Maskless Lithographic PCB/Laminate MEMS for a Salinity Sensing System

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ABSTRACT

We have employed a micron-sized resolution maskless photoimaging/patterning tool that permits the creation of small, arbitrary features, for constructing devices, structures and packages, in any photoimageable material. The fabrication technology can provide features down to 10 microns simultaneously over a field of view of 2 cm height and 2 cm width. The instrument relies on the use of microoptics and spatial light modulation to create the required 2D pattern aerial image for photoimprinting.

We are developing a salinity system in package and additional water measurement systems using PCBMEMS or Laminate MEMS based on liquid crystal polymer (LCP) and Polyimide(PI) materials with the various sensing elements made within the LCP and Polyimide laminates. Single layer, double layer and laminate constructions have been accomplished. The salinity design is based on three sensing functions: RF based inductive type conductivity sensor, thin film temperature sensor and thin film pressure functions. All functions were created using the direct write technology combined with both plating and etching pattern transfer processes. The PCBMEMS components constitute a salinity total analysis system with integrated fluidic and electronic function made in an economical PCBMEMS format.

1. Introduction

Salinity, which can be determined through conductivity-temperature-depth (pressure) measurements, is an important, fundamental property of seawater in the open ocean and coastal regions. Salinity directly affects biological and physical processes of the ocean and provides critical information on processes related to environmental health and human impact and is the most common measurement made in ocean science. We are developing an expendable salinity system in package using PCBMEMS or Laminate MEMS based on liquid crystal polymer (LCP) materials with the various sensing elements made within the LCP laminates. The chosen designs of the three sensing functions: RF based inductive type conductivity sensor, thin film temperature sensor and thin film pressure cells have been fabricated in LCP and Polyimide (PI). The processing of the designs relies on a maskless photolithographic technique to define the various electronic and fluidic circuits of the PCBMEMS package. The maskless tool utilizes microoptoelectromechanical (MOEMS) systems to directly write patterned circuits from computer images. The technique has proven to be a direct method of prototyping and photofabricating devices, circuits and packaging materials including metals polymers and ceramics used in creating micro total analysis systems.

2. **Maskless Lithography**

We have employed a unique microfabrication prototyping technology (Model SF-100, Intelligent Micro Patterning LLC, St Petersburg FL) that allows us to create micromechanical structures rapidly and with ease. The technology is a maskless lithographic photofabrication process for creating microstructures and eliminates the use of masks. In the technique microoptoelectromechanical systems are used to spatially modulate light such that light can be controlled on the several micron size regime over centimeter sized field of view. The performance of the tool is similar in scale to cellular building processes where small-scale features are built up into large-scale constructions. This approach yields an advantage in design and also in manufacturing since the technique writes directly using parallel planar light, which is more efficient than rastering a single laser spot over the same field of view. The lithographic technique eliminates masks from the microfabrication process and can additively create microstructures of non-linear geometries.

We have also coupled the direct write approach with pattern transfer processes to impart patterns into a variety of metals, polymers, and ceramics necessary for MEMS fieldable systems. A key point to be made is that the creation of microstructures in non-standard (i.e non-Silicon) MEMS materials is of importance for fieldable MEMS devices since implantables, whether in the body or in the ocean, are most likely to be made from a variety of materials and silicon is not considered a harsh environment compatible material.

