Design and processing of nanoparticle ferrites for ultrahigh frequency applications

Vincent G. Harris

Director, Center for Microwave Magnetic Materials and Integrated Circuits
W.L. Smith Chair Professor, Electrical and Computer Engineering,
Northeastern University, Boston, MA USA

Ferrite materials have long played an important role in power conditioning, conversion, and generation across a wide spectrum of frequencies (up to 10 decades). They remain the preferred magnetic materials, having suitably low losses for most applications above 1 MHz, and are the only viable materials for nonreciprocal magnetic microwave and millimeter wave devices that include tunable filters, isolators, phase shifters, and circulators, among others.

Recently, novel processing techniques have lead to a resurgence of interest in the design and processing of ferrite materials as nanoparticles, films, single crystals, and metamaterials. These latest developments have set the stage for their use in emerging technologies that include next generation radar and communications as well as cancer remediation therapies such as magnetohyperthermia, magnetic targeted drug delivery, and magnetorheological fluids, as well as enhanced magnetic resonance imaging.

Here, we review recent successes in the design and chemical processing of ferrite nanoparticles. The nanoparticles are characterized using magnetic, structure, and chemical tools in addition to state-of-the-art synchrotron radiation techniques leading to the measurement of cation distribution within the unit cell and subsequent calculation and measurement of the Néel temperature. Remarkably, an enhancement of more than 80K in Néel temperature is demonstrated for spinel systems, thus providing the unambiguous tuning of magnetic properties for specific applications. The impact of size and surfaces of said particle properties are discussed.