ESRF	**Experiment title:** **Creep damage of Magnesium based Metal Matrix Composites**	**Experiment number**: MA-749
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Report:

For automotive, aerospace and other industrial applications materials are needed which combine less weight, durability, ductility, thermal conductivity, and machinability with mechanical resistance, low thermal expansion, form stability and heat resistance at elevated temperatures. These requirements are achieved by hybrid materials combining lightweight metallic materials reinforced with non-metallic materials, such as ceramic particles and/ or fibres (short/ long). Lightweight Metal Matrix Composites (MMC's) show better high-temperature strength compared to their respective unreinforced matrix materials. Therefore lightweight MMC's are especially interesting for creep applications at constant elevated temperatures (T>0,3*Tm, Tm-melting temperature) and constant mechanical load.

In-situ tomography during creep gives a three dimensional insight into the ceramic reinforcement distribution, eventually their cracking and delamination from the metallic matrix, as well as into the pore formation and development, especially the location, volume fraction and morphology as a function of time. The creep behavior of Magnesium (AE42) based lightweight MMC's with randomly oriented and distributed hybrid reinforcement consisting of 10% Saffil (δ-Al_2O_3) short fibre and 10% SiC-particles was studied. Different temperature and load regimes were investigated.

Miniature creep samples of the MMC AE42+10% $(Saffil)_f$+ 10% $(SiC)_p$ fitting into a miniature creep device exhibiting a gauge volume of appr. 1mm³ were used for the tensile creep experiment.

The FReLoN tomography CCD-camera featuring a 2048*2048 pixel CCD-chip was used. The resolution was 0.56*0.56µm/ pixel. The distance sample to detector was 40mm. A "pink beam" exhibiting a high photon flux was used. During the rotation of the sample station about 180° 1500 radiographs were taken with an exposure time of 0.1s each resulting in a total measuring time of appr. 6 min for one tomogram. The field of view was 1.2*1.2 mm².

Alltogether ten samples at two fixed temperatures (T_1=543K and T_2=573K) and five fixed loads (σ=35, 40, 45, 50 and 60MPa) were measured. Six samples fractured during the beamtime.

Fig. 1 shows the creep curve of sample 5 (T=573K, σ=40MPa) which is representative for all investigated samples. All samples exhibited a long secondary creep stage and a short tertiary creep stage independent from the respective temperature-load-regime. The strain of the sample is nearly 10% and the whole creep time was t_{creep}=511min.

Fig. 2 shows 2D longitudinal cuts at φ=0° and φ=90° of the tomogram of the sample 5 (T=573K, σ=40MPa) at the initial state and the last tomogram before fracture at t_{creep}=505min. The comparison of longitudinal cuts at φ=0° and φ=90° illustrates the planar distribution of the short fibre reinforcement. In the initial state small pores located at reinforcement agglomeration caused by the manufacturing process can be detected. Only few cracks in the fibre reinforcement were found. By comparing the longitudinal cuts of the initial state and the last tomogram before fracture the growth of pores and presence of cracks in the matrix (Fig. 2b, black arrows, Fig. 3a, black arrows) and the increasing number of cracks of the short fibre reinforcement were observed (Fig. 3b and 3c, white arrows). Delamination of the reinforcements were detected, too (Fig. 3d, white arrows). Further evaluations of the experimental data in view of the quantitative analyses of the time dependent reinforcement delaminations, pore evolutions and crack formations are still under way.

