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Application of Potassium Carbonate as Space Holder for Metal Injection Molding Process of Open Pore Copper Foam

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Abstract

Copper foam has recently being applied to replace aluminium as heat sink. In this study, copper foam was manufactured via metal injection molding technique. Copper feedstock were prepared comprising 0 wt.% , 30 wt.% and 40wt.% of potassium carbonate into copper powder to produce open pore cell structure, which also mixed together with a binder system consisting palm stearin (PS), polyethylene (PE) and stearic acid (SA). The feedstock was then injection molded into tensile shape test piece prior to solvent extracted in heptane prior to sintering using tube furnace at 850°C for 4 hours in nitrogen atmosphere. The sintered samples were immersed in warm water to dissolve the carbonates. Copper foam has successfully manufactured at 850°C for 4 hours in nitrogen atmosphere followed by the dissolution process. The porosity value increased as the addition of potassium carbonate increased from 0 to 40 wt.% which given the highest value of 52.985% porosity and thermal conductivity of 520.46 W/m.K.

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1. Introduction

Metallic foam or cellular material with controlled pore structure has unique properties such as low density, high strength-to-weight ratio, large specific surface, high gas and liquid permeability, high thermal conductivity and

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excellent energy assorption[1]. Thus, it has many potential applications such for biomedical implants[2,3], filters, insulations and cushions. Many metals have been researched and developed to produce as metallic foam such as aluminium, copper, titanium and so on. Their structure form is a foam structure, i.e. a composite between gas and metal[4].

Porous metal foam can be produced by several processes[5]. Aluminium foams are produced by addition of foaming agent into the molten metal[6] while another method is coats metal onto a template material to produce nickel foams by Chemical Vapour Deposition (CVD)[7] or by galvanizing onto polyurethane foam[8]. Using foaming agent and a gelatin of a metal powder slurry produces higher porosity metal foams compared to conventional metal powder processes[9, 10]. Although all of these above-mentioned methods can produce metal foams with high porosity, each method has its own inherent problems[11]. According to[12] *Zhao Y.Y. et. al (2005)*, one of the method of powder metallurgy is employed a mixture of powder metals with the addition of potassium carbonates and dissolution process.

The foam structure is controlled by the space holder particles[13]. The shape, volume fraction of PSH and the sintering condition determine the structure of the metal foam. In practice, it is not easy to control the cell size and its distribution especially for micro-porous metal[14]. Lost carbonates sintering (LCS) is a simple, low cost method and enables to control over pore size and porosity. Meanwhile, sintering-dissolution process (SDP) is employed when there are two phase precursors with one phase is water soluble. Powder metallurgy using a powder space holder (PSH) is a process that can produce both open- and closed-cell metal foam made of any sinterable materials[13]. Manufacturing Cu foam using powder metallurgy and dissolution technique is considered as part of the development of eco-materials.

Despite the limitation in producing near net shape product, conventional powder metallurgy is that the pore size and its distribution do not affect much on the mechanical properties due to the anisotropic nature of the foam produced due to the space holder particles were rearranged during compaction process leading to non-homogeneous distribution of Cu particles across the thickess[15]. Thus, MIM is the best option to produce near net shape Cu foam.

Wide range of materials like organics, inorganics, and ceramic particles or even metallic hollow spheres could be used as space holder. Due to the higher melting point and the ability to dissolve in water, potassium carbonate (K_2CO_3) has been applied in this research work. This research aims to produce the copper metal foam via MIM process with addition of potassium carbonate ranged from 0 to 60wt%, as its thermal conductivity is higher than Al which widely used as LED heat sink nowadays, consequently expected will further enhance thermal conductivity properties as open cell Cu foam will exhibit high surface area than wrought Cu**.** Thus, the objective of this study was to produce open pore cell Cu foam using K_2CO_3 via MIM technique. The manufacturing process of metal foam in this study is similar with the previous study conducted by[13] *A.Manonuku et al., 2010*.

Nomenclature

Cu	copper
K_2CO_3	potassium carbonate
PS	palm stearin
PE	polyethylene
SA	stearic acid
LCS	lost carbonates sintering
LED	light emitting diode
MIM	metal injection moulding
SDP	sintering-dissolution process
PSH	powder space holder
SEM	Scanning Electron Microscope
TRS	transverse rupture strength
TC	thermal conductivity