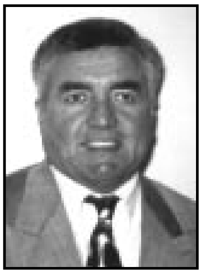

Design Engineering

Steve Koelzer
Vice President, Research & Development
K & K Products & Consulting
709 W. Remington Drive
Sunnyvale, CA 94087
e-mail: smbk@slip.net

Micro- & Nano-Finishing

On a regular basis, I attend the San Francisco Bay Area Micro Electro Mechanical Systems (MEMS) club meetings, where many fascinating developments are reported for biotechnology, diagnostics, accelerometers, microdiffraction optics, etc. Even the annual conference reported a "zero friction" from a tungsten AFM needle gliding over silicon. When parallel alignment deviated to perpendicular by the atomic lattices, zero friction went through nodes of partial to full friction. The capabilities of plating and surface finishing have not fully impacted the micro/nano design community.

A recent communication in *Nature* (Vol. 392, p. 796, 1998) deals with electroplating to miniaturize devices with "soft" magnetic properties. Such property of low-coercivity exhibits low critical field strength [Hc] to flip magnetization direction. These central components of electromechanical devices are common to step motors, magnetic sensors, transformers, magnetic recording heads and such. When miniaturized, MEMS material of construction requires it to develop higher saturation flux density [Bs] to preserve requisite flux density upon reduction, while achieving a low [Hc]. Typical materials used are electroplated cobalt-iron-based alloys, such as CoNiFe and sputtered iron-based nanocrystalline and iron nitride films. Where thick films are needed, sputtering won't do.

Conventional electroplating uses sulfone-based stress reducers (saccharine, thiourea, etc.) but their films don't get below [Hc] of 2 Oe (160 A/m) because of the inclusion of 0.3 at %S (Permalloy, Ni80Fe20, has 0.1 %S). Their best film (Co65Ni12Fe23) has very good magnetic properties and superior performance as write head core of a magnetic recording head, plus a pitting corrosion potential more anodic than Permalloy. Plating conditions and testing methods were reported.

Another example of MEMS surface finishing is electrochemical micromachining (EMM). *Design News* (September 22, 1997, p. 70—www.designnews.com) reported a patented process using pulsed current instead of DC to EMM herringbone grooves in journal or spiral in thrust bearings to improve the distribution of air or fluid film to increase load-carrying capacity, stiffness or stability.

The example cited was for self-acting aerodynamic bearings of high-performance optical scanning for digital enlargers, functioning at extreme speeds (>10,000 rpm). The EMM patterns were grooved 7μ deep and 2mm wide on a scanner shaft rotor, 19mm journal and 37mm thrust bearing, in a matter of a few seconds. The process uses a stationary workpiece, stationary conforming cathode, with pumped electrolyte and pulsed current power supply.

Photolithography is extensively used for MEMS structures. The process borrows from IC manufacture. Also from *Design News* is a report on a University of Texas (Austin) team led by Grant Willson, which printed 0.08 micron features on a semiconductor wafer using a 193-nm-wavelength stepper. The industry's roadmap did not expect 0.08 micron features until the year 2009. It had been predicted that post-optical technology would produce sizes at or below 0.10 micron, but Willson generated the nanometer features using an etched-quartz, phase-shift photomask, and reports that it appears there is sufficient latitude in the process to allow generating even smaller features.

The World Wide Web has a plethora of information on MEMS. Here are two: Nanometals Publications' Abstracts (http://cheemat.chee.queensu.ca/mat/nanometals/nano_abs.html) and Government links (http://science.nas.nasa.gov/Groups/Nanotechnology/links.html). **P&SF**

Free Details: Circle 120 on postpaid reader service card.