Towards a Minimally Invasive Integrated Microwave Approach for Image-Guided Thermal Ablation of Cancer

L. M. Neira, J. F. Sawicki, H. Luyen, Y. Mohtashami,
B. D. Van Veen, N. Behdad, and S. C. Hagness*
Department of Electrical and Computer Engineering
University of Wisconsin-Madison, Madison, WI, USA

Surgical resection coupled with chemo-, radiation, and/or endocrine therapy is the current gold standard for cancer treatment. However, these treatments carry risks of short-term side effects, chronic morbidities, and life-threatening toxicities. Minimally invasive microwave ablation (MWA) is a promising alternative, offering quicker recoveries and far fewer risks. MWA involves inserting an interstitial antenna into the diseased tissue and delivering the power necessary to induce coagulation necrosis. Promising clinical results to date have motivated further MWA research to expand the range of MWA tumor targets and performance capabilities; examples include the design of new ultra-compact antennas that have the potential to further reduce the intrusiveness of the MWA antenna, as well as antennas that permit greater customization of the shape of the ablation zone.

Real-time image guidance is necessary for monitoring the growth of the ablation zone and verifying the completeness of ablation. Ablation monitoring with ultrasound, MRI, or computed tomography poses challenges in terms of accuracy, safety, portability, and cost; these challenges motivate the development of integrated microwave technology for simultaneously ablating a malignant tumor and monitoring the therapeutic response. The rationale for microwave monitoring of MWA is two-fold. First, microwave monitoring can take advantage of not only the temperature dependence of tissue dielectric properties at microwave frequencies, but also the large contrast between ablated and non-ablated tissue. Second, microwave monitoring can exploit the presence of the interstitial MWA antenna, using it as a local sensor or internal transmitter to obtain information-rich microwave signals sourced right at the site of the ablation.

This talk will highlight recent advances in minimally invasive MWA antennas and recent progress towards the integration of MWA with real-time microwave monitoring, including the development of accurate spatio-temporal ablation-zone models that may be used as *a priori* information in microwave monitoring algorithms.