ESRF	**Experiment title:** ***In situ* studies of dendritic growth and fragmentation in Ga - In alloys**	**Experiment number**: MA 3490
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Report:

The coarsening of dendritic structures plays an important role in formation of the finally solidified microstructure of metal alloys. It typically proceeds by three mechanisms: (i) retraction of small side-arms towards their parent stem, (ii) pinch-off or detachment of sidebranches at the narrow neck with the parent stem, and (iii) coalescence of neighboring side-arms. In the present experiment we focused on the essential dynamics of the dendrite sidearm development.

Radiography as a 2D imaging method provides dynamical data of high time and spatial resolution at a low noise level. However, 2D radiography data are not enough for verification of the existing 3D microstructural models. Tomography, unfortunately still with a much lower time resolution, allows us to obtain 3D spatial information about the morphology and to get very accurate 3D images about the evolution of the dendritic sidearm structure itself.

A tomography/ radiography experiment during the alloy solidification process was carried out using a solidification setup tested at HZDR [1, 2]. The nominal composition of the Ga–35 wt. % In alloy was prepared from 99.99% Ga and 99.99% In. The alloy was melted and filled into a windowed Hele-Shaw cell with a liquid metal volume of $23 \times 23 \times 0.15$ mm^3 and into capillary samples (diameter ~ 1 mm). The sample was first cooled down to 20 °C at a cooling rate of 0.01 K/s. Then, cooling was stopped, leading into an isothermal stage that was maintained over a period of 4 – 6 hours at a constant temperature of 20 °C. During the experiment, a monochromatic beam (40 keV, radiography) or a pink beam (energy of ~ 40 keV, tomography) were used to penetrate the sample, and a high speed CCD camera (PCO Edge) was used to record the images.

During an isothermal holding phase, the side-branch structure coarsens continually, resulting in an increase of the secondary dendrite arm spacing and diameter of the primary trunks. The solid fraction obtained from 3D analysis is approximately 0.15 for 35 wt% In composition. The three-dimensional observation of the evolution of a dendrite arms shows several coarsening mechanisms (Figure 1). The experimental data are promising to quantify morphological transitions such as retraction, coalescence and pinch-off of the sidearms. Quantitative analysis and image processing are still in progress.

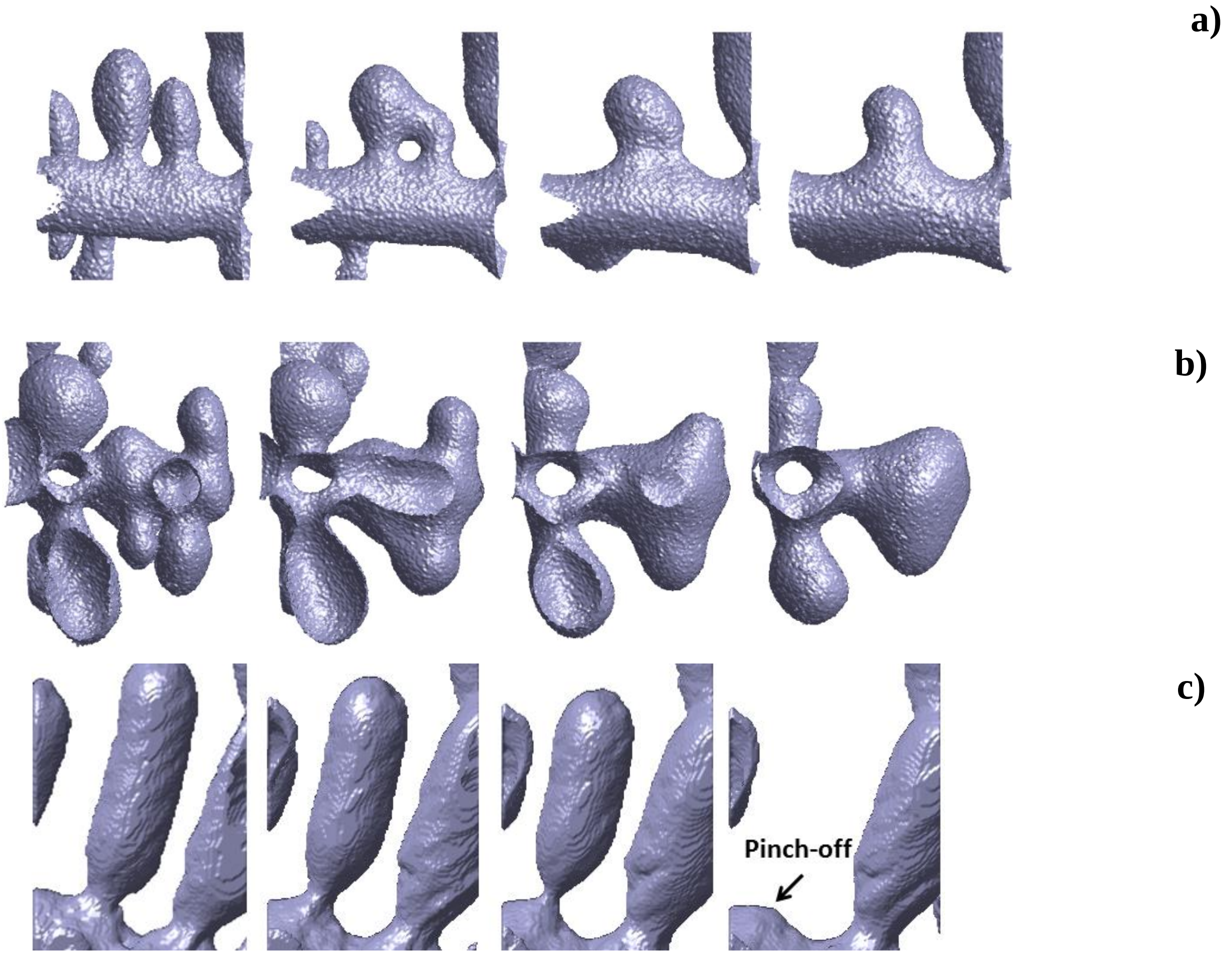

Fig. 1: Three-dimensional observation of the evolution of a dendrite arms with isothermal holding time: (a) coalescence of two adjacent sidearms; (b) coalescence and retraction of several arms; (c) pinch-off of the sidearm (the arrow shows position of the detached arm). Tomography data processing was done by Dr. D. Hoppe, HZDR.

Recently we showed [3] that synchrotron radiography of a thin sample is a highly suitable experimental technique for studying the interface dynamics of dendritic structures in metallic alloys. The measured evolution of the dendrite sidearm shape is found to agree very well with the predictions from a relatively simple axisymmetric numerical model [4]. This is true for not only the neck diameter but also for the sidearm tip retraction rate and other geometrical features. Hence, the synchrotron radiography experiment provides conclusive validation of the numerical model [3].

This experiment is the first step towards the validation of a more realistic 3D pinching model providing statistically relevant 3D experimental data of the evolution of individual sidearms.

References

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