ESRF	**Experiment title:** Investigation of the foaming process and material distribution in metal foams	**Experiment number:** ME-41
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Report:

The Fraunhofer IFAM developed one of the most promising routes to produce metallic foams. A precursor material consisting of a metal powder mixed with a blowing agent is compacted and subsequently heated up. The blowing agent releases gas and pores form up in the liquid metal.

The experiment ME-41 was proposed in order to investigate the foaming process in metallic foams and their resulting microstructure. This has been done by two complementary experiment methods:

1. High-resolution microtomography for the determination of the microstructure of readily produced metallic foams.
2. In-situ real-time radiography for the tracking of the foaming process.

During the successful measurements carried out in March 2000 different sample materials have been examined by the two experimental methods: AlSi7 and the commercially widely employed alloy Al6061 with TiH_2 as blowing agent and Zn with ZrH_2 as blowing agent. The foaming process has been investigated for free foaming without any spatial restriction and uniaxial foaming in a mould and for different heights and widths of the samples.

For in-situ radiography, we built a high-temperature furnace with highly-polished aluminium windows, which has been integrated into the beam line in order to heat the samples. It proved to be well adapted to the experimental needs. The automatized, more accurate temperature reading at the sample location will be improved in the future experiment.

First it was possible to track the formation of cracks and ist transformation into pore structures (in projection) of the evolving foam. Fig. 1 shows radiographs which were recorded in real time (in-situ) during foaming of an aluminium foam sandwich structure, i.e. an aluminium foam (low melting AlSi7 alloy) with two dense aluminium face sheets (higher melting wrought alloy). The core layer is essentially a densified mixture of AlSi7 powder with titaniumhydride powder which acts as the blowing agent when the material is heated to its melting point. Upon heating the core layer melts and develops its cellular structure while maintaining its melting temperature for some time. The higher melting face sheets therefore remain solid for some time (1st to 3rd frame). However, if the expanded sandwich is not cooled down after reaching its maximum expansion (3rd frame), further increasing temperatures melt the face sheets and finally lead to a destruction of the foam (4th and 5th frame). It is interesting to note that the foamable precursor material had a crack-like defect in the example shown which, however, dissapeared after foaming. For the first time it was possible to observe details of the foam evolution. The radioscopic method is therefore very useful in detecting details of the foaming process which are normally obscured.

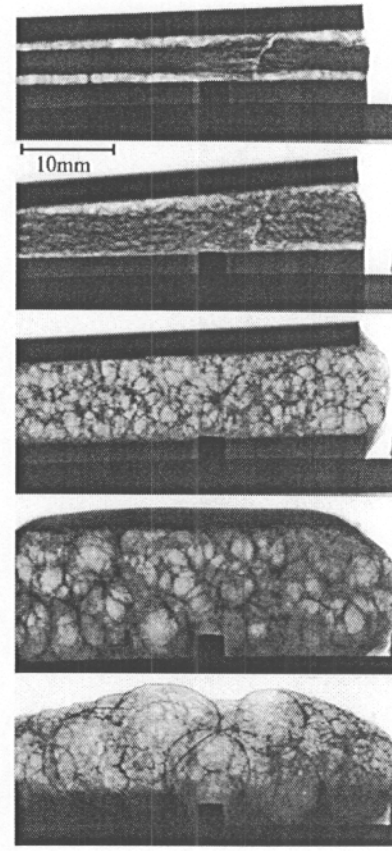

Figure 1: Five stages in the evolution of a foaming metal, from top to bottom: appearance of cracks, formation of round pores, melting of the cover sheets, drainage up to the collapse of the foam's structure. X-ray energy was 30 keV.

As shown in fig.2, by taking difference images between two succeeding frames, cell ruptures could be emphasized. In this way the central question of coalescence process can be evaluated.

For tomography, a resolution of about 6.5 μm was used in order to resolve the features within the cell walls and to get a picture of pore morphology. However, the measurements in ME-41 revealed the unexpected perspective to determine for the first time additionally very precisely the spatial distribution of the blowing agent in the foams. Concerning two possible models of pore nucleation, from our experimental results could be concluded, that one model for might be wrong.

