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Tunable Fabry-Perot Optical Filter with a Resonant Cavity Based on a Piezoelectric Polymer

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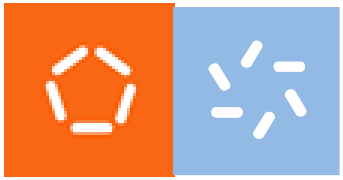

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Introduction

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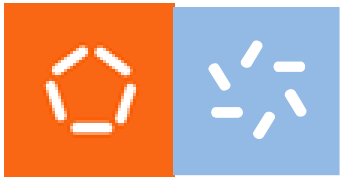

- Tunable Fabry-Perot optical filter with its resonant cavity based on a piezoelectric polymer, for application in the biochemical analysis of biologic fluids.
- The filter is composed by two thin-films of silver -mirrors- located parallel one to the other and separated by a nanometer size thin polymer film of poly(vinilidene fluoride), PVDF, in its β-phase.
- When applying an electrical voltage to the mirrors, the thickness of the polymer changes, changing the distance between the mirrors and thus modifying the response of the filter.

Motivation

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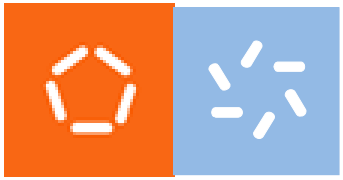

- The analysis of biological fluids has shown to be a very important factor in the detection and/or treatment of illnesses.
- Normally the analyses are performed in central laboratories dislocated from the doctor's office, being their results available only some hours or even days later.
- In order to avoid the drawbacks existing in conventional analysis devices, it is being developed small portable and easy of use devices that provide higher comfort to the patient.

Laboratoy Mycrosystem

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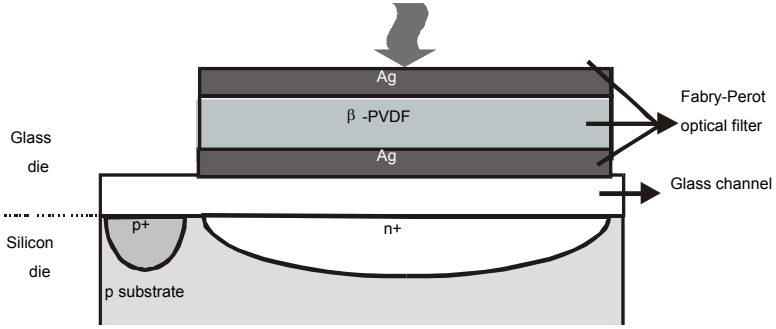
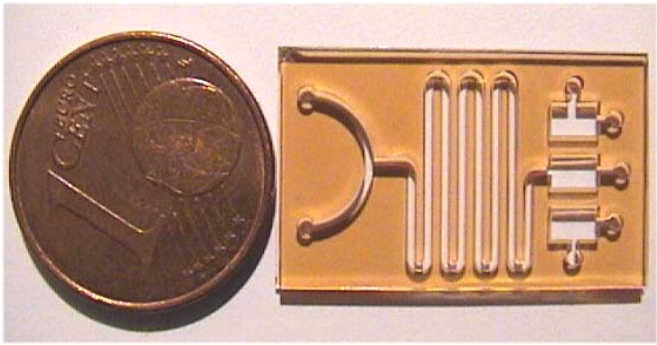
- The device is composed by a glass die and a silicon die.
- The glass die contains the fluid channels and the tunable optical filter.
- The silicon die includes a photodetector and readout electronics, fabricated in CMOS.



Cross-section of the laboratorial microsystem



Structure of the Microchannels based on SU-8

Tunnable Fabry-Perot

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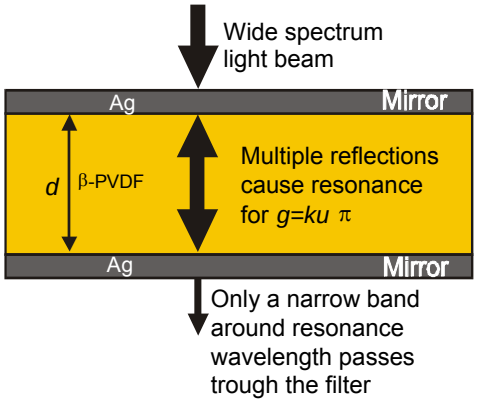
- The resonant condition is achieved when the phase change in the dielectric is null.
- By applying a DC field to the β-PVDF, the dipolar orientation will change, having influence in the thickness of the film.
- Therefore, it is a Fabry-Perot optical filter, where the thickness of the resonant cavity determines the tuned wavelength.



Fabry-Perot optical cavity.

β-PVDF

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- As the best all-round piezoelectric polymer is still poly(vinylidene fluoride) - PVDF, in its β-phase, this material was used as the active part of the Fabry-Perot filter.
- Piezoelectric material: two effects can be used in order to be implemented in the filter: the application of an ac-voltage that will change the dimensions of the film, or the application of a dc- voltage that will mainly act on the dipolar orientation and consequently in the polymer dielectric response.
- In the first case, the thickness variation affect the wavelength response
- In the second case, the transmittance will be affected.
- Main advantage: the ability to maintain the mirrors parallel.

Fabrication

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Tunable optical filter

- The optical filter is fabricated on the top of the glass die.
- The first fabrication step is the deposition of the thin silver contact layer (30 nm thick) on the glass, by thermal evaporation process.
- Then, a 300 nm thick β-PVDF film is deposited on the silver contact by spin coating.
- A second layer of silver is deposited over the β-PVDF film.

