Employing mechanically detected magnetic resonance for nanoscale electron and nuclear spin imaging

Abstract: A universal platform to non-destructively image soft materials – such as organic electronic devices or individual biomacromolecules – in three-dimensions with nanoscale resolution would be an enabling advance. By detecting magnetic resonance as a force on an attonewton sensitivity microcantilever, magnetic resonance force microscopy offers a >10^10 improvement in sensitivity over conventional nuclear magnetic resonance and offers a promising avenue for nanoscale magnetic resonance imaging (nano-MRI). Exciting advances in mechanically detected magnetic resonance include the <10 nm viral imaging experiment of Degeń et al. and the nanomagnet tipped cantilevers developed by Longecker and Marohn which have demonstrated a sensitivity capable of detecting a few hundred proton magnetic moments. This talk will discuss our efforts to combine these advances, while decreasing signal acquisition time, to achieve force-detected single-molecule imaging by detecting single electron spin labels with angstrom resolution and using nitroxide radicals as a polarizing agent for imaging hyperpolarized nuclear spins with <10 nanometer resolution. I will discuss the design and integration of coplanar waveguides operating on 200 mW of input power to generate millitesla strength magnetic fields from radiofrequency up to 40 GHz. These coplanar waveguides have enabled the simultaneous detection of electron spin resonance and nuclear magnetic resonance in a single scanning-probe microscope experiment for the first time. Using dynamic nuclear polarization, I will show how we have detected hyperpolarized proton magnetic resonance in a nitroxide-doped polystyrene thin film. I will further discuss our work toward imaging this hyperpolarized spin signal and single electron spins.

Biography: Corinne Isaac is a PhD candidate in the Department of Chemistry and Chemical Biology at Cornell University. Since joining Prof. John Marohn’s laboratory in 2012, Corinne has been developing ultrasensitive methods for detecting electron spin resonance and nuclear magnetic resonance. Her thesis work has involved designing and integrating broadband coplanar waveguides into a custom, scanning-probe microscope, inventing protocols for generating and detecting hyperpolarized ^1H magnetic resonance, and investigating methods for three-dimensional nanoscale magnetic resonance imaging. Corinne’s research interests broadly include determining the structure of soft materials with nanoscale spatial resolution, organic electronics, and developing methods for understanding the fundamental processes occurring in novel energy materials.