Automated crack advancement detection for small scale fracture experiments

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Accurate knowledge of the current crack length is crucial for the evaluation of fracture mechanical tests. Macroscopically, this is achieved by well-established methods, e.g. the potential drop method, partial unloading technique or optical crack length observations. At the micron to sub-micron regime, such experiments are frequently performed in electron microscopes. There, the crack length is accessible via continuous stiffness measurements and/or image-based observations. The latter requires a high image acquisition rate to visualize crack growth. Digital image correlation, which is a standard method for image-based evaluation, can be hardly applied to in-situ crack growth experiments, as this technique requires a distinctly patterned surface. Hence, images are usually evaluated manually, which is a tedious and user-dependent task.

In this work, we performed miniaturized in situ fracture experiments on focused ion beam fabricated TiAl alloys within a scanning electron microscope using a Hysitron PI 85 nanoindenter equipped with a continuous stiffness measurement module. Image processing techniques are subsequently utilized in order to introduce a semi-automatic procedure to measure the crack extension and improve the crucial step of crack growth measurement. The semi-automatic procedure searches for contour lines around the previous crack shape and locates the new crack tip according to the position on the previous frame. The crack length results obtained by the semi-automatic procedure agree well with the manual assessment as well as the crack length determination using the continuous stiffness data. Thus, our semi-automatic procedure enables the investigation of small-scale fracture processes in more detail, as a more data can be analysed user-independent, which in particular benefits detection of slight crack growth events.