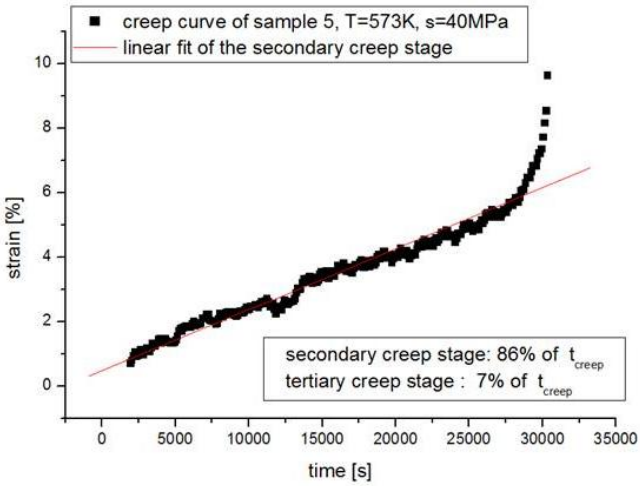

Fig. 1 creep curve of sample 5, T=573K, σ=40MPa

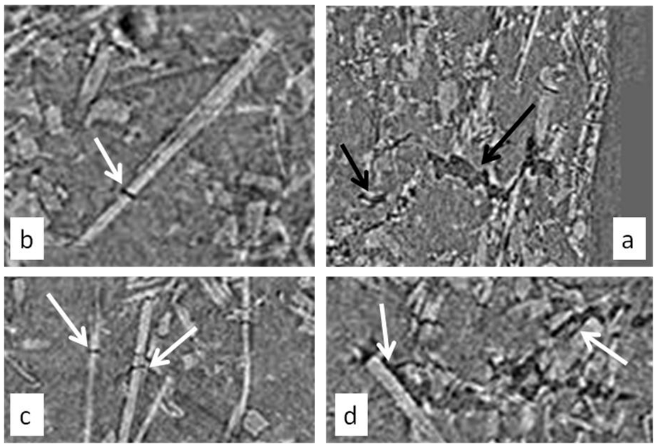

Fig. 3 sample 5, T=573K, σ=40MPa, t_{creep}=505min
a) cracks and pores in the matrix, b,c) cracks in the fibre reinforcement,
d) delamination of reinforcements

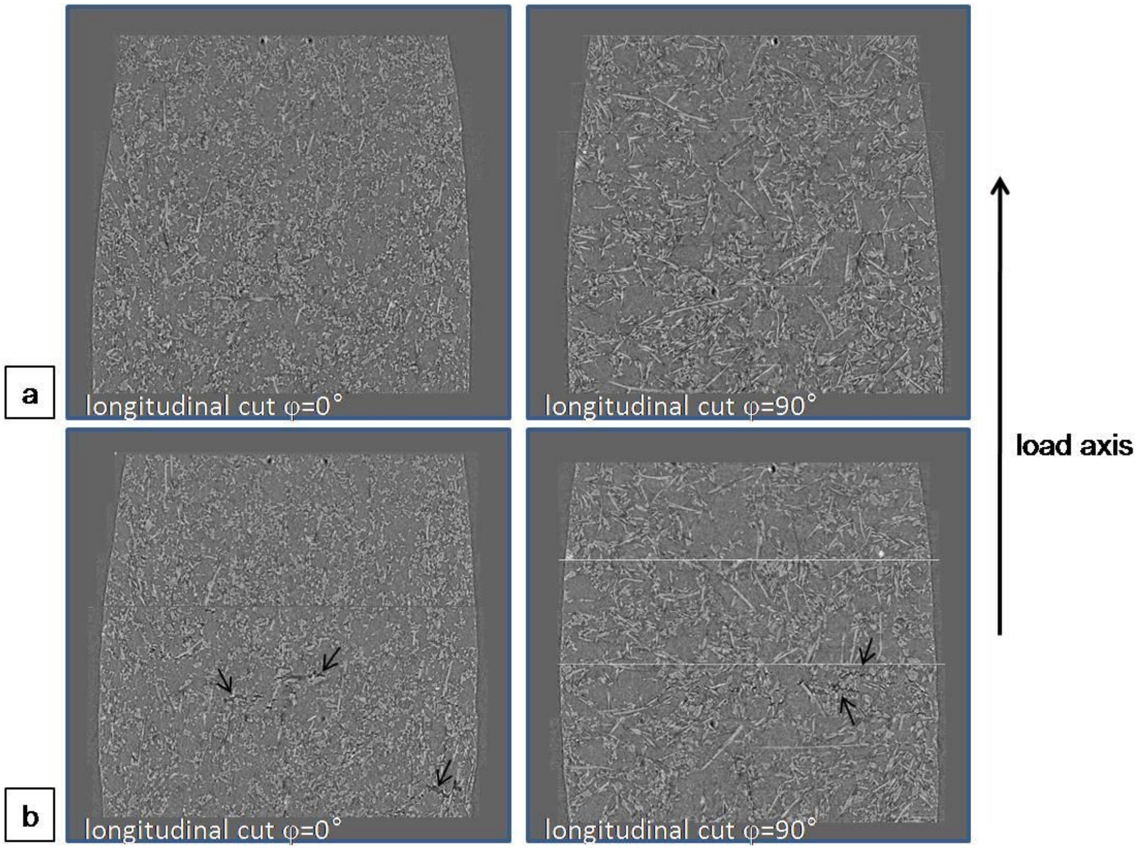

Fig. 2 sample 5, T=573K, σ=40MPa, a) initial state
b) last tomogram before fracture at tcreep= 505min