Modular arrays of optically pumped magnetometers for electric vehicle battery characterisation

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Optically pumped magnetometers (OPMs) are established quantum sensors used in medical research, navigation, and industrial applications. Here, we demonstrate the feasibility of using OPMs to non-invasively measure the current density distribution inside an electric vehicle cell, and the development of magnetometer arrays with shared systems to increase sensor resolution and sensitivity. The uptake of electric vehicles is central to the green transition in clean transport, whereby every other car sold globally is expected to be electric by 2035. The existing limitations in manufacturing yield, recycling of cells, and life-cycle assessment can be met with novel cell characterisation methods. In this work, we present the development and application of magnetic imaging techniques to characterise electric vehicle batteries, utilising both classical fluxgate sensors in the µT-regime and quantum magnetometers down to fT sensitivity, allowing dynamical processes to be measured with spatial resolution.

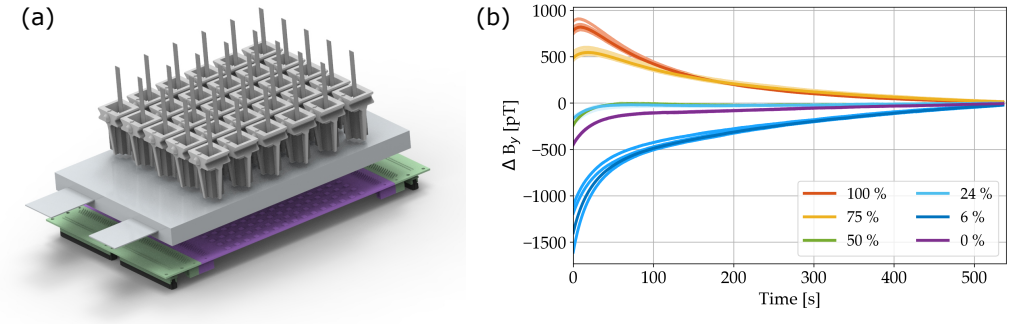

Figure 1. (a) A CAD render of an OPM array above a lithium-ion cell. Below the cell is an array of fluxgate magnetometers, used for high magnetic field measurements. (b) Measurement of the relaxation of the magnetic field over time, following a short discharge pulse (0.1 C, 60 s), taken at decreasing states of charge.

[1] M. Bason et al., Non-invasive current density imaging of lithium-ion batteries, Journal of Power Sources, **533**, 231312 (2022).
[2] T. Coussens et al., A modular optically pumped magnetometer system, Quantum Sci. Technol. **9**, 035045 (2024).
[3] IEA (2024), Global EV Outlook 2024, IEA, Paris, https://www.iea.org/reports/global-ev-outlook-2024, Licence: CC BY 4.0.