MICROWAVE MICROFLUIDICS

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Microwave microfluidics integrate microwave circuits with microfluidics for quantitative electrical measurement of fluids. This emerging field has the potential to advance industrial applications of impedance spectroscopy, including point-of-care diagnostics and quality assurance for pharmaceutical and chemical manufacturers. For these commercial applications to be realized, it is important to accurately and quickly correct the electrical measurements of microwave-microfluidic devices for the attenuation and phase shift of the measurement leads and the standing waves between the fluid-under-test and the vector network analyzer (VNA).

NIST has contributed to microwave microfluidics through a series of developments that include on-chip coplanar waveguides (CPW) with integrated microfluidic channels. These microwave-microfluidic devices are capable of measuring nanoliter fluid volumes non-destructively, making them ideal for chemical and biological characterization. We have made microwave-microfluidics measurements more viable for commercialization by developing fast and accurate on-chip calibration methods. To improve the portability and repeatability of fluid measurements, we have designed a packaged device that routes fluids and electrical signals to on-chip devices. The packaged device includes a transmission line for broadband measurements, as well as a 10 GHz resonator to measure changes in the electrical properties in the fluid on the microsecond timescale. Together, the simultaneous broadband and narrowband measurements provide a powerful tool to investigate the dynamics of non-equilibrium biological and chemical systems. Here, I will review our prior work and present our new microwave microfluidic package, the culmination of nearly six years of work. I will provide a detailed summary of our fabrication procedures, highlighting the intersection of calibration theory and design considerations that enabled this device. Finally, I will show complex permittivity measurements of water, colloidal suspensions, and solutions to 110 GHz with uncertainties.