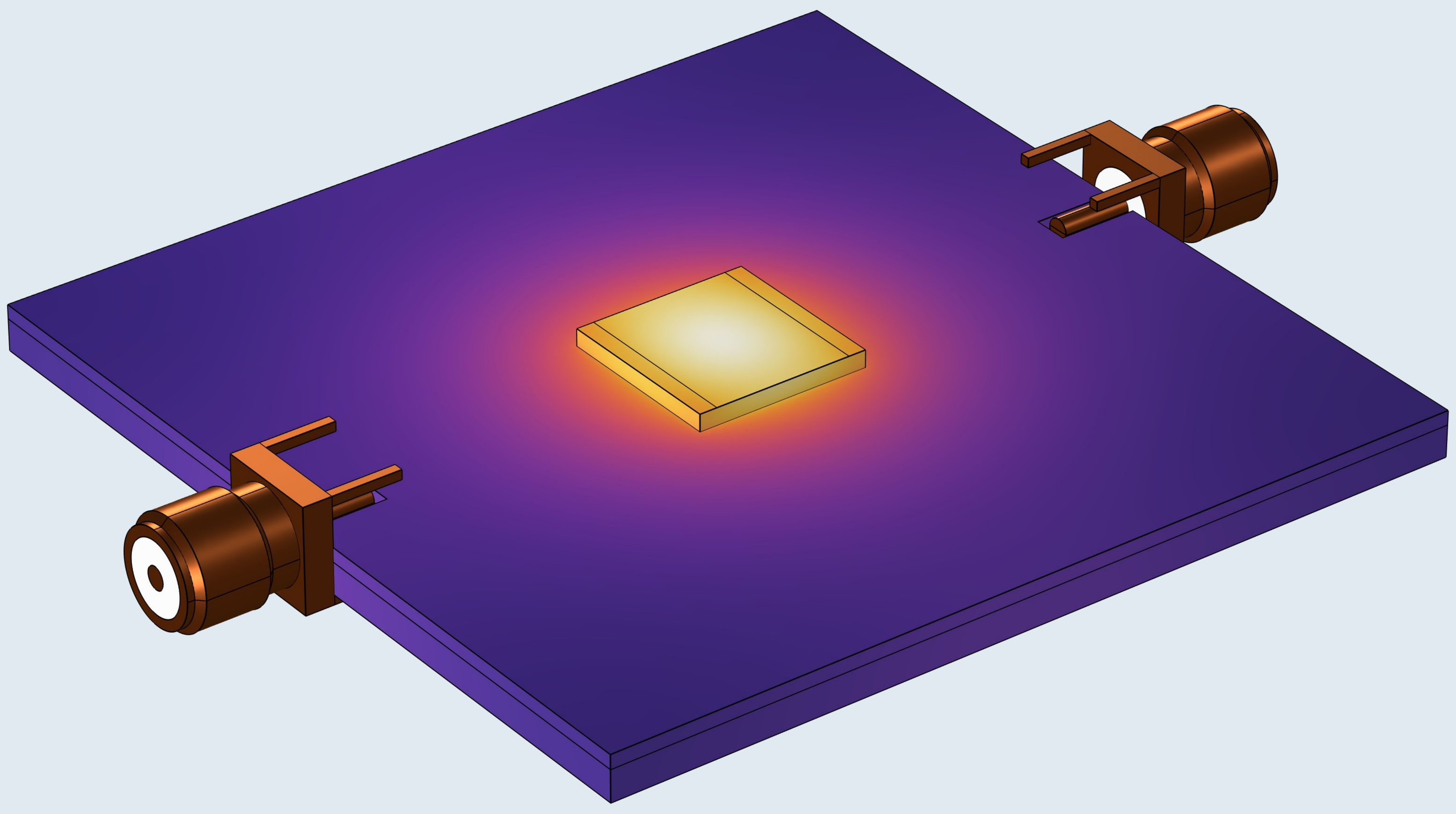

Designing of the Diamond-Based NV Quantum Chip for the *in Vitro* Application.

Developing of the nitrogen-vacancy (NV) based nanoprobe thermometer for the monitoring of the selective opening of the ion channels in the neural cellular wall.

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Abstract

We aim to develop Nano Magnetic Resonance (NMR) sensors based on the optical readout of the nitrogen–vacancy (NV) spin state in the diamond for measuring of the temperature in vitro with sensitivity of 10mK/√Hz[1]. High sensitivity allows us to observe temperature gradient in the biological systems, particularly the thermo-receptor: Transient receptor potential (TRP) vanilloid-type 4 that is studied[2] due to its importance in axonal growth and path finding in neurons during development and after brain injury. Making it a therapy target in various diseases such as axonal neuropathy, autism or chronical pain.

In this work, we aim to design the PCB in the way that it can maintain the specific body temperature (37°C) required for in vitro applications and provides the sufficient homogenic MW field that is required for the optical readout of NMR.

