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# Disposable Micro-Cantilever Arrays for Sensing

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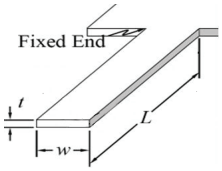
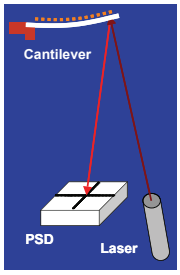
## INTRODUCTION

Micro-fabricated cantilevers, similar to those used in scanning probe microscopes, have become increasingly popular as transducers in chemical and biological sensors. In the field of biomedicine, silicon-based micro-cantilevers are applied but they are often too expensive for single usage. Polymer materials offer tailored physical and chemical properties including biocompatibility that can be combined with low-cost mass production. We have established the injection molding technique to fabricate different polymer cantilever arrays with dimensions in the micrometer range to be functionalized and calibrated for applications in biomedicine.

## CANTILEVER SENSORS




$L$ = 500 µm

$w$ = 100 µm

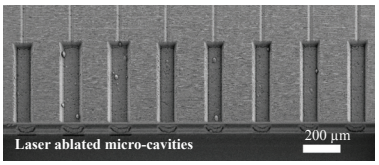
$t$ = 20 - 50 µm

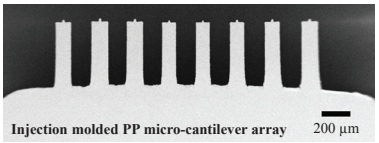
Spring constant:

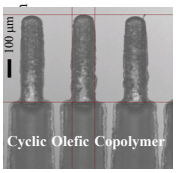
$$k = \frac{Ewt^3}{4L^3}$$

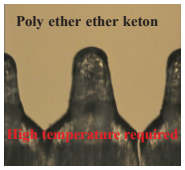
Cantilever sensing involves detection of cantilever bending. Adsorption of analytes onto the functionalised cantilever surface produces a differential stress between the two surfaces and induces bending.

## FABRICATION



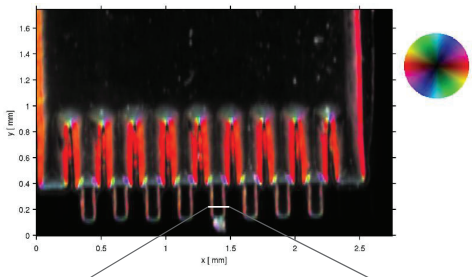



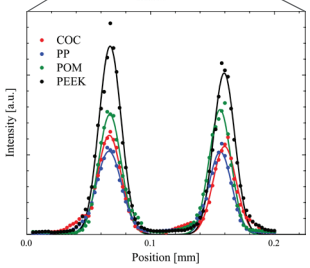

Process: Injection molding (IM)
- mass fabrication
- different polymers

Mold: Fine grain size steel molds
- laser ablation
- precise micro machining
- high aspect ratio (L/t)

## CANTILEVER NANOSTRUCTURE

Orientation map of micro-cantilevers in the periodicty 418-286 nm



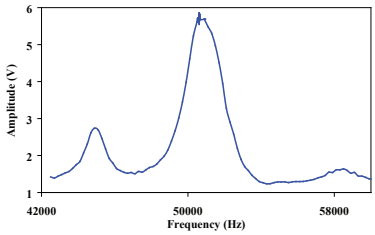

Small angle X-ray scattering reveals
- degree of order
- long-range order orientation of nanostructures
- orientational anisotropy
- nanostructures oriented at the rim region
- prominent rim (~9 µm) region for all polymers

## CHARACTERISATION RESULTS

PVDF micro-cantilever resonance frequencies measured.
Calculated resonance 30 µm – 58.6 kHz, 40 µm – 78.2 kHz

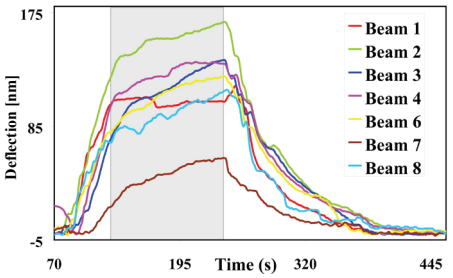
| Beam No | Measured (kHz) 30 µm thick | | Measured (kHz) 40 µm thick | |
|---|---|---|---|---|
| | Air | Water | Air | Water |
| PVDF 1 | 79.42 | 41.12 | 79.99 | 61.15 |
| PVDF 2 | 54.7 | 41.12 | 77.58 | 61.16 |
| PVDF 3 | 59.86 | 41.12 | 79.99 | 61.12 |
| PVDF 5 | 61.99 | 41.12 | 80.86 | 61.37 |
| PVDF 6 | 47.04 | 41.12 | 74.91 | 61.16 |
| PVDF 7 | 68.93 | 41.20 | 70.69 | 61.43 |
| PVDF 8 | 76.5 | 41.12 | 77.61 | 61.47 |

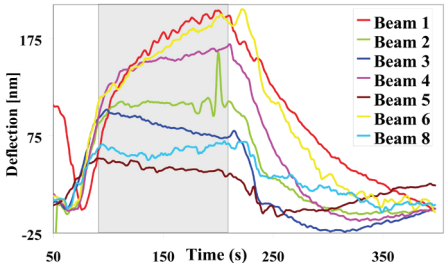
Resonance peak of PP micro-cantilever in air




- Dynamic measurements
- Q factor good - sharp resonance
- Measurements in air reliable
- Resonance of PP,PVDF;POM measured

## HEAT TEST RESULTS




Heat test (25 °C to 35 °C) on PVDF micro-cantilevers in air (left) and water (right). Grey area shows temperature at 35 °C

$$\delta = \frac{3\sigma(1-\nu)}{E}\left(\frac{L}{t}\right)^2$$

- Static measurements
- Nm deflection : Sensitivity nN
- Thiol bending tests successfull
- Damping of polymers in liquid

## CONCLUSION AND ACKNOWLEDGEMENT

Micro-cantilever arrays from Cyclic Olefin Copolymer (COC), Polyoxymethylen Copolymer (POM-C), Polyvinylidenflouride (PVDF) and Polypropylene (PP) have been successfully injection molded. The heat and thiol tests imply that the cantilevers are mechanically compliant for use in biochemistry and biomedicine. The structural characterization using SAXS reveals orientational anisotropy and long-range orientation of nanostructures leading to deviations in mechanical properties. The target of this research is the micro-cantilever array to quantify the cell-material interactions and the molecule adsorption under intentionally modified conditions.

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