COMPOSITE BASED ON AlMg ALLOYS OBTAINED BY GAS INSUFFLATION

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ABSTRACT

Composite materials are the most advanced class of materials invented and produced by humans in modern times as well as a challenge for the future in the field of scientific and technological performance. They are made up of at least two phases of different nature which are so combined to form a new material with a superior combination of properties. They are generally materials with unusual performances on the relationship between properties and specific gravity. Composites are multiphase materials with distinct and well-defined interface between the constituent phases ensuring a transfer of property but can lead to obtaining a product with exceptional performance from the starting material. Stabilized Aluminum Foams (SAF) are new class of materials with low densities and novel physical, mechanical, thermal, electrical and acoustic properties. They offer potential for lightweight structures, for energy absorption, and for thermal management; and some of them, at least, are cheap. Metal foams offer significant performance gains in light, stiff structures, for the efficient absorption of energy, for thermal management and perhaps for acoustic control and other, more specialized, applications. They are recyclable and nontoxic. They hold particular promise for market penetration in applications in which several of these features are exploited simultaneously. Metal foams are metal matrix composites (MMC) characterized by: higher specific properties, high capacity vibration damping and sound, mechanical energy absorption etc. The wide range of possible properties can lead to innovative applications, which is a strong driving force for the improvement of metal foam production technologies. Investigated and studied materials are composite of aluminum alloy matrix where the stabilisation of the gas bubbles has been done by ceramic particle added. To obtain SAF we have focused research on Al-Mg alloys with different concentrations of magnesium and silicon carbide (SiC). To obtain these materials has been chosen a different gas blowing method (N_2, SO_2 şi C_4H_{10}). It was observed that the best results in terms of pore volume gave the blowing with C_4H_{10}. The samples obtained were analyzed by electron microscopy.

KEYWORDS: AlMg alloys, gas insufflations, metal foams, stabilized aluminum foams (SAF), porous metals, cellular materials

1. Introduction

Metal foam or metallic foam has become a very popular term which is nowadays used for almost any kind of metallic material which contains voids. It might be useful to distinguish various expressions:

- cellular metal: space is divided into distinct cells. The boundaries of these cells are made of solid metal, the interior are voids. Ideally, the individual cells are all separated from each other by metal but often this restriction is relaxed.

- porous metal: the metal contains a multitude of pores, curved gas voids with a smooth surface.

- metal(lic) foam: foams are special cases of porous metals. A solid foam originates from a liquid foam in which gas bubbles are finely dispersed in a liquid.

- metal sponge: space is filled by pieces of metal that form a continuous network and co-exist with a network of empty space which is also interconnected [1].

Aluminum foams are a new class of materials with low densities, large specific surface and novel physical and mechanical properties. Their applications are extremely varied: for light weight structural components, for filters and electrodes and for shock or sound absorbing products. Recently, interesting foaming technology developments have proposed metallic foams as a valid commercial chance; foam manufacturing techniques include solid, liquid or vapor state methods. The foams presented in this study are produced by Melt Gas Injection (MGI) process starting from melt aluminum [2, 3].

There are a lot of applications of metallic foams, but most of them are in the automotive, aircraft and building industries, in which the SAF manufacturers have the objective to achieve a market penetration that will bring stabilized aluminum foam to where magnesium is today (e.g. light weight structures, sandwich cores, strain isolation (compression), mechanical damping, biomedical industry, acoustic absorption, acoustic control, kinetic energy absorbers (compressive), blast resistance, storage and transfer of liquids, fluid flow control, heat exchangers/refrigerators, thermal isolation, electrical shielding, electrodes and catalyst carriers, electrode material, spargers, sporting equipment, decoration and arts [4].

2. Experimental procedure

The injected air causes bubbles to rise to the surface of the melt, forming liquid foam which is stabilized by the presence of solid ceramic particles on the gas liquid interfaces of the cell walls. The stabilized liquid foam is then mechanically conveyed off the surface of the melt and allowed to cool to form a solid slab of aluminum foam. The aluminum foam structure (cell size and cell wall thickness) is controlled by the process variables such as the volume fraction of the solid particles; foaming temperature, airflow rate, and impeller design the foam making process. Unfortunately, no publication has been found in the work on the influence of the process in variables on the cell structure of aluminum foam. In the future we will study and investigate the effect of the concentration of SiC particles on the cell structure and mechanical properties.

