Chapter 15
Characterization and Spectroscopic Applications of Metal Foams From New Lightweight Materials

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ABSTRACT

Lightweight materials such as metallic foams possess good mechanical, chemical, and physical properties, which make them suitable for a wide range of functional and structural applications. Metal foams have recently gained substantial interest in both industry and academia due to their low cost, thermal conductivity, high working temperature, vibration damping, specific mechanical properties, energy absorption, and heat resistance. The use of metal foams on a large scale and successful applications depend on a detailed understanding of their characteristic properties. Metallic foams are characterized by the morphology of the porous cells (size and shape, open or closed, macro and micro), pore topology, relative density, properties of the pore wall, and the degree of anisotropy. This contribution focuses on x-ray diffraction, Fourier transform infrared (FT-IR), and Raman spectroscopic applications used for the characterization of metal foam, and also a brief of the most important applications, including a significant number of examples given.

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GENERAL INTRODUCTION TO METAL FOAMS

Metal foams were first produced in the 1950s, and with the developments in recent years, they have attracted attention among the light-weight materials. Metallic foams have the advantages of a unique combination of mechanical properties like lower weight, high energy absorbing capacity, high stiffness, and high damping capacity. For these reasons, they are becoming the most promising class of materials in the industrial and scientific areas. Metallic foams have a role in many areas of our lives day by day. Metal foams are being used in many industrial applications such as light weight structural applications, biomedical applications, filters, electrodes, heat exchangers, home appliances etc. In addition, metallic foams are also used at high temperatures. They are used in areas such as the transpiration cooled rocket nozzles, a cooling system in the combustion chamber of gas and steam turbines, and as heat shielding for aircraft exhaust. (Ashby, 2001; Bauer et al., 2013; Qin et al., 2016; Liu and Chen, 2014; Banhart et al., 2019; Sutygina et al., 2020). Metal foams are a structure consisting of air and metal, and they can be obtained by many production methods with different pore ratio. The advancement of technology and materials science has enabled the discovery of many metallic foam production methods and the production of metallic foams with different properties. Photograph of metal foams with different porosity produced in the laboratory is given in Figure 1. This figure is taken from the PhD thesis of Nuray Beköz Üllen, one of the authors of the chapter (Beköz, 2011).

Figure 1. Steel foam specimens having different porosities (Beköz, 2011)

In fact, it is desired that the material does not contain pores in many production methods such as casting and welding, but the advantages of the pore structure are used in these materials (Degischer and Kristz, 2010). Porous structure provides thermal and sound insulation as well as impact absorption in addition to light-weight construction (Banhart, 2003). Usage areas and properties of porous metals depend on the pore type. Foam structures can be defined as several types which includes pore type: open foams (pores connected to each other so that matter can pass through them), closed foams (isolated closed pores filled with any gas), and partially open foams (Beköz, 2011; Patel et al., 2018). Metal foams with closed pores are used in light structures thanks to their high hardness and low-density properties. Due to their deformation capacity when undergoing constant stress, they come to the fore as ideal energy absorbers in packaging applications and especially in the automobile industry. They can also be used in acoustic damping applications. On the other hand, open cell foams offer a wide variety of applications, e.g. as a

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