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DISTINGUISHED LECTURE SERIES

Summer Term 2021

Prof. Dr. Jeffrey McCord

University of Kiel

Magnetic domain behavior in high sensitivity magnetic field sensors – magnetic noise and magnetic domain control

Magnetic domain formation 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 promising routes for sensing ultra-low magnetic signals. As the sensors are operated by external stimuli from the kHz to the GHz regime, understanding the complex physics of magnetic domain activity at these modulation frequencies are one of the most important factors that determine the performance of the magnetic field sensors.

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. Using time-resolved magneto-optical Kerr effect microscopy with time resolutions down to picoseconds, we show the effect of magnetic domains on ME, ΔE-effect, SAW, and GMI sensor noise performance. With the spatial and temporal domain analysis together with complementary electrical measurements, the physical origin of the various effects is determined.

Magnetic noise density originating from magnetic domain activity and not sensitivity is the main figure-of-merit for improving sensor performance. Even minimal magnetic domain activity is restricting magnetic sensor performance. Localized magnetostrictive effects are central to the magnetic domain behavior. We show that understanding the magnetic domain physics and actively controlling magnetic domain behavior is the key to improved sensor performance. The data proves the importance of micromagnetic processes for real-world applications.

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