Investigating the influence of applied loads on degrading Mg-10Gd

Birte Hindenlang, Helmholtz-Zentrum hereon GmbH, Imaging and Data Science, Institute for Metallic Biomaterials, birte.hindenlang@hereon.de

Helmholtz-Zentrum hereon

Experiment

Aim

- Degradation of Mg-based implants is influenced by the applied loads
- Due to the applied load stress-corrosion cracking (SCC) can be initiated

Procedure

- Sample is strained until the ultimate failure using different strain rates in air and simulated body fluid (SBF)
- At specific forces, µCT tomograms are acquired showing the degradation and crack evolution in 3D

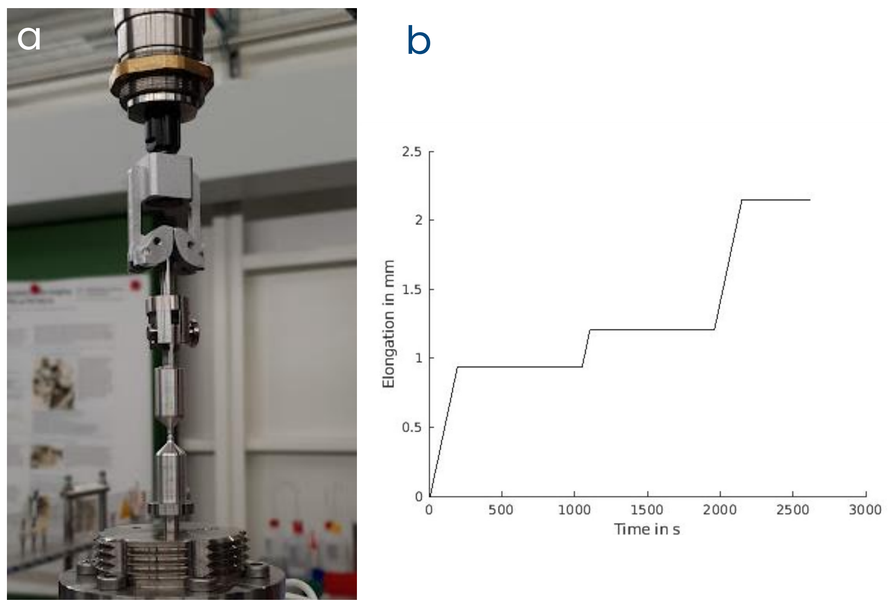

Fig. 1: a) Experimental setup at the P05 beamline at PETRA III, DESY. b) Exemplary straining curve of the samples with the steps indicating the acquisition of a tomogram.

Differences in air and SBF

Air

- Very brittle cracking
- No big differences between the different strain rates

SBF

- Maximum stress needed for fracture significantly lower than for air
- Difference between strain rates regarding maximum stress negligible

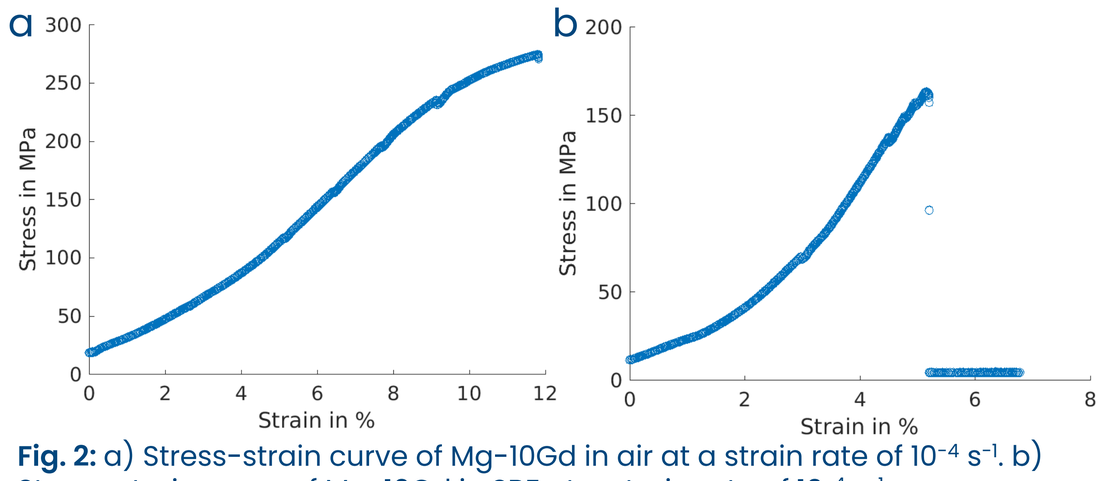

Fig. 2: a) Stress-strain curve of Mg-10Gd in air at a strain rate of 10^{-4} s^{-1}. b) Stress-strain curve of Mg-10Gd in SBF at a strain rate of 10^{-4} s^{-1}.

Failure mechanisms

- High strain rates: no influence of the degradation leading to purely mechanical driven failure
- Intermediate strain rates: degradation is starting while having no big influence on mechanical failure
- Low strain rates: degradation influences failure and SCC is initiated
- Degradation only at locations of highest stress

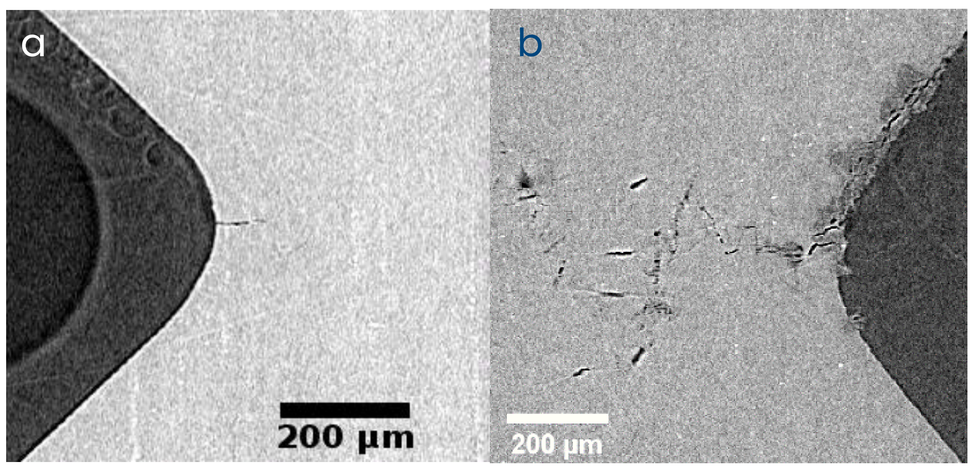

Fig. 2: a) Crack formation in degrading Mg-10Gd at 200 MPa and a strain rate of 5×10^{-4} s^{-1}. b) Cross-section of degrading Mg-10Gd sample at 230 MPa and a strain rate of 10^{-4} s^{-1} showing degradation, mechanical cracking, and SCC.

Conclusions

- Degradation medium decreases strain and stress until fracture
- Changing strain rate leads to equal moment of fracture whereas the failure mechanism changes
- At slow strain rates, SCC leads to fracture of the samples instead of mechanical failure
- Degradation occurs only in regions of highest stress

Helmholtz-Zentrum **Hereon** • Max-Planck-Straße 1 • 21502 Geesthacht I Germany • www.hereon.de
Contact: Birte Hindenlang • T +49 40 8998 5322 • birte.hindenlang@hereon.de