Coupling of a sub-THz liquid sensor for online microfluidic sensing

S. M. da Silva Junior [1,2,3], J. Stiens [1], J. W. Swart [2], S. Moshkalev [3], Y. Zhang [1], V. Matvejev [1], C. De Tandt [1]

[1]*Laboratory of Micro- and Photoelectronics, LAMI-ETRO, Vrije Universiteit Brussel (VUB), Pleinlaan 2, Brussels 1050, Belgium.*

[2]*School of Electrical and Computer Engineering (FEEC),State University of Campinas (UNICAMP),Cidade Universitária, 13083-852 Campinas, SP, Brazil.*

[3]*Center for Semiconductor Components and Nanotechnologies (CCSNano),State University of Campinas (UNICAMP),Cidade Universitária, 13083-870 Campinas,SP, Brazil.*

salomaomoraes@yahoo.com.br; jstiens@etrovub.be

This paper reports on the performance of a sub-THz liquid sensor tool coupled to a microfluidic system. Non-invasive, non-destructive and on line measurements are demonstrated for the determination of methanol, ethanol and biomolecule concentrations and for controlling microfluidic devices. Techniques to characterize liquids are of fundamental importance for chemistry and life sciences [1][2]. The frequency 10^{10} to 10^{13} Hz range allows sensors for such interrogation in a label-free manner through electromagnetic measurements of small permittivity changes. We have developed a chemical sensing methodology that integrates sub-terahertz sensor technology into microfluidic devices fabricated on silicon, glass and polydimethylsiloxane.

The proof-of-concept sensor in micromixer applications operating at 60 GHz was demonstrated for known ethanol concentration ranging from 0 to 100%, with a corresponding signal change of 2.79 dB. For microchannels dimensions of 100 µm width and 20 µm depth. The sensor allowed to establish the relationship between the flow rate controlled by a syring pump and ethanol concentration in the microfluidic system, the sensor allowed to control the ethanol concentration with a precision of <1.65%. Similar setup was used at room-temperature for water-to-methanol ratio determination with high dynamic range [3]. The same technology was applied for biomolecule studies (determination of concentrations, conformational changes, concentration and molecular binding), using a very small sample volume and high sensitivity [4].

The technology could be applied for the characterization of micromixers, the analysis of biomolecules (e.g. proteins, DNA), including concentration measurements, and hydration shell studies.

References: [1] Madou, M. J. "Fundamentals of Microfabrication: The Science of Miniaturization." *CRC Press*. Washington, USA. 2ed. 2002. [2] Whitesides, G. M. "The origins and future of microfluidic." *Nature, Vol. 447. n.27.368 – 373, 2006*. [3] Matvejev, V., et al., "Integrated waveguide structure for highly sensitive THz spectroscopy of Nano-liter liquids in capillary tubes", *Progress In Electromgnetics Research, Vol. 121, 89-101, 2011*. [4] Matvejev, V., et al.. "High performance integrated terahertz sensor for detection of biomolecular processes in solution." *IET Microwaves, Antennas and Propagation, 2013, **8**, (6), pp. 1-7.*