

# Measuring Magneto-Mechanical Hysteresis during Fatigue Testing using Optically Pumped Magnetometers

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Magnetic and magneto-mechanical testing are commonly used for qualitative characterization of damage in devices [1] and in large test sites [2]. This presentation reports first results obtained with an optically pumped zero-field magnetometer (OPM) in combination with a micro fatigue setup. The small sample volume of about 1 mm<sup>3</sup> allows metallographic characterization of specific material defects occurring during the fatigue process and linking them to features in the magnetic signal.

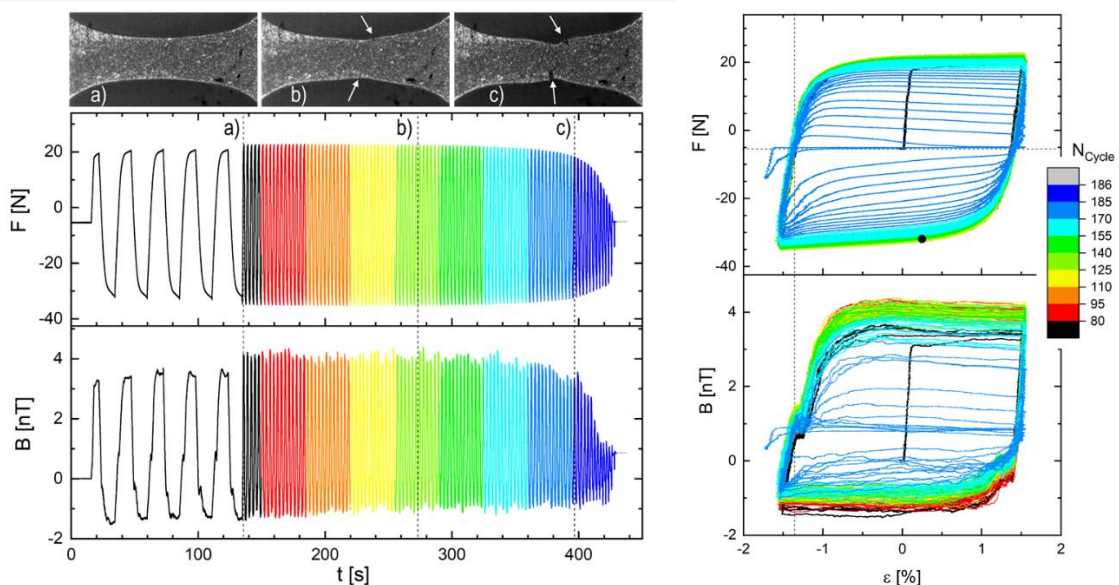


Figure 1: Magneto-mechanical curves from a strain-controlled low-cycle fatigue experiment.

Figure 1 shows magneto-mechanical signals of a low-cycle (LCF) fatigue experiment with a strain amplitude of  $\pm 1.5$  percent and 183 cycles in approximately 430 seconds. On the left, the force  $F$  and the magnetic signal  $B$  are drawn over time  $t$  together with images from the sample together with images from the specimen made from ferritic steel with a length of about 1.5 mm. In the first 280 s, no damage is visible on the sample (a). Afterwards, crack initiation occurs (arrows in b and c) with cracks growing until the sample breaks. On the right,  $F$  and  $B$  are drawn over strain  $\varepsilon$  with the color indicating cycle number  $N_{Cycle}$  in both graphs. The final aim is to derive a quantitative measure for material damage from features like position and height of the Villari reversals in the magneto-mechanical hysteresis curves  $B(\varepsilon)$  on the bottom right.

[1] Wolter, B.; Gabi, Y.; Conrad, C. (2019): Nondestructive Testing with 3MA—An Overview of Principles and Applications. In: Applied Sciences 9 (6), pp. 1068.

[2] Guralnick, S. A.; Bao, S.; Erber, T. (2008): Piezomagnetism and fatigue: II. In: J. Phys. D: Appl. Phys. 41 (11), pp. 115006.