Electrolyte Effects on the Microstructure and Mechanical Properties of Ni Alloy MEMS Devices

J. Kelly, S. Goods, and A. Talin
Sandia National Laboratories
Microsystems Processing Dept.
MS 9401 Livermore, CA

Electrodeposition through thick photoresist (such as SU8 or polymethylmethacrylate) has enabled the fabrication of high aspect ratio (i.e. large height to width ratio) metallic structures (HARMST) for various microsystem applications.[1-2] The electrodeposited metal of choice is nickel, typically deposited from a sulfamate bath. Where these metallic structures have a mechanical functionality (e.g. actuators, springs, flexures, etc.), the stresses they experience necessitate using materials having high yield strengths and known moduli.

The principal driver for strength in electrodeposits is grain size of the as-plated material while the modulus is directly related to the crystallographic texture. A variety of approaches may used to refine the grain size and increase the strength of electrodeposited Ni.[3] For example, Fe, Co or Mn may be co-deposited with Ni from a sulfamate electrolyte, resulting in a grain size of an order of magnitude less for the binary systems relative to the unalloyed nickel. Each of these deposit systems has its own unique crystallographic textures as well.

Ni-only or binary alloy deposition may be straightforward for blanket films. However, the application of such processes for through-mask electrodeposition of high aspect ratio features can be very challenging as local electrolyte conditions in high aspect ratio features may be very different than those in the bulk (or low aspect ratio features). These difficulties are often ascribed to transport limitations that may compromise the ability to deposit a film (or in this case a through-mold structure) with uniform microstructure and properties. Such uniformity in film microstructure is important in ensuring the proper mechanical device response; thus, a thorough understanding of the impact of deposition parameters and electrolyte conditions is required for achieving consistent material properties. An example of such an effect is illustrated in Fig. 1 which shows the influence of filtering-induced changes in the borate ion on the crystallographic texture. In this presentation, the impact of electrolyte conditions on film microstructure will be characterized for blanket films and variety of aspect ratios, with and without alloying elements.

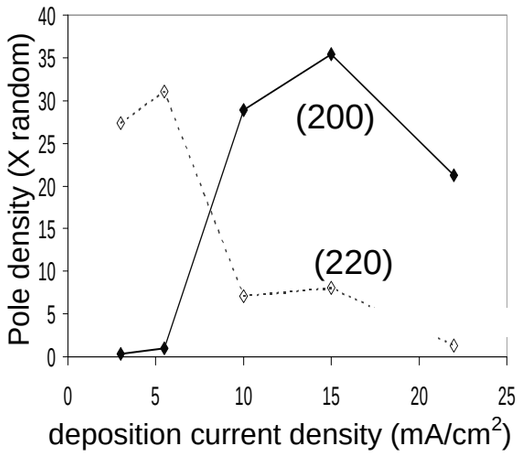

Figure 1. Texture of blanket Ni films. Passage through a 5 micron particle filter at low electrolyte temperatures (desirable to minimize thermal expansion of the PMMA mold) affects the boric acid in solution, leading to changes in film texture. Unfiltered solutions result in (200) texture for all current densities.

REFERENCES

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