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## Interests of Microwave Dielectric Spectroscopy for biological characterizations

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Gold standard instrumentations for biological characterization are based on optical techniques. Even if very efficient and precise in the observation of cells and tissues, with spatial and temporal resolutions on the order of nanometers and nanoseconds, they may still have some limitations. The price of accuracy lies in the use of staining and labeling consumables, which may interfere with the phenomenon to be observed, and requires time to be integrated at the tissue or cellular levels. Cost is also another consideration for both markers and optical equipment.

In complementarity to these very mature analysis methods, electrical and electromagnetic ones are being developed. Depending on the frequency range, different interaction phenomena occur, leading to the detection of different biological behaviors and compartments from the cellular to the tissue level. Beyond several hundreds of MHz, microwaves do penetrate cells, giving access to intracellular investigations. Due to its non-destructive and non-invasive characteristics and combined to its large scalability to various biological elements to be analyzed, it makes it particularly attractive. The sensing capability has already been demonstrated from single cells [1, 2] to cell suspensions [3, 4] as well as from microtissues [5] up to tissues [6] for various applications. It may be applied to the quantification of cells, their discrimination [4], as well as to the monitoring of cells subjected to physical or chemical stimuli in real time or in time lapse with a wide range of temporal resolution (from microseconds to day and more), such as electrochemotherapy studies, drug screening and personalized medicine. In addition, due to the explosion of wireless communications, RadioFrequency equipment is getting extremely affordable, costing much less than optical instrumentations. It therefore offers an interesting characterizing technique of cells and tissues, which may complement existing ones.

## References

- [1] A. Tamra, A. Zedek, M. -P. Rols, D. Dubuc and K. Grenier, "Single Cell Microwave Biosensor for Monitoring Cellular Response to Electrochemotherapy," in *IEEE Transactions on Biomedical Engineering*, vol. 69, no. 11, pp. 3407-3414, Nov. 2022, doi: 10.1109/TBME.2022.3170267.
- [2] K. Grenier, W. Chen, D. Dubuc, "Non-invasive real time monitoring of cellular modifications with microwave dielectric spectroscopy at the single cell level," 20220 URSI GASS, Roma, Italy, 2020, pp. 1-3
- [3] K. Grenier *et al.*, "Integrated Broadband Microwave and Microfluidic Sensor Dedicated to Bioengineering," in *IEEE Transactions on Microwave Theory and Techniques*, vol. 57, no. 12, pp. 3246-3253, Dec. 2009, doi: 10.1109/TMTT.2009.2034226.
- [4] K. Grenier, F. Artis, M. Poupot, J. -J. Fournié and D. Dubuc, "Label-free discrimination of human lymphoma cell sub-populations with microwave dielectric spectroscopy," 2018 IEEE/MTT-S International Microwave Symposium - IMS, Philadelphia, PA, USA, 2018, pp. 907-910, doi: 10.1109/MWSYM.2018.8439472.
- [5] O. Peytral-Rieu, D. Dubuc and K. Grenier, "Microwave Microfabricated Sensor Dedicated to the Dielectric Characterization of Biological Microtissues," 2022 3rd URSI Atlantic and Asia Pacific Radio Science Meeting (AT-AP-RASC), Gran Canaria, Spain, 2022, pp. 1-4, doi: 10.23919/AT-AP-RASC54737.2022.9814189.
- [6] M. Lazebnik, M. Okoniewski, J. H. Booske and S. C. Hagness, "Highly Accurate Debye Models for Normal and Malignant Breast Tissue Dielectric Properties at Microwave Frequencies," in *IEEE Microwave and Wireless Components Letters*, vol. 17, no. 12, pp. 822-824, Dec. 2007, doi: 10.1109/LMWC.2007.910465.