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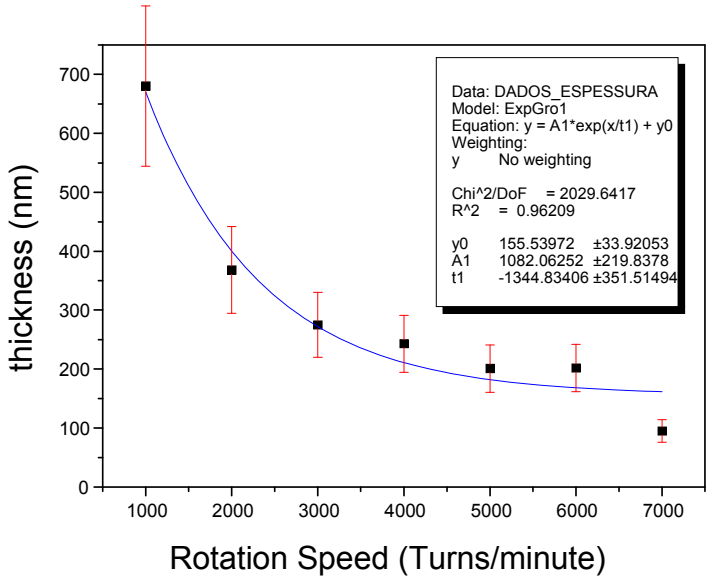
- The thickness of 300 nm for the β-PVDF film is achieved by controlling the rotation speed of the spin-coater.
- For a constant density and time of spinning, the thickness decreases exponentially with the speed.



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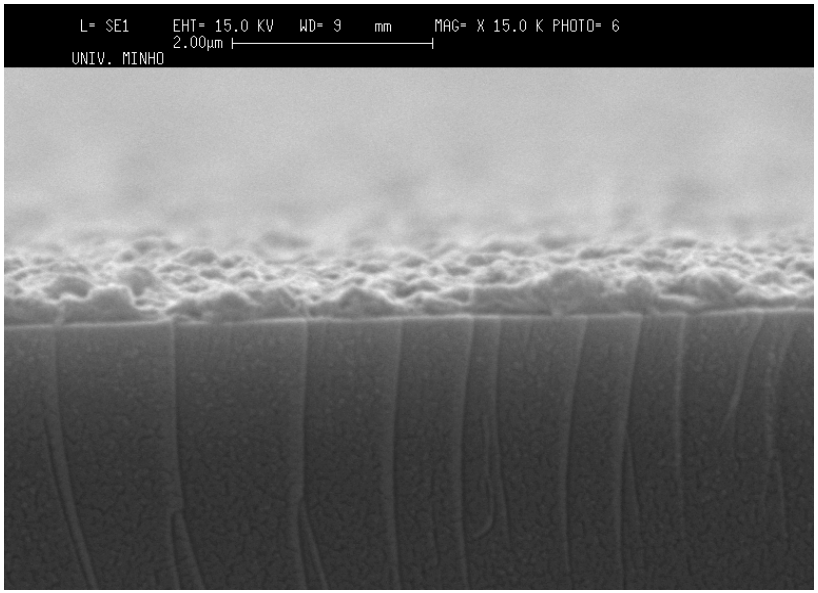
- SEM picture of a cut-off of the β-PVDF film on glass.
- The film is homogeneous and the microstructure can be tailored by pressure and/or temperature treatment.



Experimental results

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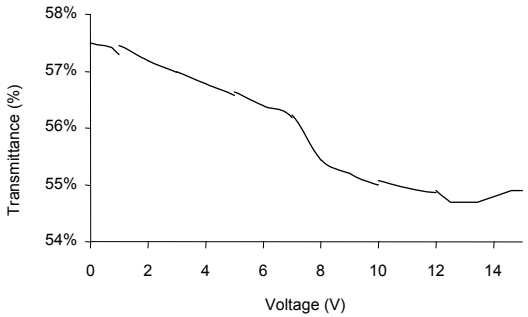
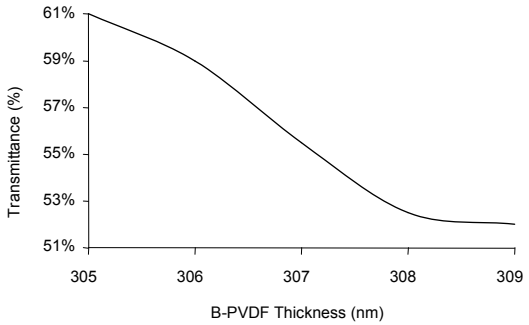
- A voltage between 0V and 15V was applied to the silver mirrors.
- There are changes in the behavior of the filter with the increase of the applied voltage.
- Simulations show that the variation of thickness of the β-PVDF produce the same behavior.



Measured transmittance vs applied voltage



Simulated transmittance vs cavity thickness

Conclusion

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- The concept, fabrication and performance of a tunable Fabry-Perot optical filter with a piezoelectric polymer as the resonance cavity were reported.
- Due to this cavity material, which features thickness variations at a molecular level, the ability to maintain parallel mirrors, during the tuning of the filter, is achieved.
- The filter can be an integrated part of portable (bio)chemical micro total analysis systems once it enables the spectrophotometric measurements using only white light source