Atomic Microwave Spectrum Analyzer and Near-Field Imager Using Microfabricated Vapor Cells

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Atomic-vapor-cell-based quantum sensors are widely used in atomic clocks, magnetometry, and gyroscopes, and have recently been employed for detecting and imaging high-frequency electromagnetic fields. We present our latest results using microfabricated atomic vapor cells for microwave (MW) sensing, operating in two modalities: frequency spectrum measurement of broadband MW signals and near-field MW field imaging at a single MW frequency.

Our atomic MW spectrum analyzer offers a broad instantaneous bandwidth of 1 GHz and high frequency resolution of 3 MHz, achieved by placing a MEMS cell in a large static magnetic field gradient [1]. We propose an optimized setup with a 25 GHz bandwidth, indicating potentials for future real-time broadband MW spectrum analysis that is currently limited by the bandwidth of electronics.

Our atomic MW near-field imager enables calibration-free and non invasive MW field imaging at variable frequencies. Using frequency domain Rabi spectroscopy, we simultaneously image a MW field at 15 GHz and a 0.5 T static field with a spatial resolution of $50\mu\text{m} \times 50\mu\text{m} \times 200\mu\text{m}$. This work enhances the technological readiness level of quantum MW imagers for MW circuit diagnostics.

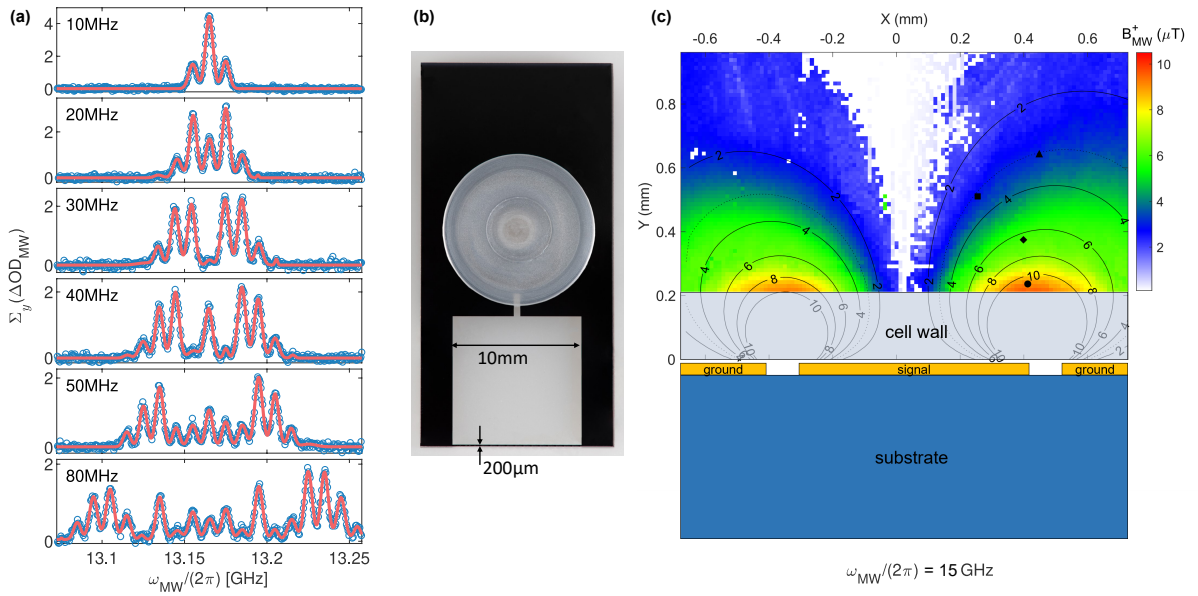

Figure 1. (a) Atomic MW spectrum measurement of frequency-modulated MW signals. (b) One of the MEMS cells. (c) Atomic MW imaging at 15 GHz above a coplanar waveguide.

[1] Y. Shi, T. Ruster, M. Ho, S. Karlen, J. Haesler, and P. Treutlein, arXiv:2403.15155, to appear in Phys. Rev. X (2024).