The continuation of this proposal shall further clarify that fact and verify an alternative model. Beside others, measurements employing a detector with a pixel size of 2 μm for tomographic scans would allow us to investigate especially the inhomogeneous surroundings of blowing agent particles.

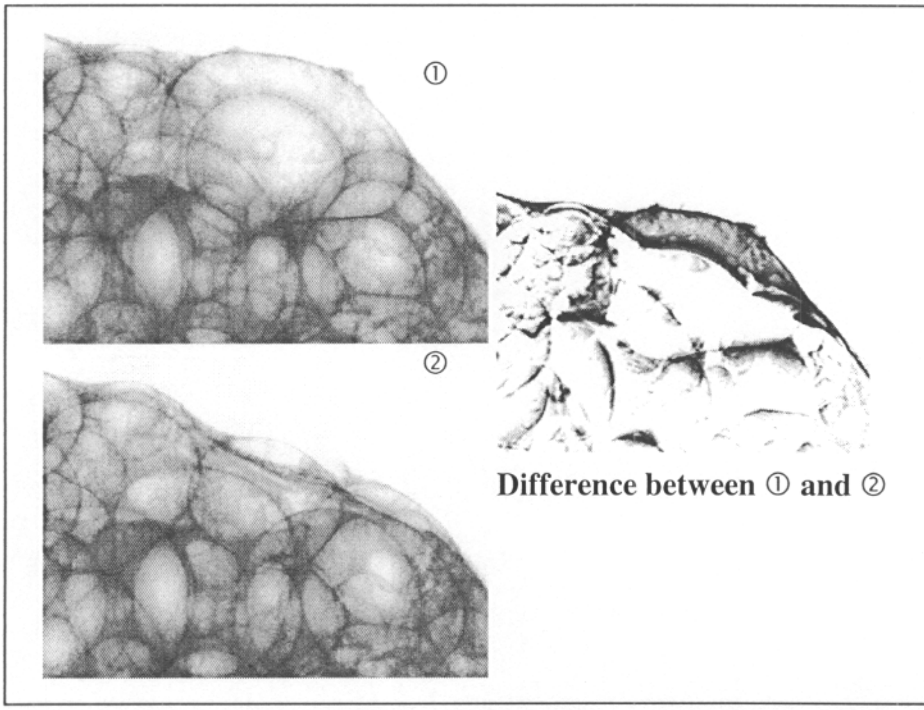

Figure 2: An example for cell rupture monitored with real-time radiography. X-ray energy: 30 keV

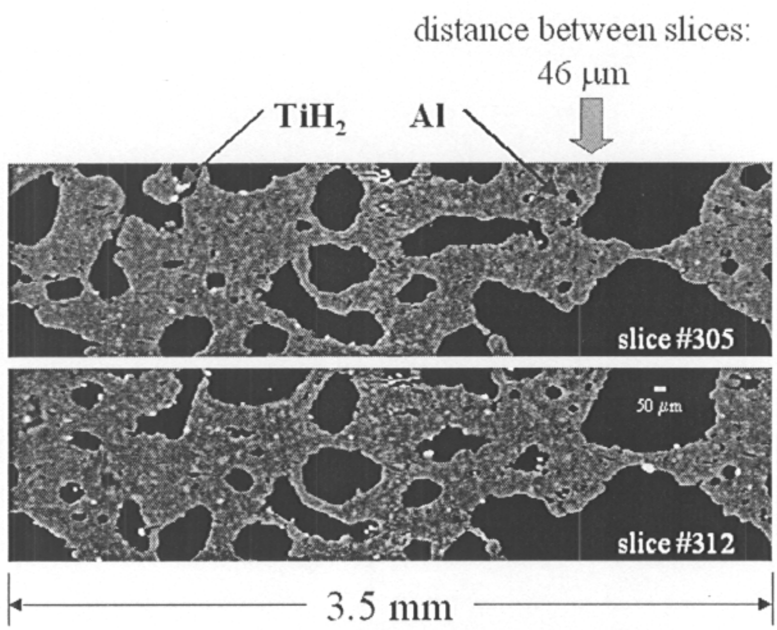

Fig. 2: two microtomographic slices of a 6061 alloy foam. White colour indicates TiH_2 particles, gray is Al, black are pores.