The experimental equipment consists of an electric resistance furnace (maximum heating temperature 800 ºC), which was adapted for insufflations gas (C_4H_{10}) It is also equipped with a wide agitator and a trough acquisition of foam formed (Figure 1). Has been obtained metal foam by mixing the alloy melt AlMg10 with 20% SiC powder 120μm size, at a temperature of 710 ºC and with C_4H_{10} injection at 1.2 atm pressure. The obtained foam was analyzed by electron microscopy.

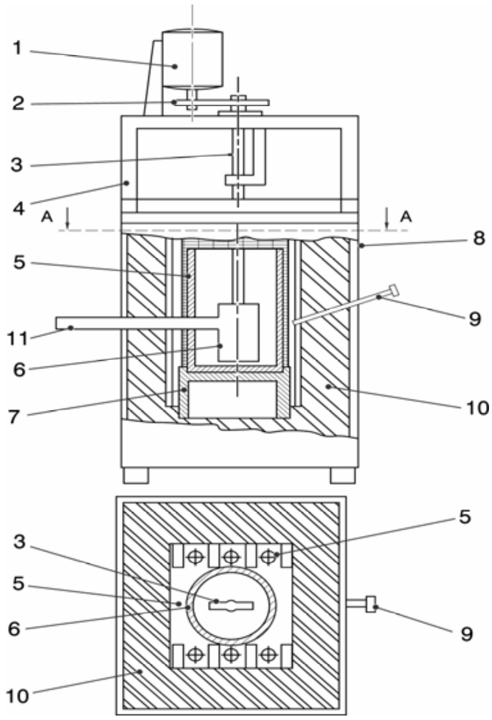

Fig. 1. *Electric resistance furnace. 1 – engine, 2 – reductor, 3 – port rod paddle, 4 – metal frame, 5 – crucible, 6 – paddle, 7 - crucible support, 8 – silica bars, 9 – thermocouple, 10 – refractory shield, 11 – collecting gutter foam [5]*

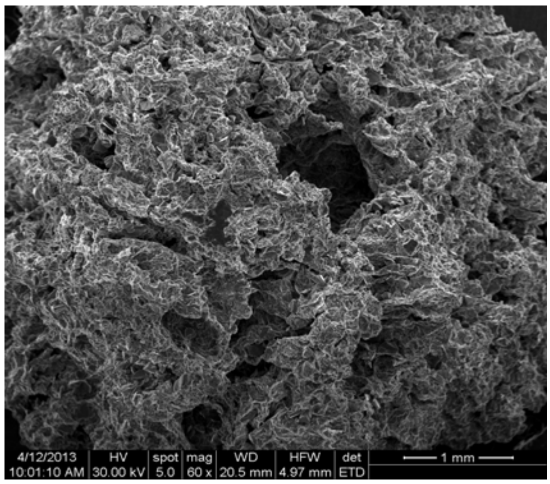

Fig. 2. *Analysis by scanning electron microscopy SEM to highlight the overall appearance of the overall composition and the morphology of the constituents and distribution of the pores in the matrix of the composite. It is noted that the pores are imbued each other and also appear ligament bridges porous*

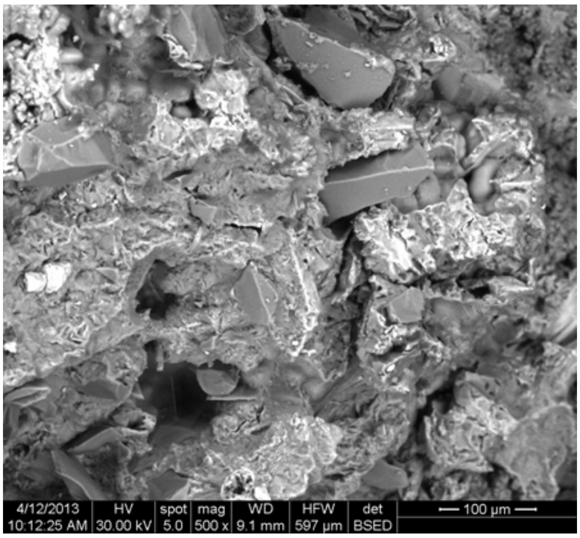

Fig. 3. *SEM image highlighting the distribution and morphology of carbides and the porosity that was formed in the composite structure. Are shown a variety of hydrocarbons as well as pores which have dimensions of the order of 50 µm which are distributed throughout the mass of the composite. X 500*

