MAMINA GROUP

Matériaux et Acoustique pour les MIcro et NAno systèmes intégrés

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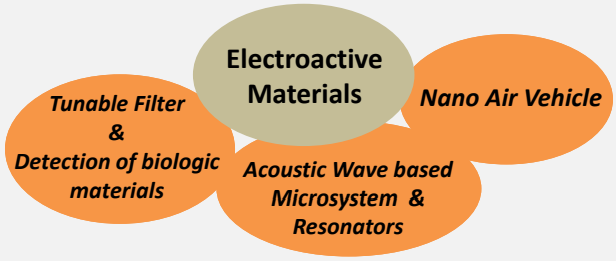
RESEARCH ACTIVITIES OF THE MAMINA GROUP

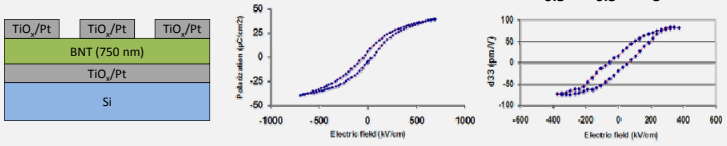


INNOVATION IN MATERIALS ARE DRIVING NOVEL APPLICATIONS

- Long term work on the fabrication and characterization of active materials (piezoelectric materials, ferroelectric materials, electroactive polymers)
- Integration of these materials into microsystems (based on III-V semiconductors, silicon, glass, polymer)
- Development of finite element and analytical models
- Electrical and mechanical characterizations
- Designing and fabrication of devices based on MEMS technologies

ELECTROACTIVE MATERIALS

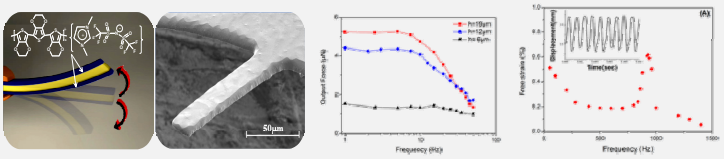
Ferroelectric & piezoelectric properties in lead-free $Bi_{0.5}Na_{0.5}TiO_3$ films



Dielectric Results : ε_r = 520, tanδ = 3%
Ferroelectric Results : Pr= 5 µC/cm2, Ec= 55 kV/cm
Pmax= 40 µC/cm2 at 700 kV/cm,

Piezoelectric results : d_{33}max= 83 pm at 400 kV/cm
d_{33}remant= 17 pm

Conducting Interpenetrating polymer network thin films



Results :
Self standing micro-beam transducers
High speed actuation

Perspective :
- Production of demonstrators in soft devices

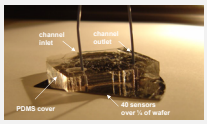
DEVICES

Lab-On Chip for high frequency acoustic characterization

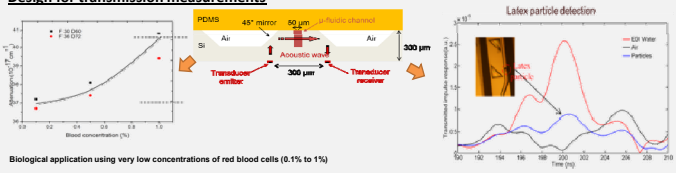
Acoustic wave based Microsystems

Acoustic evaluation (GHz) of wetting on pillar array

Toward acoustic microscopy (1 GHz) in Lab-On-Chip :
- State of the art : **Integrated device** for RF Filter applications
No integrated device for HF ultrasonic biosensors
- Interest : High resolution → **local investigation** (1.5 µm)
→ **small volume characterization** (~ 250 nl)
Non destructive, on line elastic characterization



Design for transmission measurements



Biological application using very low concentrations of red blood cells (0.1% to 1%)

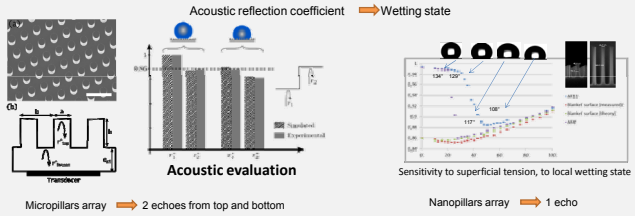
Results :
High frequency acoustic wave guiding on silicon chip
Red blood cell concentration evaluation
Micrometer size particle detection

Perspective :
Cell mechanical properties evaluation
Application to single cell handling and sorting
(higher power /lower frequency)

Classical evaluation : contact angle observation
Interest of acoustic: Local measurement at the interface solid/liquid

Microscale characterization → **Nanoscale characterization**

Acoustic reflection coefficient → Wetting state



Micropillars array → 2 echoes from top and bottom

Nanopillars array → 1 echo

Results :
Local and dynamic evaluation of wetting state at micro and nanoscale

Perspective :
- Evaluation of wetting efficiency of etching and cleaning solutions for nanoelectronic applications
- Application to nanostructures /biological objects interfaces

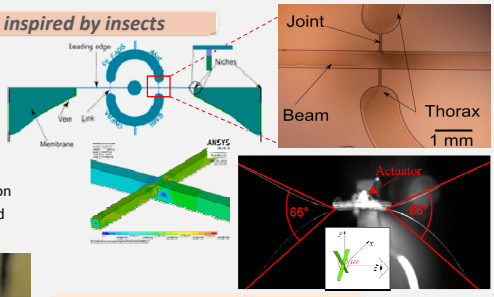
Nano air vehicle

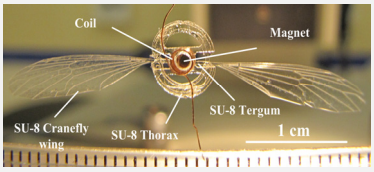
Interest :
- Study and understanding of flapping flight at the insect scale
- Development of a complete and autonomous flying vehicle mimicking the insect flight and relying on MEMS technology and microelectronics

Targeted applications :
- Overseeing of hazardous environment
- Search and rescue missions
- Monitoring of elderly
- Information gathering
- Pollination

Structure design inspired by insects

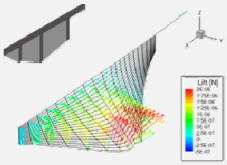
- Mimicking the **insect actuation** through a **resonant thorax**
- No transmission system
- Direct coupling between the tergum and the wings thanks to compliant torsional hinges
- Structures fully in **SU-8** and **PDMS** membranes
- **Easy**, **reliable**, **fast** and **cost-effective** fabrication
- Increased **robustness** through the **material** and **resonant wings concept**





Aeroelastic framework: a preliminary design tool

- Balance and interaction between the aerodynamic and structural loads accounted throughout the stroke
- Aerodynamic model based on the **quasi-steady analysis of insect flight**
- Structural model handles **non-linearities**
- Automatic computation and post-processing with **Python + Ansys**



Perspective :
- Improvement of the flapping kinematics
- Increase of the actuation efficiency
- Optimization of wings towards lift-off

ACADEMIC COLLABORATIONS AND INDUSTRIAL COLLABORATIONS

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