Network of Excellence on Micro-Optics

Array Waveguide Sensor

SIXTH FRAMEWORK PROGRAMME

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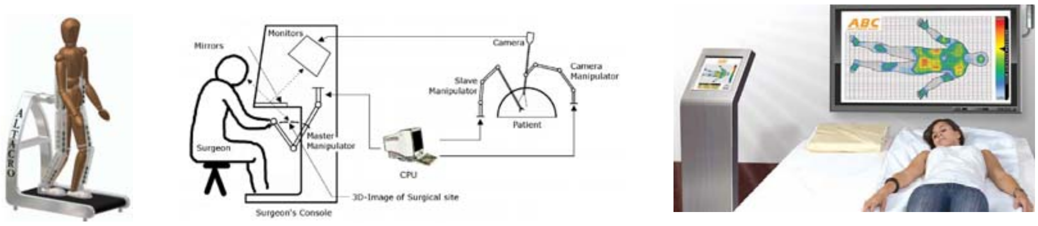
Abstract—This poster describes the fabrication of an artificial optical skin, a flexible foil in which a novel type of optical force sensing element is integrated: the array waveguide sensor. The principle relies on the change in coupling between arrays of crossing waveguides: two layers of polymer waveguides are separated by a thin layer of soft silicone. When no pressure is applied, no crosstalk is detected. When pressure is increasing, the distance between the waveguides decreases and consequently power is transmitted from one to another. This low-cost sensor is ideally suited for small areas with very high densities.

I. INTRODUCTION

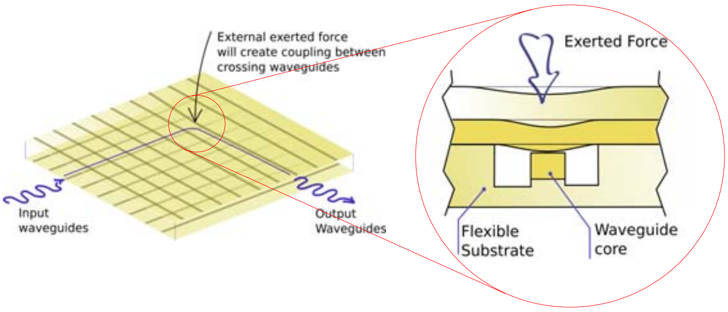
An artificial optical skin is defined as a surface with a large amount of optical sensors (analog to a human skin). The immunity with regard to EMI (electromagnetic interferences), the resistance to harsh environments, the high sensitivity and the possibility in parallelizing the readout all make these sensors attractive and more useful than their electronic counterparts.



The optical sensing foil will be applied to irregular surfaces (e.g. for distributed sensing applications), on movable surfaces (e.g. in robotics) or can be folded into compact modules (for portable devices, automotive, etc.).

II. PRINCIPLE

The principle relies on the change in coupling between arrays of crossing waveguides: two layers of polymer waveguides are separated by a thin layer of soft silicone. When no pressure is applied, no crosstalk is detected. When pressure is increasing, the distance between the waveguides decreases and consequently power is transmitted from one to another.



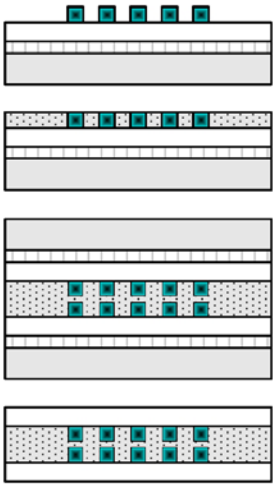
Proof-of-principle demo showing crosstalk between arrays of crossing waveguides, in direct contact, and slightly rotated with respect to each other.

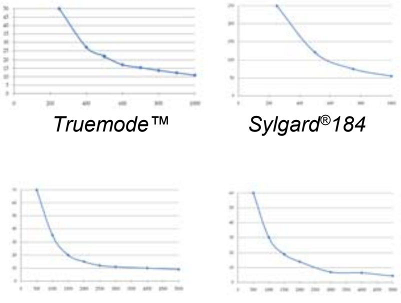
III.PROCESS FLOW

The stack is built on a rigid FR4 substrate on which a double-sided tape and a pyralux foil is attached, to smoothen the release of the flexible layers afterwards. The bottom layer, sylgard®184 (which does not cure in absence of the pyralux foil), is spin-coated at 250 rpm with a film thickness of 250 µm. Sylgard®184 acts as waveguide cladding, protects the sample and makes the skin flexible and even stretchable. The cores of the waveguides are defined by lithography, using Truemode™ (50 x 50 µm²). For the cladding layer between two waveguide layers, the silicone sylgard®527 is used. Other silicones (SE 1740, sylgard®184) are evaluated as well, but do not allow for crosstalk. Spin-coating sylgard®527 on top of the 50 µm high waveguides, results in a non-uniform layer with bad step coverage. For that reason doctor blading is used.

This stack is fabricated twice, and bonded together with a thin (6 µm) spin-coated layer of sylgard®527 in between.

Finally the rigid substrates, tape and pyralux are removed. The adhesion of the tape loses its strength when heated above 125 °C, simplifying the release process.



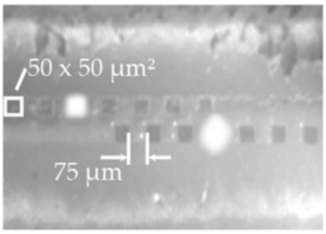


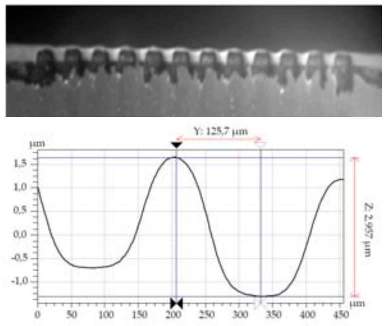
Truemode™
Sylgard®184
SE 1740
Sylgard®527

Layer thickness (µm) as function of spin-speed (rpm) for the different materials.

IV.RESULTS

The sensor is evaluated by coupling light in the lower waveguide and observing a cross-section with a CCD camera. When pressure is applied crosstalk becomes visible. Because the two layers of waveguides are rotated with respect to each other, crosstalk is seen more to the left in the image below.





Cross-sectional view and optical profile measurement showing the planarization after doctor blading of the soft silicone on top of the 50 µm high waveguides.

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