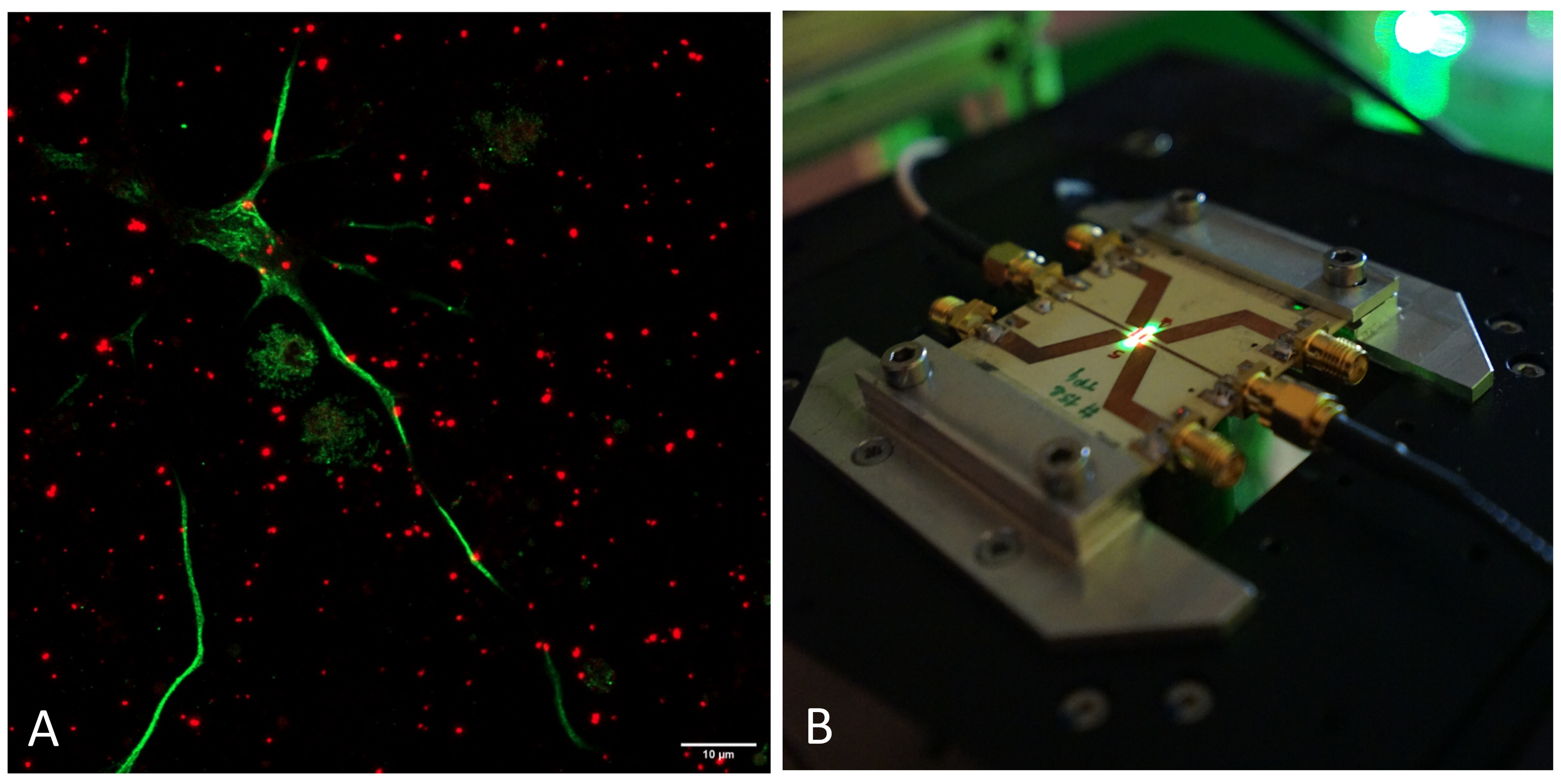

FIGURE 1. A: Fluorescence image of a cortical neuron in culture (4div) (Green, immunofluorescence) incubated overnight with 2μg/ml NDs (Red, NV- fluorescence), B: example of chip under the green illumination (532nm).

Methodology

To achieve heating, a thin layer of indium tin oxide (ITO) glass, with a thickness of 120 nm, is deposited on a fused silica glass substrate measuring 1x1x0.1 cm. The ITO layer is electrically connected to an external circuit. A liquid sample containing the neuronal cells with nanodiamonds is placed in the cavity located beneath the glass plate.

Microwaves, with the frequency range of 2.6-3.1 GHz are applied via the SMA ports and directed through a 50Ω impedance-matched microstrip line to a 50Ω termination load.