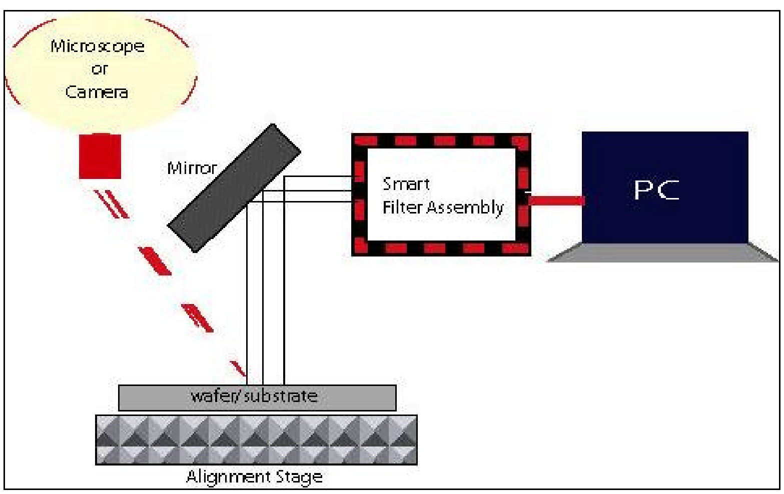

Figure 1. Maskless Lithographic Exposure Workstation- major subsystems

3. **Process Flow**

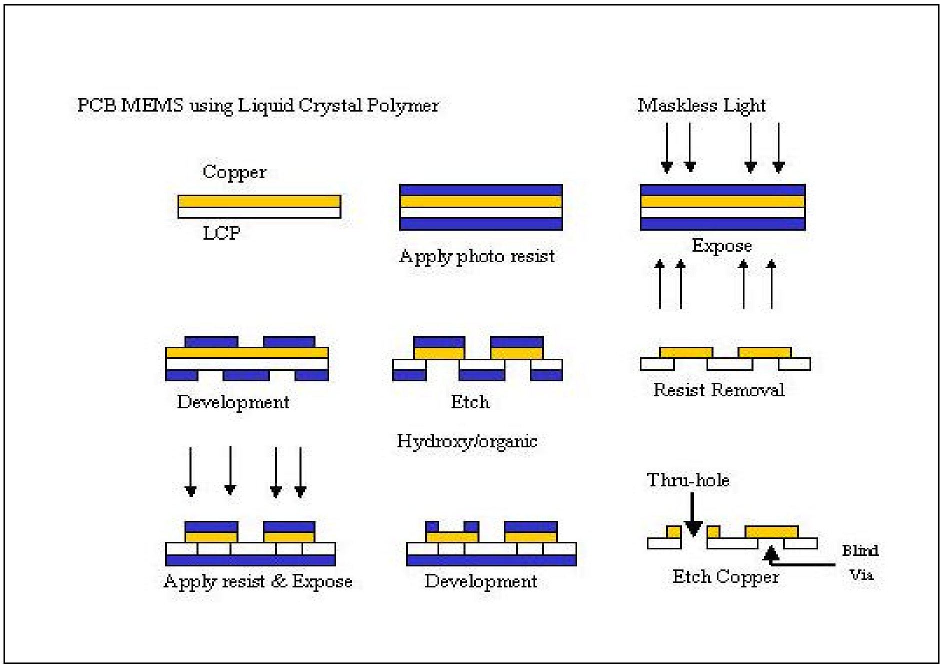

Figure 2. Process Flow for Maskless Lithographic PCBMEMS

4. **Fabricated Systems and Modeling**

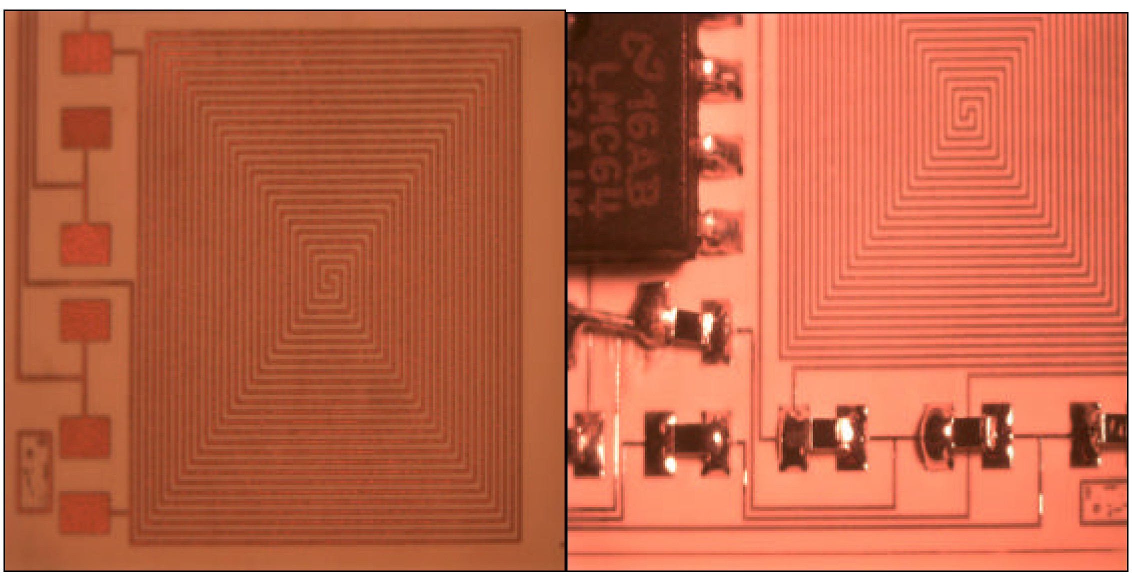

Figure 3. Maskless Lithographic generated Cu/LCP temperature sensor.