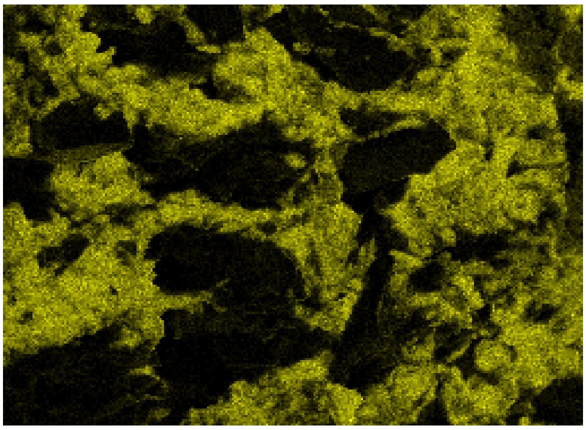

Fig. 5. *EDX qualitative analysis to highlight the detail of the map matrix aluminum alloy. We are identified spherulites on the basis of aluminum oxide, and the network of pores was also developed around the carbides of silicon*

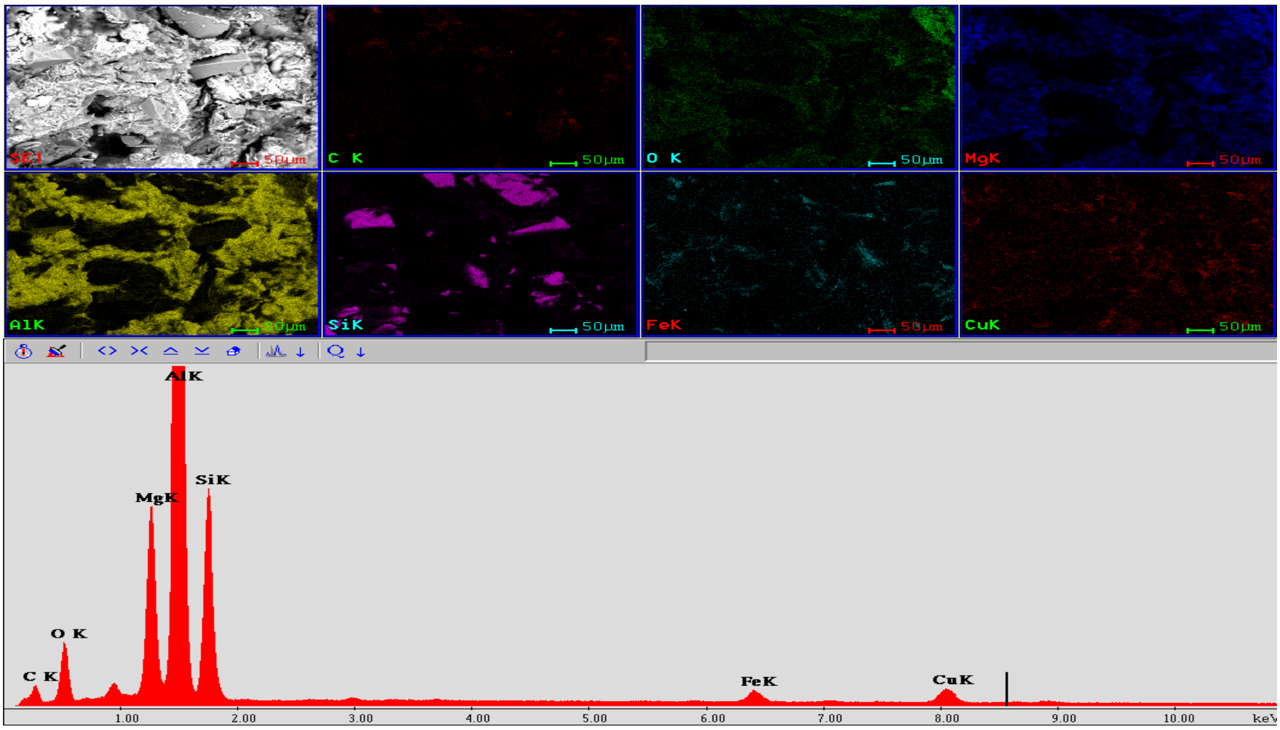

Fig. 4. *Analysis by electron diffraction EDX with SEI images distribution maps that highlight the main constituents of the composite. The colors are chosen in order to differentiate the distribution of the constituents on the basis of: Al, Si, Fe, Cu, Mg, O and C*

