1 Description of SU-8

Many MEMS (Micro Electo Mechanical Systems) devices require processing of thick photoresist for new microstructures with high aspect ratios [2]. SU-8 has enabled the development of many new MEMS devices. Thanks to its high sensitivity, chemical resistance and compatibility with electroplating SU-8 appears to be an ideal photoresist for MEMS fabrication. There are already many examples of its use as material for micromolds, packaging and devices. [3]

It has been originally developed, and patented by IBM-Watson Research Center (Yorktown Height-USA, US Patent No.4882245 (1989) and others). In 1996 the material has been adapted for MEMS applications by EPFL-Institute of Microsystems and IBM-Zurich (CH). [4]

The properties of epoxy-novolack Epon SU-8 are as follows:

- Low molecular weight
- Good solubility
- High transparency
- Glass and film formation
- Low glass transition temperature (Tg)
- Highly viscous solutions
- Ultra thick layers up to 500 µm by single coating
- Highly uniform coating
- Low edge bead
- Vertical sidewalls
- Aspect ratio > 15
- A excellent chemical resistance
- Good biocompatibility [5, 6]

In appendix B the mechanical, physical and electromagnetic properties are given an indication of their values.

The resist consists of a polymeric epoxy resin by dissolving in an organic solvent and adding a photoacid generator.

The SU-8 consists of 3 basic components:
a) An epoxy, which is available at Shell Chemicals, called Epon SU-8.
b) A solvent, called gamma-Butyrolactone (GBL), see Fig. 1-2.
c) A photoacid generator taken from the family of the triarylim-sulfonium salts (Fig. 1-2).
The molecule in Fig. 1-1 is “idealized” because in reality the molecules exist in a wide variety of sizes and shapes.

![Fig. 1-1 SU-8 molecule with epoxy groups. Also, that on average a single molecule contains 8 epoxy groups, hence the “8” in SU-8. [4]](image)

Because of the good mechanical/chemical stability the SU-8 can be used as building material for devices.

### 1.1 Chemical reaction

On the basis of the exposure runs the followed reaction, the photoimaging mechanism can be described by the equation below:

\[
\text{Eq. 1.1.1 Photoimaging mechanism during the exposure. [1]}
\]
Photoacid, designated H⁺A⁻ in the above, is photochemically produced in the solid photoresist film upon absorption of light. The photoacid acts as a catalyst in the subsequent cross-linking reaction that takes place during Post-Exposure-Bake (PEB). In other words, the exposed resist contains acid catalyst, while the unexposed resist doesn’t (negative photoresist).

The following PEB is responsible for the cross-linking mechanism in the SU-8 layer. The bake is necessary because the reaction kinetic of the cross-linking mechanism is very slow at ambient temperature. Heating the solid above its glass transition temperature (T₉=55°C) the molecular motion is increased, and therefore assist the cross-linking process. (For a polymer, T₉ is the temperature at which the transition between solid glass and viscous fluid occurs). [1]

The cross-linking reaction which is catalyzed by acid takes place in a “zipping up” fashion, where each epoxy group can react with another epoxy group, either in the same or different molecule. Cross-linking does not occur in the absence of acid, at the temperature of the PEB. Extensive cross-linking will yield a dense network since as described above each epoxy is “pre-connected” to 7 others on the average. This dense network is insoluble in the developer. The reaction is illustrated in Fig. 1-3:

![Cross-link reaction](image)

*Fig. 1-3 The cross link reaction during the post exposure bake. [1]*

The PEB must be carried out at temperatures greater than T₉ in order to be effective. Due to this the resist film properties will change in several ways [1]:

1. Some shrinking will inevitably occur due to reduction in free volume and increase in density.
2. The T₉ will also rise as the film becomes increasingly cross linked.

Cross-linking proceeds the film gradually until the film is solid and the cross link reaction will slow down and eventually stop. Therefore, the final T₉ of the material is dependent on the PEB temperature.
1.2 SU-8 100 process scheme

A complete SU-8 process consists of: spin coat, soft bake, exposure, post expose bake and development. A controlled hard bake is recommended to further cross-link the imaged SU-8 structures if they are supposed to remain part of the device. The variables of the process should be optimized for the specific application, which will be treated in the next sections. [1]

Fig. 1-4 Process SU-8 100 scheme.

2 References

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