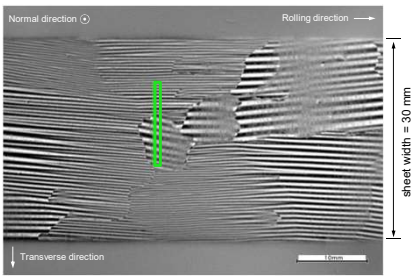
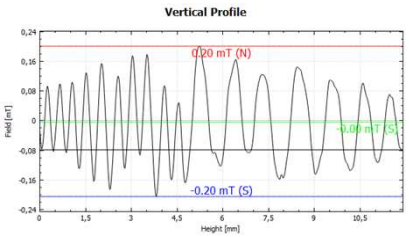
Domain Observation of Grain-Oriented Electrical Steel Sheets

M. Lindner[a], T. Reimann[a], B. Wenzel[b], R. Holzhey[a]
[a]INNOVENT e.V., Magnetic and Optical Systems, Prüssingstr. 27b, Jena, 07745, Germany
[b]Matesy GmbH, Löbstedter Str. 101 - 103, Jena, 07749, Germany

Magneto-optical (MO) instruments enable visualization of stray field distributions from grain-oriented electrical steels (GOES). Misoriented grains can be analyzed via magnetic domains observation. Thus, the causes of core loss can be detected in GOES. Domain observation can be used for quality control of texture after manufacturing. Monitoring grain misorientations on a micros-copic scale is essential for further improvement of achieved (110) [001] Goss texture in GOES. The MO devices CMOS-Magview XL and S are suitable for static domain testing and the Domain Tester for dynamic domain observation under AC field conditions.

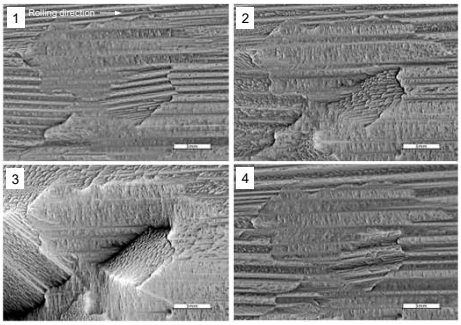
Large-area domain observation (formation of domain structure) of GOES sheets



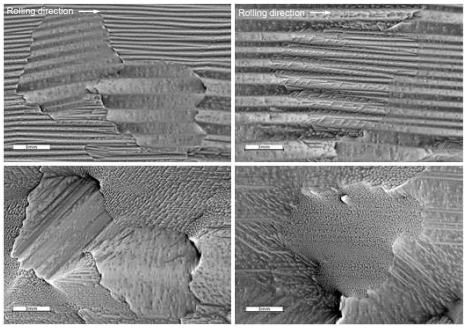


Domains visualization via magneto-optical imaging and field strength profile (green marked area) of a GOES steel H105-30 by thyssenkrupp: The Epstein sample lying on the MO sensor is characterized across its entire width of the sheet, allowing multiple domains to be analyzed simultaneously. GOES usually have crystallographic misorientations of the grains, giving each grain individual domain width and stripe domain formation. The domain width is an indicator of the tilt of the Goss texture and the stripe domain formation indicates the direction of the magnetic easy [001] axis. The field strength profile represents the geometric domain width along the transverse direction of two marked adjacent grains.

High-resolution domain observation of spontaneous state and under static field

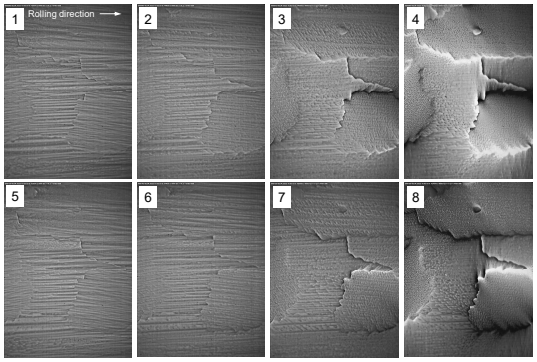


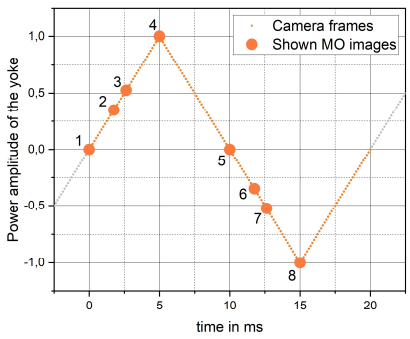
MO images: Domain behavior of H105-30
at different magnetization states:
Image 1: Spontaneous domain structure (initial state),
Images 2, 3: Increasing flux (domains, grain boundaries),
Image 4: After loading with flux (without flux).



MO images of two well-oriented grains (left image column) and one misoriented grain (right image column) of H105-30:
Image row 1: Spontaneous domain structure (initial state),
Image row 2: Domains under flux load
(different domain behavior, grain boundaries).

High-resolution domain observation with kHz image frequencies





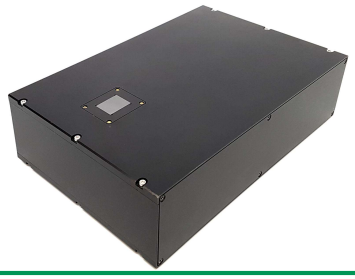
Magneto-optical images: Change of the domain structure during remagnetization with triangular AC frequency of 50 Hz of H105-30. The individual images (size: 13 x 18 mm) clearly show the different domain behavior within the individual grains, which indicates a rather irregular Goss texture due to inhomogeneous grain orientation (slight misorientations).

CMOS-MAGVIEW XL

Imaging size: 55 x 40 mm
Resolution: 35 µm
Frame rate: 5 fps
Connection: USB 3

CMOS-MAGVIEW S

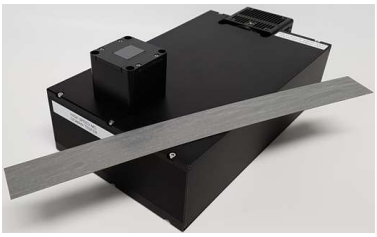
Imaging size: 18 x 13 mm
Resolution: 18 µm
Frame rate: 5 fps
Connection: USB 2



LATEST DEVELOPMENT

DOMAIN TESTER 8 kHz

Imaging size: 18 x 13 mm
Resolution: 28 µm
Frame rate: 8 kHz
Connection: GigE



supports excitation frequencies
up to 400 Hz (via an external yoke)

Conclusions

Magneto-optical devices impressively demonstrate their potential in the field of testing electrical steel sheets. The static testing of GOES requires little technical and time effort. Domain observation, using this MOIF technique in combination with image processing, allows a wide range of characterization aspects. In order to achieve dynamic observation with the AC field frequency up to 400 Hz, the high speed imaging system Domain Tester enables 8,000 MO images per second at an image size of 18 x 13 mm.
This non-destructive material testing method provides the technical basis for quality control of grain-oriented SiFe sheets due to the fast and direct domain analysis. Sample preparation is not required. Accordingly, the sheets only need to be brought into contact with the MO sensor area. Typical Epstein samples can be used directly.

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Contact
INNOVENT e.V., Magnetic and Optical Systems
Prüssingstr. 27 B, D-07745 Jena
Phone: +49 3641 2825871
Email: ml@innovent-jena.de
Web www.innovent-jena.de

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