Next generation optical widefield magnetic resonance microscopy

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Optical widefield nuclear magnetic resonance microscopy (OMRM) is a novel technique that fuses the spatial resolution of optical microscopy with the chemical specificity of nuclear magnetic resonance (NMR) spectroscopy. By leveraging nitrogen-vacancy (NV) centers in diamond, OMRM bypasses conventional magnetic resonance imaging (MRI) methods that rely on k-space encoding and magnetic field gradients, enabling direct real-space imaging of NMR signals through optically detected magnetic resonance (ODMR). In prior work, we demonstrated the capabilities of this widefield optical NMR microscopy approach by imaging NMR signals within a model microstructure, achieving a spatial resolution of approximately 10 µm over an area of ~235 × 150 µm². Each camera pixel captures a complete NMR spectrum, providing comprehensive information on signal amplitude, phase, local magnetic field strengths, and gradients [1].

Here, we present our current development for our next-generation OMRM platform, which has improved sensitivity, a larger field of view, and enhanced chemical resolution. The microscope has been integrated into a superconducting magnet with an increased magnetic field strength of > 0.4 T. It also integrates a 2.1 mm × 30 µm top-hat light-sheet illumination system and a new high-speed camera with an increased frame rate, enabling enhanced sensitivity and a 2 × 2 mm² field of view in microfluidic environments [2,3]. By combining the advantages of optical imaging with the chemical specificity of NMR [4,5,6], this technology opens up new possibilities for highly parallelized chemical analysis at the microscale. It lays the groundwork for a broad range of applications, including high-throughput NMR analysis and high-resolution magnetic resonance imaging of thin-film materials [1,7].

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