Multidimensional imaging of diamond luminescence

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Abstract: We report the development of a multidimensional fluorescence microscope designed to systematically study diamond luminescence. This instrument combines push-broom semi-confocal hyperspectral imaging with fluorescence lifetime and polarisation-resolved imaging and tunable excitation, enabling up to 7D mapping of spectroscopic properties of optically active defects in the diamond lattice and correlation with strain.

Diamond's outstanding physical properties are complemented by quantum electronic properties that enable technological applications including ultrasensitive measurements of magnetic fields and temperature, quantum computing, single photon sources and room temperature masers. These properties arise from impurities leading to optically active defects in diamond. We are developing a multidimensional luminescence microscope to enable comprehensive mapping of their complex spectroscopic signatures, including the effects of interactions and strain, to elucidate the underlying photophysics, to better understand how to grow synthetic diamonds for technological applications and to characterise natural diamonds.

We have implemented a slit-scanning semi-confocal hyperspectral microscope with a tunable ultrashort pulsed supercontinuum or UV excitation laser source utilising time correlated single photon counting (TCSPC) to enable spectrally-resolved fluorescence lifetime imaging microscopy (FLIM). Co-registered polarisation-resolved imaging enables correlation of spectroscopic readouts with birefringence to study the impact of strain within diamond samples. Figure 1 shows exemplar multidimensional luminescence data.

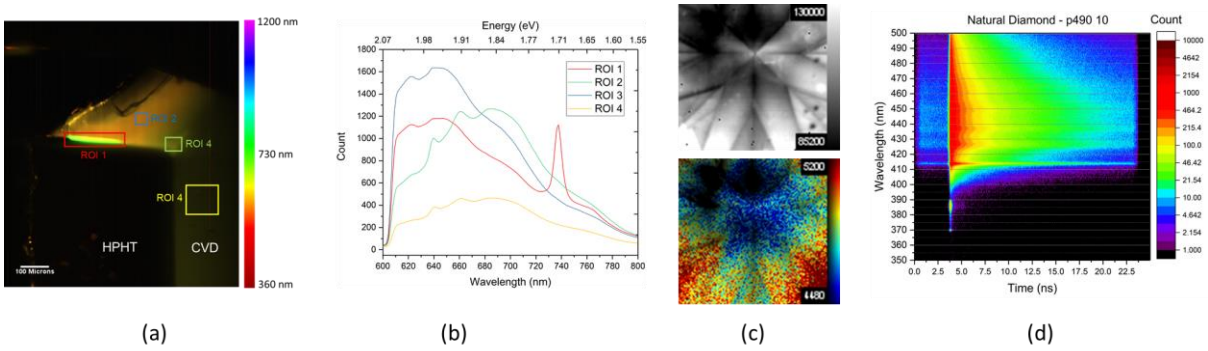

Figure 1 (a) peak wavelength map from hyperspectral data stack and (b) spectra from indicated regions of interest in a hybrid high pressure, high temperature (HPHT) and chemical vapour deposition (CVD) grown diamond with features attributed to NV^- (ROI 2&4), NV^0 (ROI 3) and SiV^- (ROI 1) defects; 1(c)(top) shows intensity and (bottom) fluorescence lifetime map of a natural diamond; (d) plot of hyperspectral lifetime data for a single point of interest