Pulse Plating

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Pulsed Electroforming

Electroforming is a method of plating on a substrate with subsequent separation of the finished product from the substrate. There are many products made by electroforming. Your electric razor shaving screen foil for example is electroformed nickel. Microelectroforming is an up-and-coming avenue utilizing pulse and pulse-reverse electrodeposition. Again, screens, laser disc masters, microelectromechanical system (MEMS) components, diffraction gratings, magnetic microgears, etc. are electroformed. The need for controlling alloy composition, surface microroughness and crystallographic texture/morphology can only really be controlled by pulse and pulse-reverse, as we limit this article to microelectroforming with nickel.

As deposit thickness increases, the surface gets rougher. Microelectroformed structures are difficult to machine and dimensional accuracy is benefitted by smoother deposits. Additives for smoothing the surface are difficult to keep at the correct concentration throughout plating time. Under the same conditions, a better surface finish is had by pulse than by DC.[1] Micromachining has recently paid attention to pulse reverse.[2] Better surface finishing at same average current densities was demonstrated for pulse reverse compared to pulse electroformed nickel.[3] Here, SS panels were sulfamate nickel plated for two hours after 220 grit emery then surface profiles were checked. Average CD (forward) ranged by 18.6 ASF steps to 74.3 ASF. The reverse peak CDs were made 20 percent of those forward and all pulses were 20 ms. Lesser increasing roughness with increasing CD was seen to be a linear slope to 40 ASF, thereafter doubling the slope under the above conditions. A parallel of slightly more increased roughness was seen without reverse at the same average CD. Surface crystallographic texture is also influenced by time *on* and *reverse*.

At different pHs and CDs, DC produces [100], [110], [210], and [211] crystal orientations.[4] [100] is considered to be free from the effect of adsorbed atomic hydrogen or of both molecular hydrogen, H_2, and nickel hydroxide, $Ni(OH)_2$, molecular hydrogen and colloidal nickel hydroxide, respectively. The three-dimensional orientation distribution function, a full quantitative description of texture, was utilized to study the effect of *on-* and *off-times* in pulse reverse current electroforming using nickel sulfamate.[5] A mandrel was polished and nickel-plated for a minute (50 µm) then pulse-reverse plated. *On-times* were varied from 2 to 10 msec with reverse time held constant at 0.5 msec and reverse time varied from 0.2 to 2 msec with *on-time* held constant at 5 msec. Peak CDs were all 223 ASF. The lowest [100] orientation density of the fiber texture during 5 msec *on-time* occurred at 1.5 msec reverse and the highest [100] density at 0.2 msec reverse. A high value at 2 msec reverse was equivalent to that of c. 0.65 msec reverse with the lowest [100] density at c. 1.2-1.3 msec reverse. The lowest density of [100] orientation is believed to be due to the effective dissolution of cathodic nickel producing inhibitory surface adsorptance by nickel hydroxide. At the constant reverse time of 0.5 msec the highest [100] orientation density of the fiber texture occurred at the lowest time on of 2 msec and decreased with longer *on-times,* again due to production of inhibitory hydrogen and nickel hydroxides. Strong or weak magnetic properties can be produced by controlling texture varied with pulse parameters.

Magnetic properties of pulse reverse electroformed nickel correlate with orientation density of the [100] fiber texture.[6] In similar conditions as in (5), *on-times* were varied from 1.2 to 5 msec with reverse time held constant at 0.5 msec and reverse time varied from 0.5 to 2 msec with constant *on-time* of 5 msec. Peak CDs were all 223 ASF. Coercivity paralleled [100] orientation density textures at constant 5 msec *on-time* with lowest values at 0.8 msec reverse time and high at 0.5 and 1.5 msec and the highest at 2 msec. Coercivity similarly paralleled [100] orientation density textures at constant 0.5 msec reverse time with a zenith at 3 msec. Nickel hydroxide breaks down more to Ni^{+2} and OH^- (which migrates to the anode) at less than 3 msec, whereas at greater than 3 msec hydrogen produced is more inhibitory. Pulse reverse microelectroforming in Watts-type baths can use levelers.

Optical disc master microreplication molds can be made by laser drilling plastic holes 300 nm wide and 135 nm deep. After metallizing the plastic by CVD silver or nickel they are to be filled and leveled using a modified Watts solution. Good throwing power is obtained by using a cathodic current pulse of 18.6 ASF for 17 msec and an anodic reverse pulse of 23.2 ASF for 9 msec.[7] An average CD of 4.1 ASF produced an almost stress-free, excellently leveled deposit using 4 ppm of 1,3,6-naphthalenetrisulfonic acid. The surface roughness was 25 nm. **P&SF**

References

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