High-Sensitivity Capacitive Humidity Sensor Using 3-Layer Patterned Polyimide Sensing Film

J. Lacoste, V. Wilmart, J.-P. Raskin* and D. Flandre

*Université catholique de Louvain, Microwave Laboratory

This paper investigates novel isolation and patterning schemes to increase the sensitivity of a capacitive humidity sensor based on a polyimide sensitive layer. We obtained for the first time an optimum sensitivity of 23% using aluminum interdigitated electrodes with fingers of 1 µm width separated by 1 µm, deposited on a first insulating polyimide layer and covered by two more polyimide layers whose upper one features a regular array of holes to increase the active surface area (Figures 1-2).

The principle of a humidity capacitive sensor lies on the increase of the apparent dielectric permittivity of a sensitive layer due to moisture absorption. Polyimide is a polymer particularly suitable as humidity sensitive layer thanks to its full compatibility with integrated circuit process, its great chemical stability, and its high permeability to water. In addition, most of new polyimides are also very easy to coat and pattern thanks to their photosensitivity properties.

In this study, we demonstrate how to modify the design and fabrication parameters of the interdigitated fingers, the isolation layer and the sensitive layer of a classical capacitive-type humidity sensor in order to improve its humidity sensitivity and its integration in a standard CMOS-IC process. We chose Pyralin PI2723 from HDMicrosystems as polyimide thanks its high water absorption factor (4.2% at 100% RH). To increase the active surface area in contact with the ambient humidity a plasma etching is proposed in. We proposed a more effective solution: coating a second polyimide layer patterned with holes on top of the first one. Finally, the parasitic capacitances which appear between the interdigitated electrodes through the substrate are reduced usually by increasing the SiO₂ insulating layer thickness. We investigated two other solutions, either to replace oxide by polyimide which has lower permittivity or to remove silicon substrate by back etching in post process to isolate the sensor on a membrane.

The linear capacitance variation vs RH was correctly confirmed. A comparison was made between the 3 studied configurations and showed the important sensitivity gain using polyimide as insulator with the substrate until a maximum of 23% with fingers of 1 µm width. Still higher sensitivity could be obtained if we release substrate under the sensor. Tests are in progress using TMAH bulk micromachining.

We demonstrated that our novel capacitive-type humidity sensor increases the sensitivity to RH by 7% in comparison with classical design. The fabrication of this sensor is easy, low cost and fully compatible with usual CMOS-IC processes on the contrary to most designs based on planar capacitor while providing state-of-the-art sensitivity values. We expect a further increase of sensitivity when removing silicon under the membrane, optimizing holes density into polyimide3 layer and increasing thickness of the polyimide2 insulating layer (Figure 2). Improvements are still in progress as well as the fabrication of a fully humidity smart sensor in SOI (Silicon-on-Insulator) CMOS technology.

Publication:
J. Lacoste et all., Capacitive Humidity Sensor Using a Polyimide Sensing Film, accepted to DTIP conference, Cannes, May 2003.