Nanoporous Copper via Chemical Dealloying of Brass

Merve Ercan[1,2], Fatih Pişkin[1,3], Tayfur Öztürk[1,2]

[1]ENDAM, Center for Energy Materials and Storage Devices, METU, Ankara
[2]Department of Metallurgical and Materials Engineering, METU, Ankara
[3]Department of Metallurgical and Materials Engineering, MSKÜ, Muğla

Abstract

Nanoporous filters are used in a variety of applications, ranging from sensing, catalysis, purification and separation devices to medicine. In this study attempts were made to obtain nanoporous copper from brass via dealloying process. This involved leaching of the alloy in NaOH solution. Experiments on cold-rolled and annealed brass have shown that while a porous surface layer can be obtained, it is difficult to obtain a full porous structure across the full thickness of the sheet.

Introduction

Nanoporous filters have attractive properties such as tunable pore size, high surface area, and the ease of surface modification [1]. Therefore they have application area ranging from sensing, catalysis, purification and separation to medicine. Nanoporous structure can be obtained by several methods e.g. anodizing, melt gas injection, vapor deposition, dealloying by leaching or through electrochemical dissolution [2]. Dealloying by leaching is the one of the promising methods to develop homogeneous nanoporous structure in alloys. It involves selective dissolution of a more active component in the alloy leaving the more passive component behind [3].

Dealloying was first investigated in an Au-Ag alloy by Pickering in the late 1960 [4]. This was followed by a comprehensive study by Erlebacher [5] which concentrated on dealloying process itself as well as developing a number of nanoporous materials.

Copper and its alloys, Cu-Zn, Cu-Al, Cu-Mg and so on, are very convenient for dealloying process where the more stable Cu is attained with a porous structure following the chemical leaching [6]. This study aims to develop nanoporous copper from Cu-30wt% Zn alloy via dealloying in NaOH solution, targeted pore size is around 200 nm.

Experimental Procedure

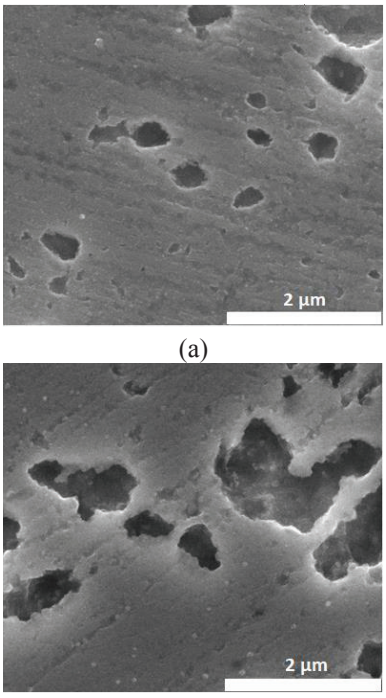
Brass used in the dealloying process had a composition of Co - 30wt% Zn. This was procured in the form of 4 mm thick plate. The plate was cold rolled repeatedly as to obtain a sheet that was as thin as possible. The final thickness achieved was 300 μm where necessary cold rolled sheet was annealed to obtain the alloy in recrystallized condition. This treatment was carried out in a muffle furnace at 450°C for 3 hours.

Samples before dealloying process was subjected to standart grinding and polishing operations as applied in standart procedure for metallographic sample preparation. Following the de-alloying treatment, the sample was examined in FEG SEM at high magnifications.

Results and Discussion

Dealloying of brass can be achieved in acidic as well as in basic conditions. But the previous study by Lin et. al. [7] showed that acidic solutions produce pores of non-uniform distribution. Therefore a choice was made so that the brass is to be dealloyed in NaOH solution. Tuan et. al. [2] studying de-alloying using NaOH found that the pore size increases with the concentration of the solution. As a result, the choice was made for 0.6 M NaOH solution.

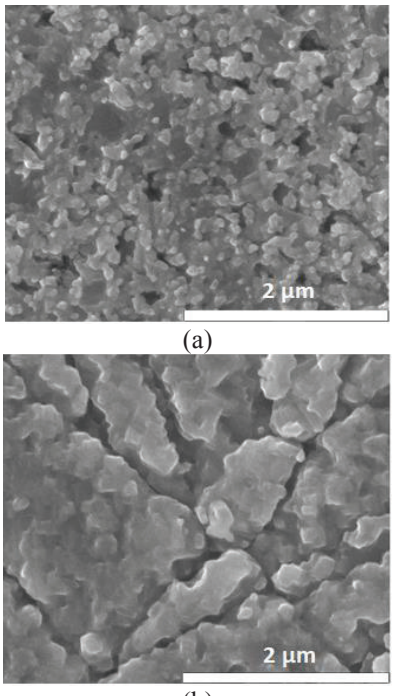
The samples typically 10 by 20 mm in size were dealloyed in 0.6 M NaOH solution for varying durations up to 3hours and subsequently prepared for metallographic examination. SEM images representative of this process is given in Fig.1. Here the samples following the treatment washed in distilled water and dipped into 3 M HCl solution.



(a)

(b)

Figure 1. SEM images of cold rolled brass dealloyed for (a) 1h; (b) for 3h



(a)

(b)

Figure 2. SEM images of annealed brass dealloyed for (a) 1h; (b) 3h

The purpose of this treatment was to remove copper oxide which might have formed at the surface. Fig. 1 shows that the sample to have pores in their surface but these are rather large and seem to have aligned along the rolling direction.

Having noted that the cold worked state influences the dealloying process, brass was annealed at 450oC for 3 hours yielding a recrystallized microstructure.

The pieces 10 by 20 mm cut from the annealed sheet were dealloyed up to 5 hours. SEM image of the annealed sample de-alloyed for 1 h is given in Fig. 2 (a). Here pores of small size can be seen clearly which are uniformly distributed. Fig. 2 (b) refers to a sample after 3 hours of de-alloying. Unfortunately here the pores are no longer visible as they seemed to have been converted into trenches.

The work, at the time of writing, is in progress and concentrates on means of how to evolve a porous structure across the full thickness of the sample.

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