Kolloquium am Mittwoch, 13. Januar 2021, ab 11:15 Uhr

Thema:

Dynamic magnetic domain behavior in magnetic sensors seen by magnetooptics

Sprecher:

Prof. Dr.-Ing. Jeffrey McCord (Institute for Materials Science – Kiel University)

Abstract:

The role of magnetic domain formation and reorientation processes reveals fascinating physics and is of great relevance for technological applications. Recent advances in thin film devices adopting magnetic films as sensing layers, involving magnetoelectric (ME) cantilever sensors, surface acoustic wave (SAW) devices, and giant magnetoimpedance (GMI) devices offer a promising route for sensing ultra-low magnetic signals. These kinds of sensors are typically operated by external stimuli from the kHz to the GHz regime. Therefore, understanding and controlling the complex physics of magnetic domain activity at the relevant modulation frequencies are one of the most important factors that determine the performance of the magnetic field sensors as the signal-to-noise ratios of the sensors are dominated by magnetic domain and domain wall activity.

In-operando time-resolved magnetic domain observation sheds light on the irreversible and hysteretic magnetization changes due to domain nucleation, domain wall resonances, precessional magnetization effects, and spin-wave phenomena, determining the various sensors' performances at different frequencies of operation. Using time-resolved magneto-optical Kerr effect microscopy with time resolutions from nanoseconds to picoseconds we show the impact of spatial magnetization distribution, especially of magnetic domains and domain walls on ME, ΔE-effect, SAW and GMI sensor performance. The domain activity in operating devices is studied and compared at a broad temporal range from a few hundred Hz up to GHz. With the spatial and temporal analysis together with complementary electrical measurements, the physical origin of the various effects is determined. From this, strategies for sensor improvement are provided, some of which are already implemented in various sensor designs.

The role and impact of static and dynamic magnetic domain and domain wall activity and their influence on the magnetic sensor response and noise will be discussed in detail. The data proves the importance of micromagnetic processes for real-world applications.