Agitation Effects on Plated Through-hole in a Dual Paddle Electroplating Cell System

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Agitation has always been an important aspect in chemical processes, particularly in electrodeposition. Some of the agitation techniques commonly used in electroplating are gas sparging, jet impingement of the plating solution into the electrode surface and vibration of the electrode [1]. Agitation, however, must be carefully controlled to avoid non-uniformity in the thickness of the deposit [1] – [3]. One way of achieving this is by utilizing a reciprocating paddle cell system, which was shown in earlier works to be capable of providing a uniform deposit thickness even on large surface areas [3].

In this study, the effect of agitation on plated through-hole with high aspect ratio (8:1) using a dual paddle electroplating cell system was investigated. An optimized plating bath containing 0.08M $CuSO_4 \cdot 5H_2O$, 1.76M H_2SO_4 and 50ppm Cl^- was used as standard solution. Various paddle speed combinations were tested while the current density was set constant at 10mA/cm^2. Electroplating was performed at room temperature. Images of the plated through-holes were taken using an optical microscope. Thickness ratios of the deposit inside the through-hole to the substrate surface (TR1) and to the opening of the through hole (TR2) were also computed.

Figure 1 shows the deposit thickness ratio of the plated through-hole at various agitation speeds. In this case, paddle agitation was performed on both sides of the through-hole at equal speed. It can be observed that high agitation speed gives high thickness ratio as a result of better deposition inside the through-hole. At high agitation speed, the flow of the solution inside the through-hole is considered to be more uniform, thereby providing enough copper ion to be deposited along the through-hole. From this, we postulated that higher thickness ratio would be obtained as the agitation speed is increased. However, significant difference in thickness ratio was not observed even if the speed was further increased. At equal agitation speed on both sides of the substrate, the flux created by the movement of the two paddle poles are thought to cancel each other out which implies that there is no stable flow of solution inside the through-hole.

Realizing this phenomena, agitation with a different speed on each surface was performed. This is thought to create a pressure gradient on the two sides thereby promoting a solution stream inside the through-hole, which is very important in improving the deposition inside the through hole [1]. Fig. 2 shows the variation of thickness ratio with unequal agitation speed on each side of the substrate. One side was set constant at 50rpm. Thicker copper deposit inside the through-hole was achieved compared to agitation with equal speed. This resulted in a high thickness ratio not normally achieved for plating solutions without additives. Furthermore, the addition of additives resulted in a very uniform copper deposit (Fig. 3) and an even higher thickness ratio.

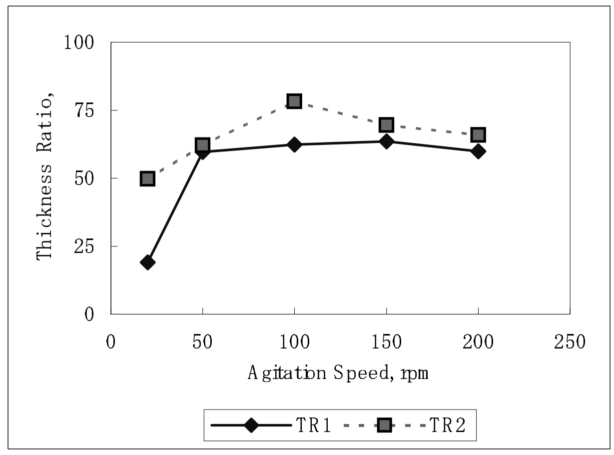

Fig.1. Variation of Thickness Ratio with Agitation Speed; Equal Agitation Speed on Both Sides of the Substrate

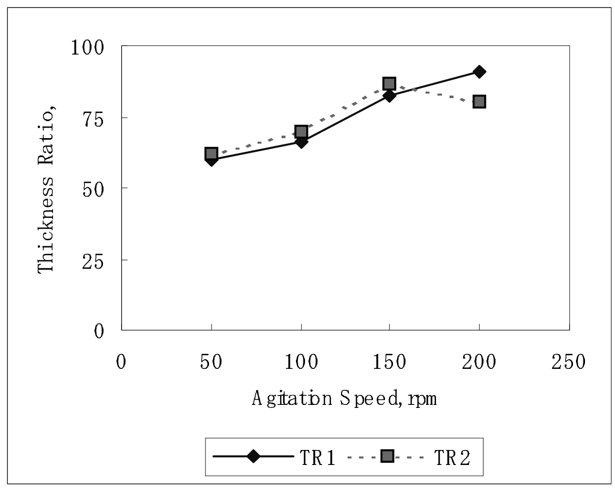

Fig.2. Variation of Thickness Ratio with Agitation Speed; Unequal Agitation Speed. Speed on One Side=50rpm.

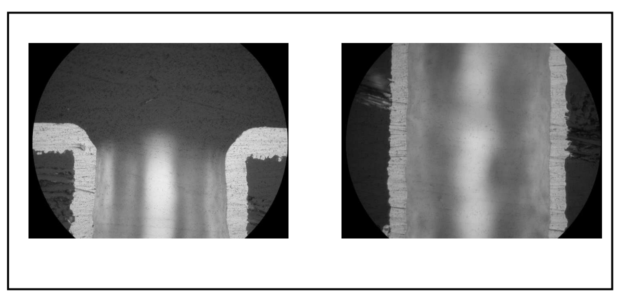

Fig. 3. Through hole image (30vs100rpm). Standard plating bath added with 100ppm PEG and 2ppm SPS.

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