BROADBAND MICROWAVE MEASUREMENTS OF LIQUIDS IN MICOFLUIDIC STRUCTURES

James C. Booth
National Institute of Standards and Technology, 325 Broadway, Boulder, CO 80305

We report on efforts at NIST to develop wideband dielectric spectroscopy techniques for bio- and/or chemical- analysis of small volumes of liquid samples. Rapid and accurate detection and/or identification of minute biological or chemical samples is essential for the development of effective homeland security technologies. Electromagnetic characterization can be a viable alternative to chemical or optical detection schemes to analyze biological or chemical liquids. One option in dielectric characterization is dielectric spectroscopy: the measurement of a samples dielectric permittivity across a very broad range of frequencies. This technique has the potential to rapidly characterize a wide variety of biological or chemical materials, from macromolecules like hemoglobin to live bacterial samples to proteins and DNA. By combining lithographically-defined broadband microwave structures with microfluidic chambers produced by state-of-the-art microfabrication techniques, it is possible to determine the dielectric response of small sample volumes (sub-microliters) over several decades in frequency. Integration with other microelectromechanical systems (MEMS), as well as microfluidic pumps and circuits, could enable rapid analysis of large numbers of different samples in high-throughput screening systems. Here we report on the design, fabrication, and evaluation of integrated microfluidic/microelectronic test structures for the determination of the dielectric properties of fluids over a broad frequency range. Our integrated devices allow for accurate S-parameter measurements utilizing on-wafer calibration techniques on sample volumes as small as 0.1 microliter, over the frequency range from 1 MHz to 40 GHz. We analyze our calibrated S-parameter measurements using 2-dimensional quasi-static electromagnetic simulations in order to obtain accurate values for the complex relative permittivity over this entire frequency range. Comparisons to bulk measurements on reference fluids such as methanol and de-ionized water show reasonable agreement over this frequency range.

Abstract Submission Form

2006 National Radio Science Meeting

Abstract: booth24588

Date Received: September 16, 2005

1. (a)
   James Booth
   NIST
   Mail Stop 818.01
   325 Broadway
   Boulder, CO
   80305 United States
   booth@boulder.nist.gov
   (b) 303 497 7900
   (c) 303 497 3970
2. A - Electromagnetic Metrology
3. (a) S-A1
4. C - Contributed Paper
5. No special instructions