Development of a Solid-State Nanopore-based platform for Characterisation of Magnetic Nanoparticles

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Magnetoresistive (MR) sensors using magnetic nanoparticles (MNPs) as reporters show great promise as molecular sensors. The MR-MNP system can be incorporated, along with microfluidics, in Lab-on-a-Chip devices, allowing for a cheap, low power device with simple signal readout.

Nanopores also show great promise as molecular sensors and are, most famously, at the forefront of the next generation sequencing of biopolymers (DNA, RNA, proteins). At the simplest level, a nanopore is a very small hole separating two compartments. Solid-state nanopores can be fabricated in thin film dielectrics (e.g. SiNx, SiO2) or 2D materials (Graphene, hBN, MoS2) Like the MR-mNP system, nanopores can be incorporated, along with microfluidics, in Lab-on-a-Chip devices, allowing for a cheap, low power device with simple signal readout.

Nanopores have also been previously used to quantify and characterise NP preparations. Each particle is “scanned” as it passes through the nanopore and a profile of the NP population can be assembled.

In this project, we propose to:

- Optimise our existing solid-state nanopore platform for detection, quantification and characterisation of mNPs. Providing a cheap (and much needed) quality control measurement for mNPs.
- Use nanopores as an alternative readout for the characterisation of reporter MNPs (MNPs coupled to an analyte of interest).
- Use magnetic fields to show that mNPs can be focussed near to, or driven through a nanopore. Thus increasing local concentration and lowering detection limits
- Use magnetic fields to introduce an extra level of control into the experimental system.
    - Particles can be retained while solutions are exchanged.
    - Magnetic fields may be used to trap particles in or near to the nanopore, allowing the same particle to be sampled many times
    - MNPs could serve as a brake on larger polymers – they could be used to slow down translocation of coupled biopolymers allowing for more detailed characterisation.

Partner 1:

The Laboratory of Single Molecule Processes at ITQB NOVA is experienced in the design and implementation of nanopore experiments. The laboratory has previously characterised gold NPs using biological nanopores and currently has funding to transfer this knowledge to their solid-state platform.

Partner 2:

The Spintronics and Magnetic Biosensors group at INESC MN has extensive experience in magnetoresistive sensing devices for industrial and biomedical applications.

Student profile:

A preference for, but not limited to, students with a background in Physics or Engineering, with an interest in magnetism, electronics and sensor applications. Experience in automation, data acquisition/treatment and cleanroom procedures would be beneficial.