Direct corrosion measurement of Mg-alloys by SRμCT

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The corrosion analysis of materials is an important field in materials science. There exist various classical methods such as immersion or electrochemical tests to determine the corrosion properties of materials. More sophisticated methods are needed for the analysis of local corrosion, especially if shape, depth and volume of a local corrosion site should be determined. Furthermore, the original sample is normally destroyed if the total sample has to be examined.

To evaluate non-destructively the local corrosion and to distinguish between different local corrosion forms a 3D imaging method showing high density resolution and high spatial resolution is needed. A suitable device is synchrotron-radiation based microtomography [1].

To observe corrosion processes in-situ the tomographic set-up at beamline BW2 was modified to allow for a continuous sample rotation. Thus, attenuation images can be obtained from different angles of the continuously rotating main axis over several hours.

The modification of the set-up for tomography at BW2 is shown in Figure 1. The external motor control system was replaced by a new CANBUS motor electronics [2] mounted on the rotation platform. The power supply is based on sliding contacts and the signals are transferred via a Bluetooth connection [3], thus enabling continues rotation.

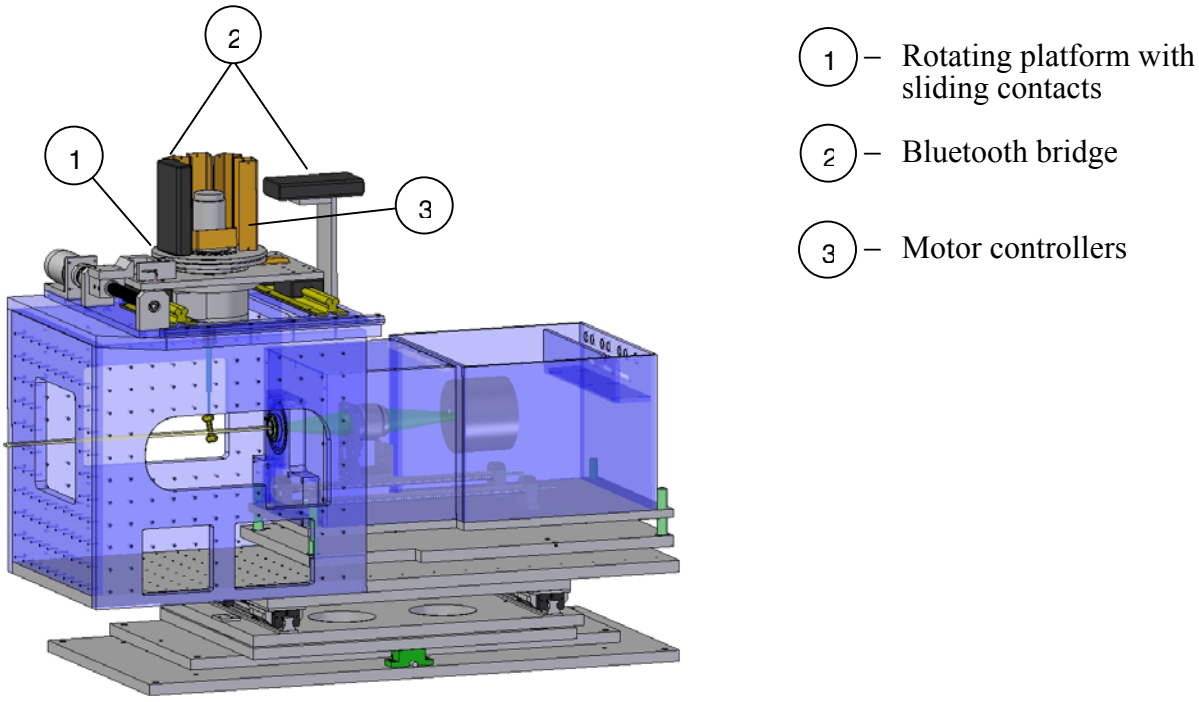

Figure 1: Sketch of modified tomographic set-up for continuous measurements.

To perform in-situ corrosion measurements a liquid cell was built out of a radiation resistant plastic (PEEK). For the corrosive sample environment during the tomographic measurements ocean water with a constantly monitored pH (according to ASTM standard) was used. The corrosive solution in the liquid cell was constantly exchanged by a peristaltic pump from a temperature monitored reservoir of two litres.

As a sample for in-situ corrosion measurements a cylindrical Mg-Apatite sample was immersed in the liquid cell and attenuation images were acquired during a period of 27 hours. Every 30 minutes a new tomographical scan was taken.

To speed up the data transfer from the CCD the tomographical scan was set to double binning of the image data. Furthermore, the normally used step-size of 0.25° rotation angle was increased to 0.5°. Thus, the overall time for a tomographical scan decreased from 2 hours to 30 minutes.

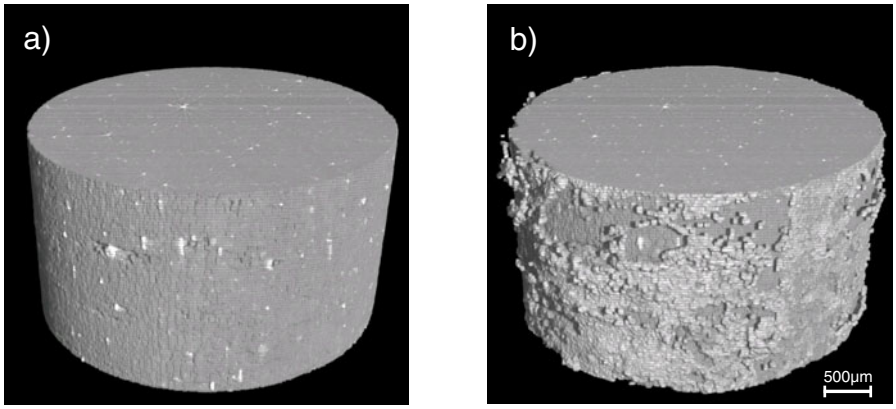

Figure 2: (a) Three-dimensional reconstruction of Mg-Apatite before corrosion.
(b) Three-dimensional reconstruction of the same sample after 27 hours. The pitting-corrosion is clearly visible.

With this method of investigation the local corrosion processes can be studied time-resolved and non-destructively in three dimensions. The corrosion parameters of many corrosive materials can be determined in this way.

References

[1] F. Witte, J. Fischer, J. Nellesen, H A. Crostack, V. Kaese, A. Pisch, F. Beckmann, H. Windhagen, Biomaterials (in press)
[2] CAN-STEPCON-1H, ESD Electronics, Hannover, www.esd-electronics.com
[3] CAN-BLUETOOTH, ESD Electronics, Hannover, www.esd-electronics.com