Towards using nanodiamonds for deep tissue microscopy

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Diamond is a material of superlatives. When considering biological applications, the stability of diamond means it is biocompatible and it does not photobleach unlike most dyes. Nanoscale sized particles of diamond have been shown to be small enough to allow endocytosis. Furthermore, the presence of optically active defects in the diamond structure, such as the nitrogen-vacancy defect, allow optical addressing of individual nanodiamonds that also serves as a readout mechanism for probing the local electromagnetic environment. It is therefore been proposed the nanodiamond could serve as a nanoscale sensor for biologically generated electromagnetic fields. We are developing a superresolution microscope which will allow characterisation of the optical properties of nanodiamond that make it a potential sub-cellular sensor, such as the sensitivity of the optically active defects to small electromagnetic fields. It will also allow us to explore the more general use of diamond as an in-vivo fluorescent marker.

Our microscope is an adaptive optics enhanced, stimulated emission depletion (STED) microscope. Multi-colour excitation means that it is not only suitable for nanodiamonds, but can also simultaneously image a number of the other more conventional fluorophores, including STED-compatible near-infrared dyes such as ATTO 647N and Abberior Star 635. We are incorporating adaptive optics elements, such as a deformable mirror and a spatial light modulator, to correct for the sample-induced optical aberrations that are inevitable when imaging biological samples. While unavoidably adding complexity to the microscope hardware, it has repeatedly been demonstrated that such correction techniques allow high quality images from deep in the tissue of biological samples without the need for additional refractive index matching protocols.

Our microscope is currently under development and this poster will demonstrate the state of play of the instrument, including progress on the integration of the STED-enabling components and the effect of the adaptive optics on conventional confocal imaging with the system. We will also present our most up-to-date work on developing nanodiamonds as fluorescent labels for biological samples.

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