Fracture Behavior of Metal Foam Made of Recycled MMC by the Melt Route

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Metal foam was made from recycled MMC precursor by the melt route. The original starting material was an Al-9Si alloy containing 20 vol% of SiC particles (10 μm), which are used to stabilize the foam during the foaming process. The starting material has been used to make foam parts from which the residue was recycled and refoamed. During the (re)foaming process Fe is present in the melt. During solidification of the foam, β-AlSiFe plates are formed with the surplus of Si and Al present in the alloy. These plates run through the entire thickness of the cell wall (40-50 pm) and their length ranges between 50 and 200 μm. During *in-situ* tensile tests fracture initiates in the β-AlFeSi plates and propagates through other β-AlFeSi plates leading to brittle fracture of the cell walls.

Keywords: *metal foam, processing, precipitation, AlFeSi, mechanical properlies. fracture. microstructure*

1. Introduction

The quality of aluminum foam made by the melt route has increased considerably over the last few years[1,2]. The number of imperfections, such as missing and buckled cell walls, have decreased resulting in stiffer and stronger foams (see fig. I). However, next to the cellular structure also the microstructure of the aluminum has a high influence on the fracture behavior of the aluminum foam, as shown in references 3 and 4. The objective of this study is to look at the fracture behavior of metal foam, made from recycled MMC by the melt route. We study crack initiation and propagation in cell walls under tensile stress and relate this to the microstructure of the foam. This information will contribute to improved manufacturing procedures to make tougher foams with an enhanced ability of recycling of the MMC melt. The paper is organized as follows. In the following section the material is described and the experimental procedures are explained. In the subsequent section the experimental observations are reported; first the microstructure is thoroughly investigated and described, followed by the results on the fracture behavior from the tensile tests.

2. Material and Experimental Procedures

2.1 Material and foaming procedure

The material of investigation is Duralcan metal matrix composite (MMC). The MMC has a cast Al-9Si aluminum alloy matrix reinforced by 20 vol% SiC particles with a mean particle size of 10 pm. The original composition of the raw materials is listed in Table 1. The MMC first was processed into foam parts, then these foams were remelted and this melt was refoamed. The foam was produced in both cases by gas injection into a melt in an adiabatic furnace. Air was used as foaming gas. Due to a special foam generator the bubble formation was well controlled. The gas bubbles could float towards the melt surface where liquid-aluminum foam is generated. The foaming temperature was kept around 700°C (above liquidus). The thickness of the cell wall is about 40-50 μm and the diameters of the pores are about 5-7 mm. The density is 0.11 g/cm^3, meaning a relative density of 4.0 % compared to pure aluminum (2.7 g/cm^3).

2.2 Experimental equipment and procedures

A Philips/FEI XL30-FEG environmental scanning electron microscope (ESEM) was used for the characterization of the microstructure of the aluminum foam as well as for the in-situ tensile tests. To investigate grain orientations using Orientation lmaging Microscopy (OIM) an electron backscatter detector is attached to an XL30S FEG-SEM, both SEMs are equipped with detectors for energy-dispersive X-ray spectroscopy (EDS). A tensile stage made by Kamrath&Weiss was used for the in-situ SEM tensile tests. During the in-situ tensile tests the image of the SEM was recorded on video to see the exact point of crack initiation and secondary electron (SE) images as well as backscatter-electron (BSE) images of the cell walls are taken before and after the tensile test. The displacement rate for in-situ tensile tests is 300 μm/min and the maximum dimensions of the foam test

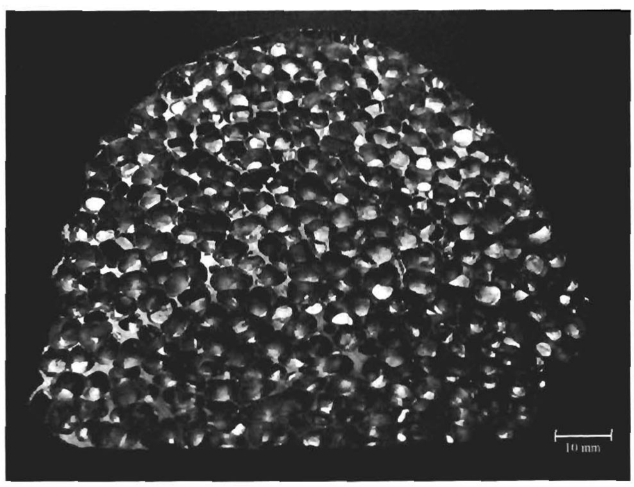

Fig. 1 Macrostructure of the metal foam made by the melt route