Induction in leaded, implanted medical devices exposed to radio frequency (RF) magnetic fields during magnetic resonance imaging (MRI) produce Joule heating in adjacent tissues causing various issues, including death. Given the importance of MRI as a diagnostic tool and the growth in leaded device-related treatments, identification of a solution ensuring their compatibility is of great interest. Electromagnetic (EM) surface property tailoring in lead materials to change their inductive response by adding functionally-graded, heterogeneous surface layers is a possible solution. However, non-uniform EM properties introduce two challenges: the added complexity of analyses and characterization of the graded region. This dissertation addresses these complexities.

An Helmholtz coil and other loops positioned in a coaxial array were used to create and monitor inductive fields that were mathematically related to the induced current in closed, circular loops with electrical conductivities ranging from 1.0 to 57 microSiemens per meter. Magnetic flux densities up to 14 microTesla at frequencies from 30 to 100 MHz were evaluated for specimens with varying loop and wire diameters. Induced current results show a linear relationship with flux density and strongly depend on the sample geometry, but not on conductivity. Trends within the data matched well with those predicted by theory that considered such a loop.

An equivalent length, semi-analytical approach modeled induced current through a graded EM property region and considered effective conductivities. Predicted results for transmissivity through Pt-doped titanium foils and effective conductivity in round wire Sn-modified Cu samples show good agreement with experimental data. The Joule heating experiment used for wire testing also demonstrates a means for characterizing conductor surface properties.

Two new technologies derived from this research including an RF magnetic field imaging technique and a contoured loop array for applying therapeutic controlled RF magnetic fields are also described.

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The public is welcome to attend.