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Editorial

Special Issue: 15 Years of SU8 as MEMS Material

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In 1997, the first paper using SU-8 as a material for microfabrication was published [1], demonstrating the interest of this negative photoresist for the near-UV structuration of thick layers and the manufacturing of high aspect-ratio components. SU-8 quickly became a cheap alternative to X-ray LIGA, at least for applications that did not require the extreme aspect ratios and precision that can be achieved with X-ray lithography. The possibility to pattern easily multilevel structures of SU-8 [2] expanded significantly its range of applications and led to its early adoption by the industry.

In the last 15 years, the interest of the MEMS community for SU-8 has never declined. SU-8 has been used for the manufacturing of a wide range of components in all application areas of microtechnology. After 15 years of use of the SU-8 resist, it is time to look back at the road travelled: This special issue of *Micromachines* is dedicated to SU-8 as MEMS material, and its developments in terms of processes and applications.

This special issue presents a total of twelve papers that cover a large spectrum of processes and applications of the SU-8 material and includes papers related to established techniques used for industrial production as well as articles dedicated to innovative processing techniques and new potential application areas of this resist.

Three of the papers are review articles, focused on different aspects of SU-8. One in particular focuses on industrial applications of SU-8 in the UV-LIGA process [3] and not only describes the primary use of SU-8 for the production of molds, electroplated microparts and multilevel components, but also addresses the fabrication of functionalized parts using inserts and the integration of diffractive optical elements. Mimotec SA, the company from which this paper originates, has its entire manufacturing chain centered on the SU-8 material and it is of particular interest for all SU-8 users to have an industrial perspective presented in this special issue. Another paper reviews non-standard techniques that can be used for processing SU-8 [4]: inclined and backside photolithography, drawing lithography, holographic interference lithography, two-photo absorption lithography and moving mask lithography. All these techniques allow to further diversify the shapes that can be produced in SU-8. The third review paper describes emerging particle physics detector technologies making use of SU-8 microstructuring [5]. This may seem extremely specific, but in fact the process developments made for producing such detectors can be directly employed for fabricating microfluidic devices of interest for biology or medical devices. This paper also describes a very clever process flow allowing the manufacture of multiple levels of superimposed microfluidic channels.

The other papers of this special issue present developments in what are traditionally the three main research areas related to SU-8 use for MEMS technologies:

- The formulation of new materials based on SU-8 is the main topic of two papers, both studying the improvement of the tribological properties of this material, by creating a new composite material based on a SU-8 polymer matrix in which either perfluoropolyether lubricant droplets [6] or droplets of an ionic liquid [7] are dispersed.
- Innovative processing methods of SU-8 are described in four papers. One investigates the photolithography of SU-8 without cleanroom facility, using printed shapes on transparencies as mask and a printed circuit board (PCB) exposure equipment instead of a mask aligner [8]. Well-defined structures can be obtained this way with a resolution of about 10 µm, sufficient for most simple microfluidic applications. Another paper investigates the fabrication of 100 to 500 nm in diameter SU-8 beads by electrospray, to reproduce the Mie light scattering performed by butterfly wings and use this effect in a glucose sensor [9]. Jacot-Descombes *et al.* use inkjet printing to shape a SU-8-based composite resist into spherical caps [10]. The composite resist contains Fe_3O_4 nanoparticles that are aligned to an external magnetic field during the SU-8 curing and the obtained components are magnetically actuated microstructures that can be self-assembled. The last paper that describes an innovative processing method is based on the carbonization of SU-8 in an inert atmosphere [11]. This allows to fabricate glassy-carbon micro components having all the possible shapes that can be achieved with SU-8 processing techniques. Glassy carbon is extremely inert chemically, impermeable to gasses. It has a large electrochemical stability window and physical properties that make it a material of interest for a large set of applications.
- Applications based on the use of SU-8 are presented in all the papers of this special issue, ranging from structural components to micro-channels, optical components, biomedical devices, *etc*. Three papers focus directly on applications of SU-8. Al-Halhouli *et al.* use SU-8 to fabricate a synchronous micromotor, and investigate its use in various microfluidic applications [12]. Huby *et al.* fabricated nanowires and nanotubes that can be used as optical waveguides [13]. Finally, Mekaru investigated the use of SU-8 in the fabrication of X-ray masks when combined with tapered silicon structures, and shows that the obtained masks can be used in grayscale X-ray lithography [14].

