PRECISION MICROMOTOR TECHNOLOGY FOR BIOMEDICAL APPLICATION

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Microelectromechanical system (MEMS) is a miniature system composed of electronic and mechanical components with average size from 1 to 100 microns. Typically MEMS consists of an electronic module (microprocessor or microcontroller) and a set of microscopic electromechanical sensors and actuators.

The main advantages of microelectromechanical systems are: small size, high functionality and reliability, low power consumption and repeatability.

Currently, one of the most promising MEMS applications are biomedical technologies (Fig. 1). The use of modern micro- and nanomotors allows people to solve such problems as isolation and transport, bio recognition, bio sensing, nano-surgery, imaging, neural implants, drug delivery and many others. According to the Yole Development bioMEMS market will grow from $ 3.5 billion in 2015 to $ 6.6 billion in 2018 [1-3].

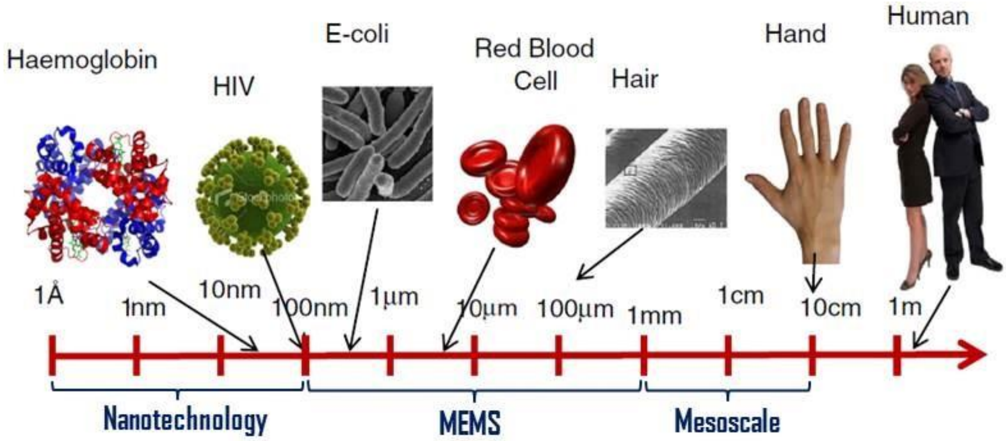


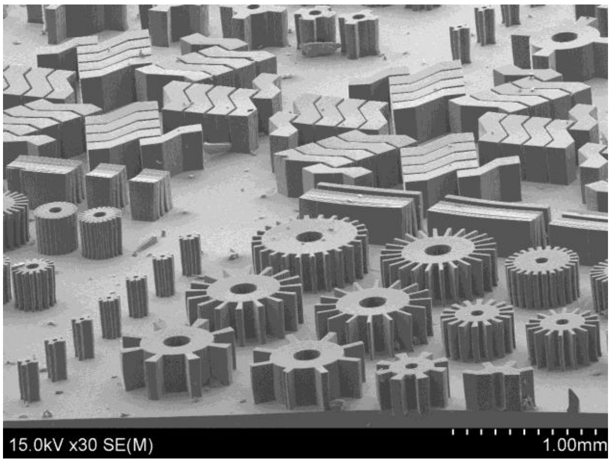
Fig. 1 - Dimensional scale of MEMS and Nanotechnology (Adapted from Nguyen et al. [4])

Nowadays different materials are used for MEMS components manufacturing such as silicon, various metals and alloys, as well as polymers. Especially, polymers are attractive for biomedical applications due to their bio-compatibility, low cost, and suitability for rapid prototyping.

We have used the SU-8 photoresists to obtain ultra-thick MEMS components with parallel side walls. SU-8 is a high contrast, epoxy based negative photoresist developed and patented by IBM. It has been used extensively in LIGA-like technologies for MEMS applications due to its excellent thermal and chemical properties. Feature height is varied from tens of micrometers to several millimeters, high aspect ratios are on the order of 100:1.

We have used UV lithography, which utilizes an inexpensive ultraviolet light source to expose a SU-8 photoresist. As heating and transmittance are not an issue in optical masks, a simple chromium mask can be substituted for the technically sophisticated X-ray mask.

Different components of micromotor with thickness from 50 to 230 µm with the minimum feature size of 10 µm were obtained (Fig. 2, 3) on the different substrates (glass, ITO, pyroceramics, copper, etc.).



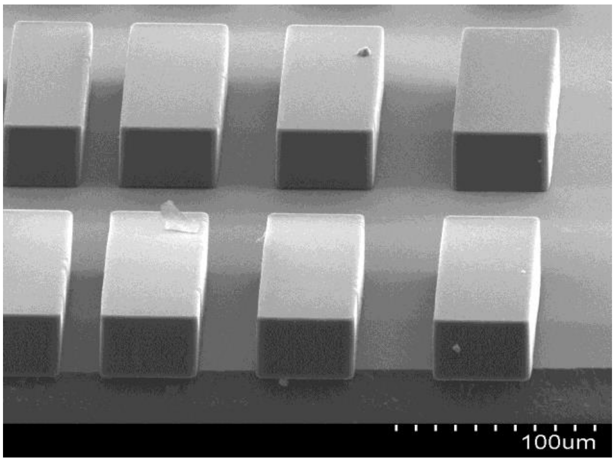


Fig. 2 - SEM photo of 230 μm thick microstructures based on the SU-8 2150 photoresist

Fig. 3 - SEM photo of 40 μm thick test micropattern with 5 μm minimum feature size based on the SU-8 3050 photoresist

Photo Surface Processor PL16-110D was used to prepare the substrate surfaces by UV cleaning. The cleaning process consists of three main processing steps: generating ozone from atmospheric oxygen (with a wavelength of 184.9 nm), ozonolysis (formation of singlet oxygen at a wavelength of 253.7 nm), and decomposition of organic pollutants (strong oxidative activity of atomic oxygen permits it to react with contaminants materials to form reaction products such as water, carbon dioxide, etc., which are then simply evaporate). Next the photoresist have been spin-coated over the substrate for uniform distribution. Then soft baking step has followed to evaporate remaining solvent in SU-8. A proper soft bake time is one of the most important control factors for a thick photoresist process. Photoresist have been exposed with UV light of i-line (365 nm) through a photomask. Lightningcure LC-L2 manufactured by Hamamatsu was used as a light source. Exposure energy was 250-300 mJ/cm^2. Further, the samples have had post exposure bake on the plate at 65-95°C. This leads local photochemical reactions to provide photoresist crosslinking. Cross-linked areas are insoluble during the next development stage, which removes the uncured resin [4].

Thereby as evident from the market trend, there are vast possibilities for MEMS in the biomedical technology. The proposed technology of MEMS components manufacturing is promising due to the use of unique materials, the possibility to obtain microstructures with vertical sidewalls of large thickness and a high aspect ratio, manufacturability, the possibility of integration with a variety of complex systems, as well as its simplicity and low-cost equipment.

References

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