Microwave field imaging with atomic vapor cells

A. Horsley, R. Mottola, J. Wolters, P. Appel, P. Maletinsky, and P. Treutlein

Department of Physics, University of Basel, Switzerland

Microwave devices and circuits are an essential part of modern communication technology and precision instrumentation, with numerous applications in wireless networks, mobile phones, satellite communication, navigation, radar systems and precision measurement. For the development and testing of microwave devices, a calibrated technique for high-resolution non-perturbative imaging of microwave fields is needed. Microwave detectors with high spatial resolution and low crosstalk are also essential for emerging applications of microwaves in medical imaging [1].

We have developed a novel technique for high-resolution imaging of microwave fields using atoms in miniaturized vapor cells as sensors [2], see Fig. 1. In this technique, the microwave field to be measured drives Rabi oscillations on atomic hyperfine transitions. The oscillations are recorded in a spatially resolved way by absorption imaging with a laser and a camera. From the measured distribution of Rabi frequencies we obtain an image of the microwave field distribution. All vector components of the microwave magnetic field can be imaged and the technique is intrinsically calibrated because the properties of the atomic transitions are precisely known. Using a custom vapor cell with thin walls (see Fig. 1) our technique provides a spatial resolution of < 100 μm [3]. By applying a static magnetic field to tune the hyperfine levels, microwave fields with frequencies ranging from a few GHz to a few tens of GHz can be detected [4]. The experimental apparatus is simple and compact and does not require cryogenics or ultra-high vacuum, making the technique attractive for applications outside the laboratory.

Our imaging method can also be applied to other systems that feature optical and microwave transitions. In a collaboration with the Maletinsky group we have recently implemented our microwave field imaging scheme with high-density layers of nitrogen vacancy centers in diamond [5].

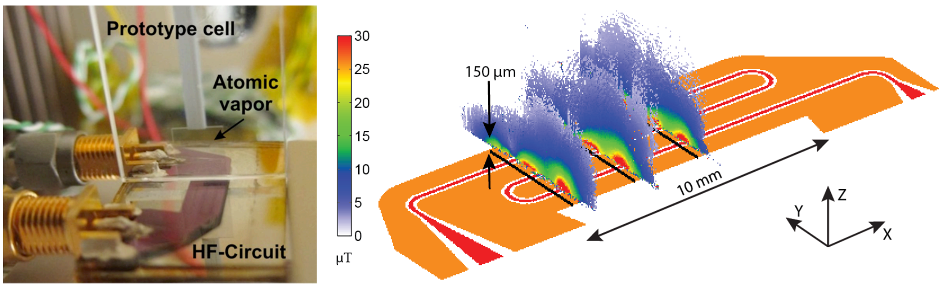

Fig. 1 Left: setup for microwave field imaging with a miniaturized atomic vapour cell. Right: images of the microwave magnetic field, |Bmw|, at several positions above a microwave circuit. The central signal line of the circuit is shown in red, and the ground planes are in orange.

References

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