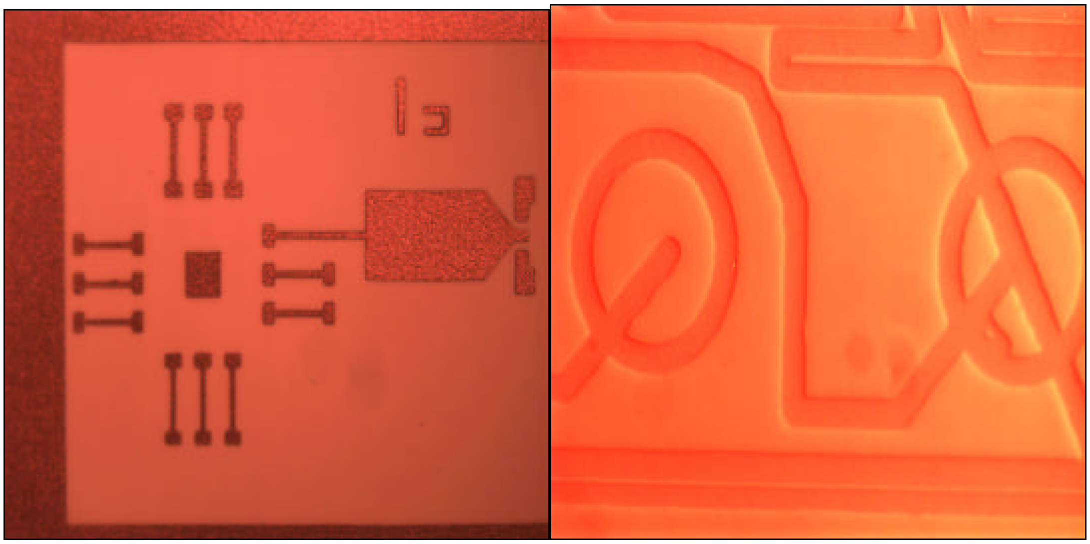

Figure 4. Maskless Lithographic generated Cu/LCP conductivity toroid element- test pattern (left); LCP microfluidic network- test pattern (right)

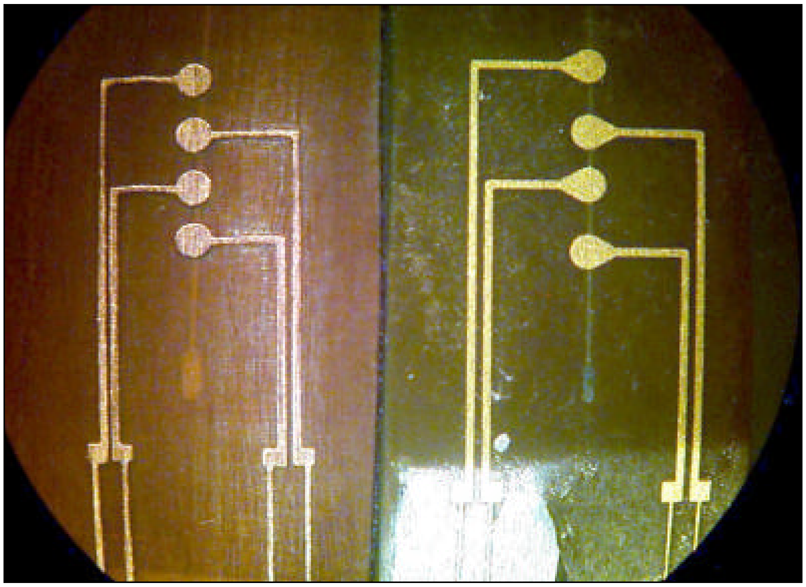

Figure 5. Maskless Lithographic generated chip: Cu electrode and embedded microfluidic channel in Polyimide (left). Compared to commercially available polyimide channel/conductor chip (right).

