Bio-Sensing with Nanodiamonds: Detection of Temperature Variations in Neurons Using Nitrogen-Vacancy Centers

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Nitrogen-vacancy (NV) centers in diamond have raised a lot of attention in the last decades for their promising sensing capabilities at room temperature, especially for magnetic field, and temperature. Both bulk diamond and nanodiamonds can be used in this context, each presenting its own advantages and challenges. In this presentation, I'll describe our recent results concerning the use of nanodiamonds for biosensing applications [1]. In particular, we focus our research on temperature sensing: this field is particularly interesting since nanoscale thermometry inside the cell can give new insights on many biological processes which are still not completely understood. Compared to other intra-cellular thermometry techniques, NDs show a better biocompatibility, insensitivity to biological environment, more stable photoluminescence and a lower noise floor [2].

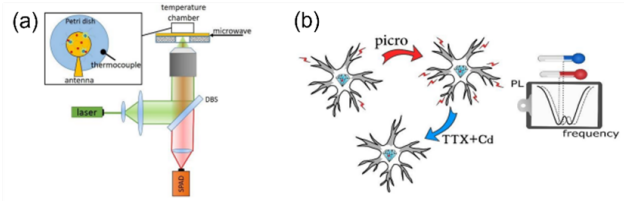

Figure 1: (a): schematic of the experimental set-up (b): key idea: using NV centers in nanodiamonds we observe temperature variation associated with neurons firing [1]

Temperature is one of the most relevant parameters for the regulation of intracellular processes. In our experiment [2], we consider hippocampal neurons and, using optically detected magnetic resonance in ND, we detect for the first-time temperature variations associated with potentiation and depletion of neuronal firing. We measure up to 1°C temperature variation when the spontaneous firing of hippocampal neurons is potentiated by Picrotoxin and 0.5°C temperature decrease when the neuronal activity is silenced by a solution containing tetrodotoxin and cadmium chloride.

The potentialities of this technique are relevant and can benefit both from proper ND functionalization and optimization of the sensing protocol, allowing to detect temperature variations below 0.1 °C.

We will also discuss our present efforts toward the integration of the ND sensing technique with micro-electrode arrays (MEAs) devices. MEAs are widespread tool in neuroscience and allow to measure the cells electrical activity, collecting signal from several cells at the same time: combining them with local temperature sensing using ND would give new insights and allow a deeper understanding of neurons function, such as the genesis of action potentials, and cell metabolism.

References

[1] G Petrini, G Tomagra, E Bernardi *et al.*, Adv. Sci. **9**, 2202014 (2022)

[2] G Petrini, E Moreva, E Bernardi, P Traina, G Tomagra, V Carabelli, I P Degiovanni and M Genovese, Adv. Quantum Technol. **3**, 2000066 (2020)