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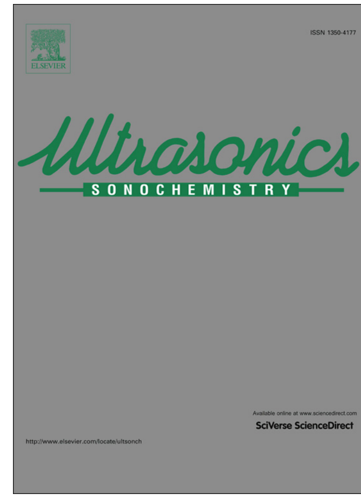

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Numerical simulations and electrochemical experiments of the mass transfer of microvias electroforming under ultrasonic agitation

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Abstract

This paper explores the mass transfer mechanism of microvias electroforming under ultrasonic agitation by numerical simulations and electrochemical experiments. Firstly, the velocity distribution of electroforming solution inside the microvias under ultrasound treatment is simulated by COMSOL Multiphysics software. The ultrasonic frequency is that of 120 kHz. The ultrasonic powers are 100w, 200w, 300w and 400w, respectively. The simulation results indicate that the mean liquid velocity inside the microvias increases with the increasing of acoustic power. In addition, under a certain ultrasonic power, the mean liquid velocity will decrease with increasing the distance between microvias and transducer, the aspect ratio of microvias and the distance between cathode and central position. Secondly, electrochemical experiments are presented to investigate the effect of ultrasonic agitation on the electrode kinetics of microvias electroforming. It is found that ultrasonic decreases the thickness of diffusion layer, increases the limiting diffusion current densities and further enhances the mass transfer of microvias electroforming. Compared with the silent condition, the diffusion layer thicknesses with the acoustic power of 100W, 200W, 300W, 400W are decreased by 50.0%, 64.1%, 69.3% and 74.5%, respectively. Finally, according to the results above, the 200×200 metal micro-column array structures are fabricated by ultrasonic electroforming under the condition of 120kHz and 200W. The metal micro-column is 250μm high and has a diameter of 80μm.The results show that ultrasonic electroforming can enhance the mass transfer of microvias electroforming, and further solve the problem of porous structure in electroforming layer. This work contributes to expand the application of ultrasonic agitation in the microvias electroforming.

Keywords: Microvias electroforming; Ultrasonic; Simulation; Electrochemical experiments; Micro-column array structures

1. Introduction

With the development of micro-electro-mechanical system (MEMS) technology, microvias electroforming have good potential applications to fabricate microarray electrodes[1,2], biopotential electrodes[3-5] and metal moulds[6], etc. However, there is a technical issue in electroforming microvias with high aspect ratio and small diameter. Influenced by the small diameter and high aspect ratio, microvias electroforming faces the problem of poor mass transfer, which easily causes the problem of porous structure in electroforming layer, finally leads to the fabrication failure [7, 8]. These problems limit the development of microvias electroforming in a certain extent. Hence, it is significant to investigate the methods of improving the mass transfer of microvias electroforming. Some efforts have been made to improve the mass transfer of microvias electroforming, such as using various additive chemistries[9,10], adding a moving cathode[11], using an air-pressure agitation, adding a thermal gradient[12], adopting pulse-reversed current[13], and optimizing process parameters[14]. But the improvement effect of these methods is unsatisfactory.