Department of Electrical and Computer Engineering
Materials Engineering Program
Texas Center for Superconductivity at Univ. of Houston
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Bioapplications of magnetic nanowires: barcodes, heaters, biocomposites

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Abstract:
Magnetic nanowires can be engineered using composition and shape, and by modulating both of these along their axes (10nm-100um) or their diameters (10-200nm). This talk will discuss applications of both single nanowires and arrays of vertically aligned nanowires in biomedical fields, such as nano-barcodes [1], and biolabels for cells and exosomes [2,3], nano-heaters for hyperthermia therapy and organ preservation [4], and biocomposites [5]. For most of these applications, the reversal mechanism of magnetization can play a critical role. For example, magnetic coercivity and remanence has been used for contact-free readout of nano-barcode signatures, and the motion of domain walls can limit heating. Magnetic reversal typically occurs by uniform precession and coherent rotation or by domain walls that are transverse or vortices. Here, a novel approach to decoding specific reversal signatures will be described via a fast modification of the first order reversal curve (FORC) technique, called the projection method. In addition to decoding, the method elucidates the mechanisms of reversal which is of interest to the fundamental understanding of nanomagnets and can lead to improved future devices, such as decoding using ferromagnetic resonance (FMR) [6]. By understanding the nanomagnetics, these nanowires have been used individually to isolate biospecies, such as cancer cells [2] and tumor-derived exosomes (TEXs) [3] for fundamental studies in medicine. As nanoscale objects, nanowires have also been suspended in cryopreservation agents to provide the rapid, uniform nanowarming needed to restore preserved tissues and organs [4]. Finally, by aligning nanowires vertically in bio-friendly polymers, applications such as internal band-aids can be coded or functionalized for personalized health care. This talk will focus on the measurement methods for each of the biomedical applications mentioned, and will relate these measurements back to the fundamental magnetization engineering of the cylindrical nanowires.

[1] MRZ Kouhpanji, BJH Stadler, *Nanoscale Advances* 584 (2020).
[2] Sharma, Orlowski, Zhu, Shore, Kim, DiVito, Hubel, Stadler, *Nanotechnology*135102 (2015).
[3] Nemati, Kouhpanji, et al, *Nanomaterials* 1662 (2020).
[4] Shore, Ghemes, Dragos, Gao, Shao, Um, Sharma, Tabakovic, Bischof, Stadler, *Nanoscale* 14607 (2019).
[5] Kouhpanji, Stadler *ACS Applied Nano Materials* 13286 (2020).
[6] Zhou, Um, Zhang, Nelson, Nemati, Modiano, Stadler, Franklin, *IEEE J Electromag, RF,Microwaves in Medicine and Biology* 134 (2019)

Short Bio:
Bethanie Stadler is a Professor and Associate Head of Electrical & Computer Engineering at the University of Minnesota, where she also holds the CS&E Distinguished Professorship and is on the Graduate Faculty of both Chemical Engineering & Materials Science and Mechanical Engineering. She earned her PhD from MIT and a BS from Case Western Reserve University. She is a Fellow of the Materials Research Society (MRS). Stadler works on magnetic nanowires for applications in RF design and biomedicine, including contact-free barcoded bandaids for deep labeling that is detected using novel magnetic readout. She also works on magneto-optical garnets for integrated photonics, including one-dimensional magnet-free isolators. Stadler has been a visiting professor at IMEC and KU Leuven in Belgium and also at Wright Patterson Air Force Base in Dayton Ohio. In 2015, Stadler was an IEEE Magnetics Society Distinguished Lecturer. She has taught at the IEEE Magnetic Summer School in India and Italy, and hosted the school in Minnesota in 2015. In serving MRS, Stadler has been a meeting chair (Fall 2004), director on the board, secretary and chair of the program development subcommittee. She has also served as chair the program committee and in many other roles for the IEEE Magnetics Society, and she will be the General Co-Chair of Intermag 2023 in Sendai, Japan.