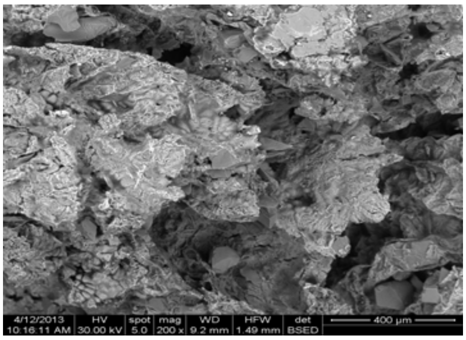

Fig. 6. *SEM image shown the porous internal structure of walls ligaments and inclusions (catches) of silicon carbide in these areas. X 200*

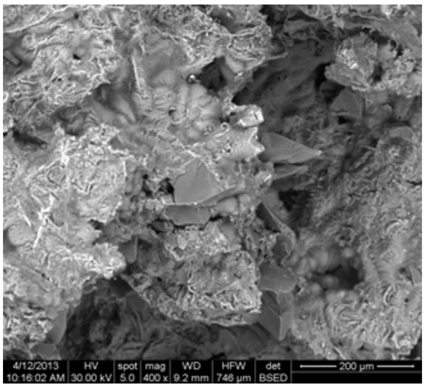

Fig. 7. *It is observed at the same time the intercommunicated area between pores. Detail of the previous image that highlights how silicon carbonates are embedded on the walls of ligaments. X 400*

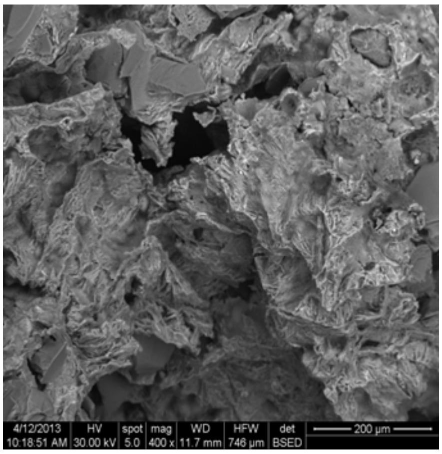

Fig. 8. *Detail of the surface morphology of cavities that can be found in the matrix composite. It is noted the "sponge" structure of the matrix and a plurality of multifilament growth (formation resulting from the segregation of the AlMgSi compounds which appeared to solidify the matrix) in preference to the surface of the mold cavity solidification*

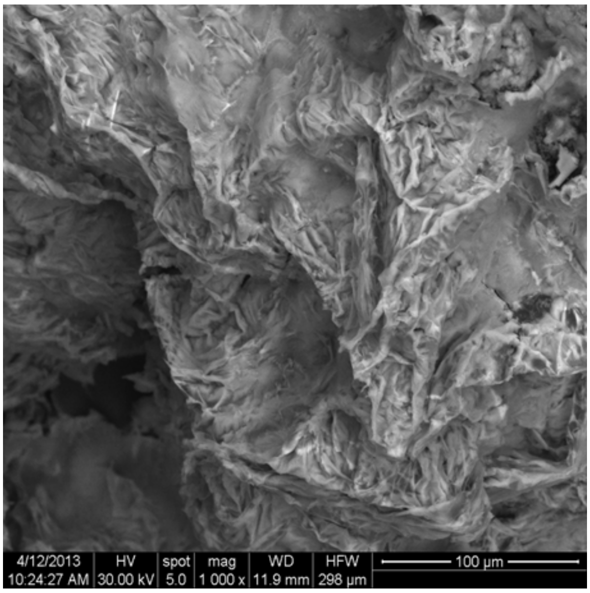

Fig. 9. *Analysis of the structure and morphology of a part of the cells formed shows that they have spongiosal consistency, and partially with micro-lamellar appearance or foil. This result we believe that emerged as a result of penetration modeling gas (butane) that we put in the whole mass of the composite before solidification. X 1000*