Since its introduction 15 years ago, SU-8 has attracted a lot of interest in the microfabrication field, because it is an easy to use, versatile material and has many advantageous properties, such as its high chemical, mechanical and thermal stability after processing. The papers of this special issue do not cover all aspects of SU-8 use in the MEMS application field, but give a good overview of the diversity of processing and applications that can be achieved with it. There is no doubt that SU-8 will still find considerable use in microtechnology for the 15 years to come.

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References

1. Lee, K.; LaBianca, N.; Rishton, S.; Zolgharnain, S.; Gelorme, J.; Shaw, J.; Chang, T.P. Micromachining applications of a high resolution ultrathick photoresist. *J. Vacuum Sci. Technol. B* **1995**, *13*, 3012–3016.
2. Lorenz, H.; Despont, M.; Fahrni, N.; Brugger, J.; Vettiger, P.; Renaud P. High-aspect-ratio, ultrathick, negative-tone near-UV photoresist and its applications for MEMS. *Sens. Actuators A Phys.* **1998**, *64*, 33–39.
3. Genolet, G.; Lorenz, H. UV-LIGA: From development to commercialization. *Micromachines* **2014**, *5*, 486–495.
4. Lee, J.; Choi, K.-H.; Yoo, K. Innovative SU-8 lithography techniques and their applications. *Micromachines* **2015**, *6*, 1–18.
5. Maoddi, P.; Mapelli, A.; Jiguet, S.; Renaud, P. SU-8 as a material for microfabricated particle physics detectors. *Micromachines* **2014**, *5*, 594–606.
6. Saravanan, P.; Satyanarayana, N.; Sinha, S. SU-8 composite based “lube-tape” for a wide range of tribological applications. *Micromachines* **2014**, *5*, 263–274.
7. Batooli, L.; Maldonado, S.; Judelewicz, M.; Mischler, S. Novel SU-8/ionic liquid composite for tribological coatings and mems. *Micromachines* **2015**, *6*, 611–621.
8. Pinto, V.; Sousa, P.; Cardoso, V.; Minas, G. Optimized SU-8 processing for low-cost microstructures fabrication without cleanroom facilities. *Micromachines* **2014**, *5*, 738–755.
9. Bonzon, D.; Martinez-Duarte, R.; Renaud, P.; Madou, M. Biomimetic *Pieris rapae*’s nanostructure and its use as a simple sucrose sensor. *Micromachines* **2014**, *5*, 216–227.
10. Jacot-Descombes, L.; Gullo, M.; Cadarso, V.; Mastrangeli, M.; Ergeneman, O.; Peters, C.; Fatio, P.; Freidy, M.; Hierold, C.; Nelson, B.; *et al.* Inkjet printing of high aspect ratio superparamagnetic SU-8 microstructures with preferential magnetic directions. *Micromachines* **2014**, *5*, 583–593.
11. Martinez-Duarte, R. SU-8 photolithography as a toolbox for carbon mems. *Micromachines* **2014**, *5*, 766–782.
12. Al-Halhouli, A.; Demming, S.; Waldschik, A.; Büttgenbach, S. Implementation of synchronous micromotor in developing integrated microfluidic systems. *Micromachines* **2014**, *5*, 442–456.
13. Huby, N.; Bigeon, J.; Danion, G.; Duvail, J.-L.; Gouttefangeas, F.; Joanny, L.; Bêche, B. Transferable integrated optical SU8 devices: From micronic waveguides to 1D-nanostructures. *Micromachines* **2015**, *6*, 544–553.
14. Mekaru, H. Performance of SU-8 membrane suitable for deep X-ray grayscale lithography. *Micromachines* **2015**, *6*, 252–265.