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Developing microfluidics and bioMEMS

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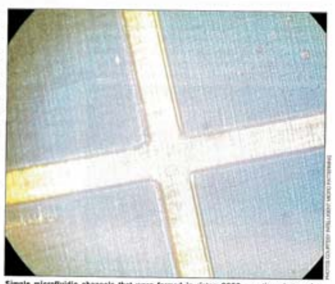
A processing technology offers alternatives for designing and manufacturing microcomponents.



Simple microfluidic channels that were formed in ristos 8080 negative photoresist. Microfluidics can be rapidly prototyped using maskless photolithography, allowing for faster development of new devices.

IVD manufacturers are always looking for ways to improve the performance of their products and reduce overall production costs. Using microelectromechanical systems (MEMS) may be one such way. MEMS are essentially microchips that have miniaturized complex systems into a small package. The majority of MEMS are fabricated by using processes for manufacturing silicon products, such as the electronics that are found in personal computers and cell phones.

MEMS are also used for biomedical applications and are called either bioMEMS or microfluidics, which use liquid flow as part of their normal operation.[1] Examples of microfluidics include miniature biochemical reaction chambers, lab on a chip, and microelectrode arrays.[2] Since these components do not have the same properties as other MEMS, they cannot be made using the same processes. Manufacturers have therefore had to use other fabrication methods and techniques. Maskless photolithography is one such technique for prototyping and developing bioMEMS and microfluidics.

Key Differences

In order to understand the challenges that biomedical manufacturers encounter, it is necessary to compare the processes that are used to produce bioMEMS and microfluidics with those methods utilized in a silicon product fabrication line.[3] The comparisons highlight the differences in the physical makeup of the components, as well as economic considerations.

Substrates and Materials. While silicon product fabricators use primarily standard, well-defined silicon wafers, bioMEMS and microfluidics makers are often forced to work with nonsilicon materials.[4] The reasons for this restriction include the incompatibility of silicon with many biological fluids, and the manufacturers' need to start with low-cost materials. Examples of substrates that are used in bioMEMS and microfluidics include glass slides, polypropylene and other polymeric materials, and rigid plastics that have topography.

Size Features. While manufacturing processes for silicon products strive for higher densities and small, submicron geometries, bioMEMS and microfluidics often require thicker materials and larger features. Since many biomaterials, such as red blood cells, that are used in bioMEMS and microfluidics tend to be large, the channels and other parts within these components also need to be large. In addition, the materials from which these components must be constructed are easier to process if they are larger and thicker. The result is that many of the essential pieces of process equipment used in producing silicon products are not needed for bioMEMS and microfluidics fabrication.

Figure 3. A thin-film glucose monitor component.

Figure 4. A photoresist-patterned polycarbonate plastic material.

from an inputted electronic signal, light is introduced into the system using a polychromatic white light source.

A directly coupled optical delivery system ensures efficient transfer of the image to the Smart Filter subassembly, which incorporates all of the optical and electronic components necessary to transfer an image onto the substrate. The projected image is free of distortion and is uniform throughout the exposure area. The light

Glossary of Terms

Contact/Proximity Printing: A common method of photolithography that employs a photomask to transfer a master image to a substrate. Typical processes require that the mask be held very close to the substrate being exposed (proximity printing) or that the photomask actually come in contact with the substrate during exposure (contact printing).

Exposure: In a photolithography process, the step at which an image is projected onto a substrate coated with photoresist.

Features: The patterns generated during a photolithography process. Typically, these are made from photoresist.

Mask (or Photomask): A glass plate that is selectively patterned with chrome or another opaque material. The mask is used to transfer a master image to a silicon wafer or other substrate.

Maskless Exposure System: An exposure system that does not require a photomask for performing exposures during a photolithography process.

Microfluidic Device: A microscopic component designed to handle liquid flow as part of its normal operation.

Minimum Feature Size: The smallest line or space (typically measured in microns) that can be resolved by an exposure system as part of a photolithography process.

Monochromatic Stepper: A system used for the exposure step in a photolithography process. Such systems employ a single exposure wavelength to provide small-feature resolution and are often fully automated for high throughput and ease of use.

Nonstandard Substrate: Any substrate used for microscopic component fabrication that is not a silicon wafer.

Photolithography: In MEMS fabrication, the process used to transfer an image to a semiconductor wafer or other substrate. Typical steps include photoresist coating, exposure, photoresist development, and baking.

Photoresist: Typically, a liquid polymeric material that is patterned during a photolithographic process. The material is then imaged using a series of exposure, developing, and baking steps.

Photosensitivity: The characteristic of a material that causes it to change properties when exposed to light.

Resolution: The smallest size that an exposure system can pattern as part of a photolithography process.

Substrate: The base material that is processed to manufacture an electronic or other micro device. Critical properties include size, shape, and bulk material.

Time of Exposure: The amount of time that light energy is projected onto a substrate during the exposure step of a photolithography process.

Wafer: The type of substrate often used in semiconductor chip fabrication. Wafers are typically made of silicon and are round.