Non-Destructive Defect Imaging with a Radio-Frequency Optically Pumped Magnetometer

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Non-destructive testing is a cost-effective option for the detection of structural defects, particularly, when there is no direct access to the surface of the studied sample. One method involves monitoring the sample's response (secondary field) to the inductive coupling of an oscillating magnetic field (primary field) [1]. Traditionally this is achieved with a pick-up coil, however, their instrumentation simplicity is outweighed by the degradation of their signal sensitivity at low frequencies. An interesting alternative is the use of an rf optically pumped magnetometer (OPM) [2, 3].
Structural defects can be imaged by recording the amplitude and phase of the OPMs atomic rf excitation spectrum at different points across the sample. We demonstrate the previously undiscussed semi vector nature of this measurement, enabling the 2D reconstruction of the measured secondary field with an unshielded, room temperature rf OPM with a sensitivity of ~50 fT/Hz$^{1/2}$ [3].

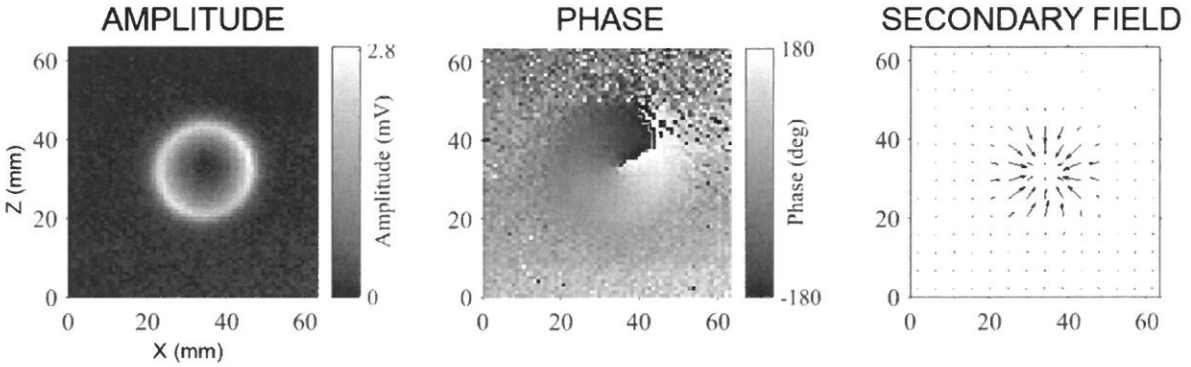

Figure 1 Measured change in the amplitude and phase of the magnetometer signal recorded over a 2.4 mm deep, 24 mm diameter recess in a 6 x 150 x 150 mm^3 Aluminum plate. The measured amplitude and phase represent the magnitude and direction of the secondary field projected on to a 2D plane. Careful selection of this projection axis enables the enhancement of the measured image contrast [3].

References

[1] L. Ma and M. Soleimani, Meas. Sci. Technol., **28**, 072001 (2017).
[2] A. Wickenbrock, et. al., Opt. Lett. **39**, 6367 (2014).
[3] P. Bevington, R. Gartman and W. Chalupczak, J. Appl. Phys. **125**, 094503 (2019);