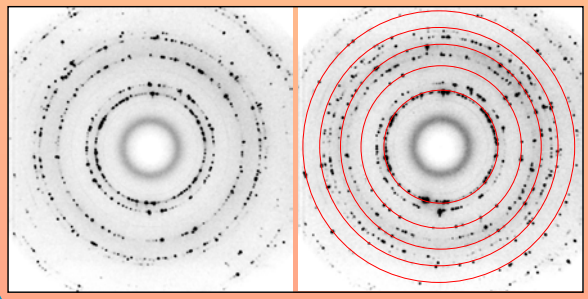


Intensity Ring

Number Spots

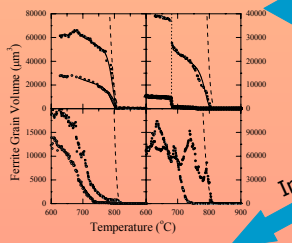


(A) Total Number of nuclei
(B) Normalized Nucleation Rate



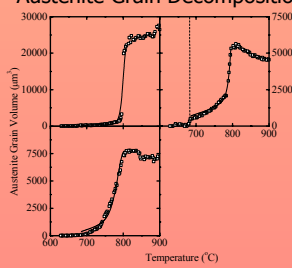
900°C: Austenite

763°C: Austenite & Ferrite (red)



Intensity Spot

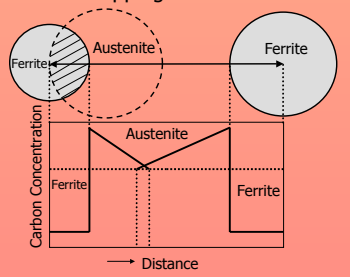
Intensity Spot



Conclusions:

1. The activation energy of ferrite nucleation is at least 100 times smaller than predicted by the Classical Nucleation Theory (CNT).
2. We observed four types of ferrite grain growth.
3. We observed an unexpected carbon exchange between the austenite grains.
4. We improved the classical growth theory by taking into account the overlap of diffusion fields, which thereby describes the first three growth modes

Developed model with overlapping diffusion fields



Papers:

1. Offerman SE, Van Dijk NH, Sietsma J, Grigull S, Lauridsen EM, Margulies L, Poulsen HF, Rekveldt MTh, and Van der Zwaag S. Science 2002;298:1003-1005.
2. Offerman SE, Van Dijk NH, Sietsma J, Lauridsen EM, Margulies L, Grigull S, Poulsen HF, and Van der Zwaag S. Submitted to Acta Materialia.

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