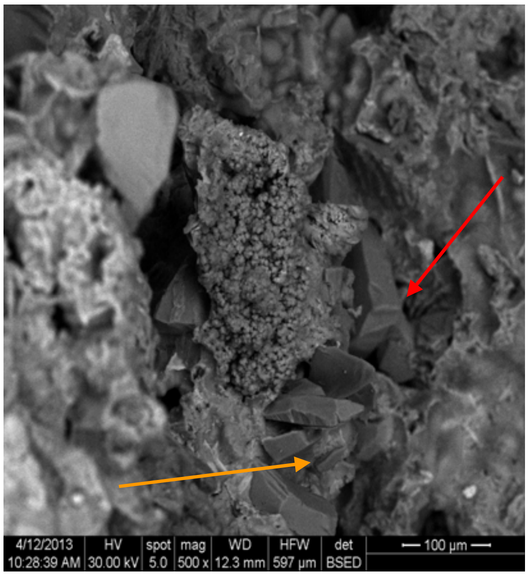

Fig. 10. *The butane gas concentration area and near the concentrations of silicon carbide (as marking) following the non-homogeneous gas bubbling can be formed in the matrix of the composite tinted conglomerate and some conglomerates of cluster-like structure (cluster structure). This cluster morphology can be observed in the SEM image shown in the center. X 500*

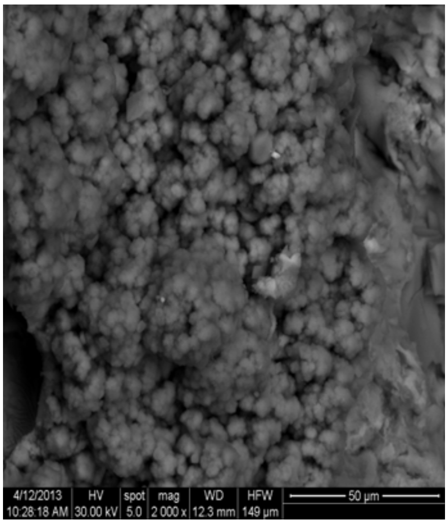

Fig. 11. *Detail of morphology development and solidification zones in the cluster. It point out that high degree of porosity exists in the solidification morphologies that are found in areas with clusters of carbides. X 2000*

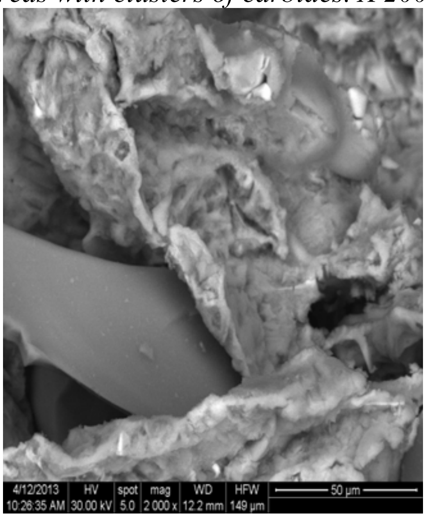

Fig. 12. *SEM image which shows the way solidification of the matrix alloy in the vicinity of the silicon carbide particles. At the interface it is found that there is a strong segregation of the alloy matrix, there is no adhesion between the matrix and the contact carbide. It is possible that butane bubbling it have leaked carbide particle surface, thus increasing trend of detachment from the matrix and carbides significantly increased the porosity of the composite. X 2000*

3. Conclusions

The laboratory equipment allowed us to obtain a metal foam by mixing the alloy melt AlMg10 with 20% SiC powder 120µm size. We used an injection of butane at 1.2atm pressure and 710ºC melt temperature.

In the metal foam microstructure obtained is observed that a network of pores penetrated it with ligaments porous bridges between them, developed around silicon carbide. Pore size is over 50µm.

Multifilament increases resulting in segregation of the AlMgSi compounds that have occurred in the solidification of the matrix, mainly on the surface of the mold cavity solidification.

We have observed the silicon carbide based on spherulites of aluminum oxide.

The formed cells, besides the spongiosal consistency, have a partial aspect or micro-laminated foil, gas ingress occurred as a result of modeling.

The gas it was observed at the interface in the absence of adhesion between matrix and silicon carbide, apparently due to "flow" surface carbides butane.

Acknowledgement

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