IPRIME Research Project Outline

**NMP:** Greg Haugstad (PI) and other Characterization Facility (CharFac) personnel as feasible

**Industrial collaborators:** Joe Delaney and other Boston Scientific personnel

**Industrial problem:**

Cardiac leads, which connect pacemakers and defibrillators to the heart, contain multiple material components that must function reliably within the heart’s environment. The polymeric electrical lead insulator requires optimized mechanical properties as well as long-term biostability and durability. Recent failures of this insulator in implanted devices necessitate an improved understanding of fundamental structure-processing-property relationships. Controllably strained insulator materials provide outstanding model cases for developing correlative analytical methods. In particular we are interested in exploring multiple analytical methods; improving our understanding of these methods; and developing new characterization methodologies to elucidate structure (crystalline/amorphous contact), uniformity (anisotropy, distribution of ordered/disordered domains), and mechanical properties (down to nanoscale) in a *correlative* fashion, and relating these results to certain formulation parameters and processing history.

**Approach:**

Investigate complementary analytical methods in the CharFac and in the analytical labs of Boston Scientific for assessing model silicone and polyurethane lead insulator materials prepared with variable formulation and processing to include commercial medical grade silicone materials cured at different temperatures and tensile stress regimes. Analytical techniques will likely include both small and wide-angle X-ray scattering (XRS), atomic force microscopy (AFM) and confocal Raman spectroscopy. Wide angle XRS will provide ensemble analysis of crystallinity and anisotropy, whereas small angle scattering will provide ensemble analysis of phase segregation in multiphase systems. These will be complemented by real-space imaging and property mapping with AFM methods (more limited in spatial sampling than the ensemble techniques). In the case of thermosets, Raman spectroscopy and magic angle spinning solid state NMR may be used to provide ensemble analysis of crosslink density and cure efficacy; if meaningful results are obtained, AFM would be explored as a source of complementary real-space and mechanical information. Rheological and calorimetric techniques may be used to study residual strain, phase separation and other physical properties in tandem with the X-ray structural probing, under conditions relevant to processing and storage. This research will help guide design of future electrical lead insulator materials.