Probing of the quantum response of the NV, we used the Livelink™ *for* MATLAB®, utilizing the results of the COMSOL® simulation as input for the calculation of Hamiltonian of the NV spin system.

Results

Fig. 2A shows the distribution of the magnetic part of the applied microwave (2.87 GHz) in the 2D plane, corresponding to a cross-sectional plane positioned at the centre of liquid sample. The results demonstrate a homogenous magnetic field, both in terms of direction and amplitude, in central top part of liquid sample. Figure 2B shows the quadratic dependency of the maximum steady-state temperature of liquid sample on the input voltage through the ITO layer. The optimal temperature is achieved at an input voltage of 10.5 V. Fig 2C presents the reconstructed optical detected MR spectra of the single NV defect, correlated with the simulated temperature and MW field distribution.

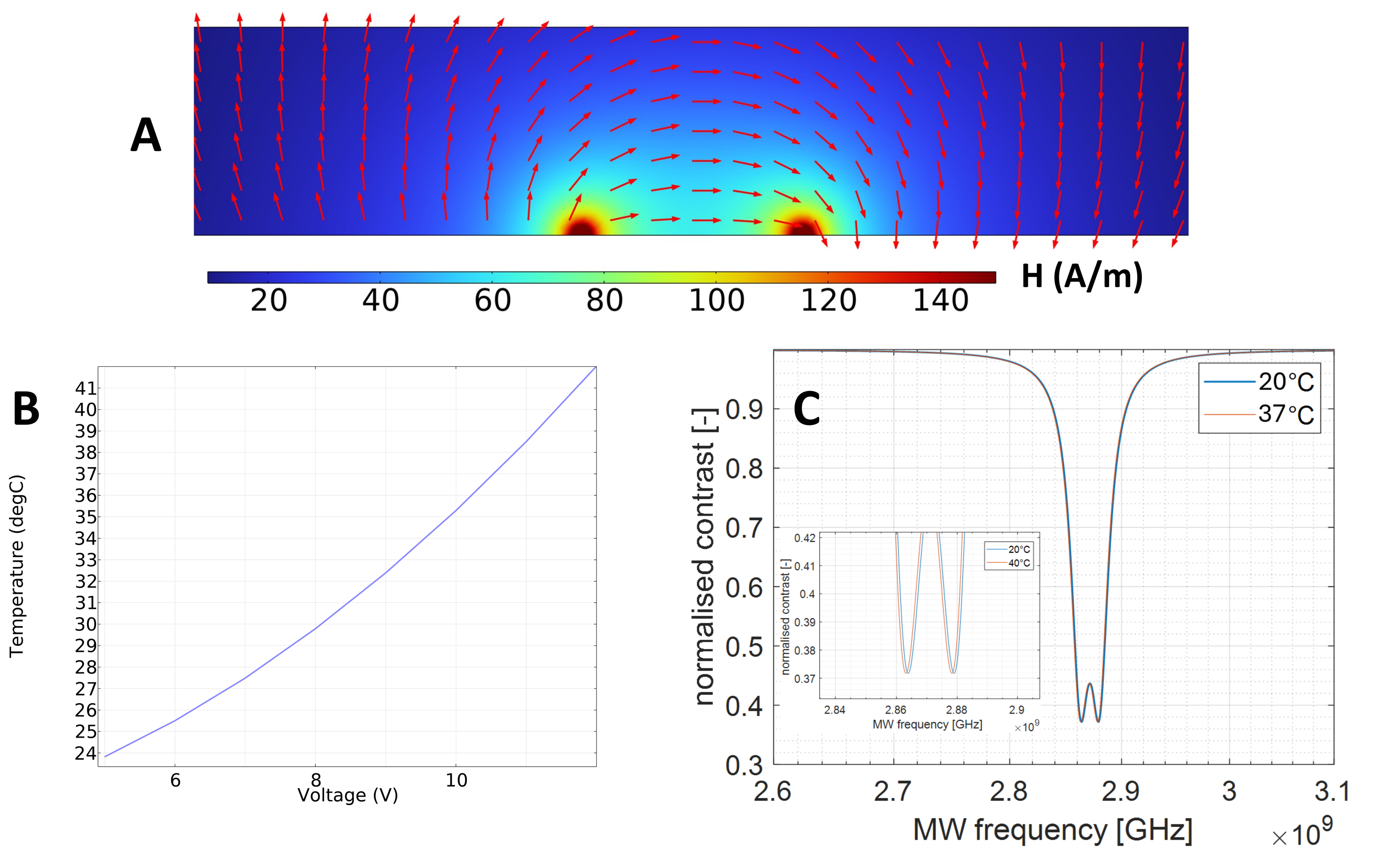

FIGURE 2. A: Microwave field distribution (H part) in YZ plane, B: Maximal temperature of liquid sample as function of input voltage, C: reconstructed optical-detected MR spectra of single NV defect.

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