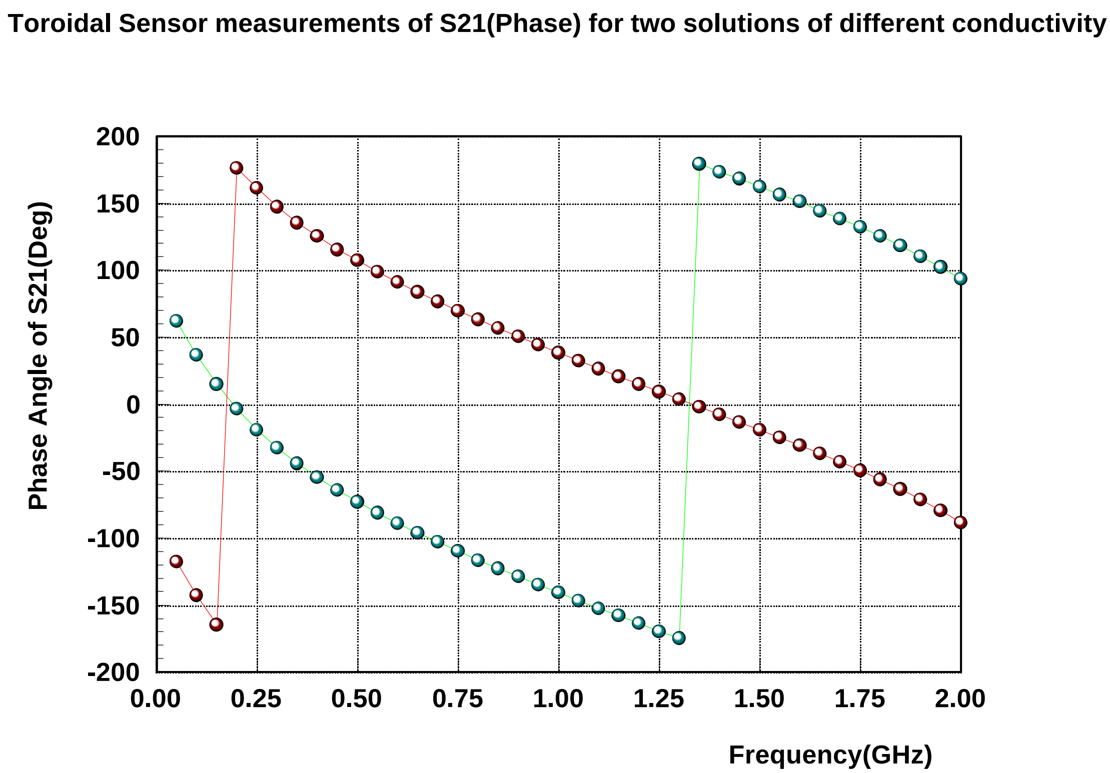

Figure 6. Phase of transmission parameter (S21) through the coupled-toroid conductivity sensor for materials of two conductivities (10 and 20 S/m) flowing through the sensor core. The phase difference is translated to a DC voltage difference through a balanced-mixer phase detector at the output of the sensor.

5. **Conclusions**

Using direct write technologies for photoimageable processing of laminate materials has demonstrated a rapid prototyoing process flow for PCBMEMS. The direct write allows computer to print capability and permits rapid change of designs with no cost, no wait, no QA for photomasks. When combined with the PCBMEMS format low cost, low investment MEMS are possible. We have demonstrated that sensors, interconnects, fluidics, electronics and packaging functions can be realized with the simple process flow. For many systems of use in harsh environments the attributes of the LCP and Polyimide are preferred and the PCBMEMS is the most versatile approach to enable micro total analysis systems.

6. **Acknowledgements**

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7. **References**

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