Micromechanical Systems for Laser Phonosurgery
A Review : Micro-actuators and Compliant Structures

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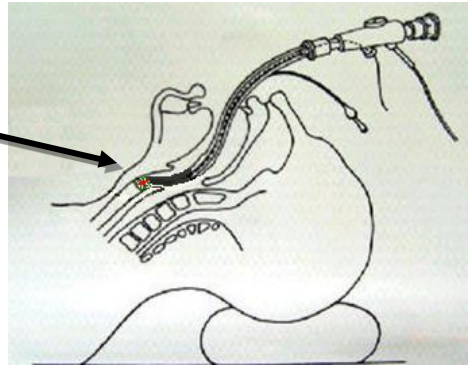
Contents

1. Context

µRalp *1 Project objectives:

- ✓ Increased quality of the intervention.
- ✓ Increased accessibility
- ✓ More precision

Systems to guide the laser



*1 www.microralp.eu

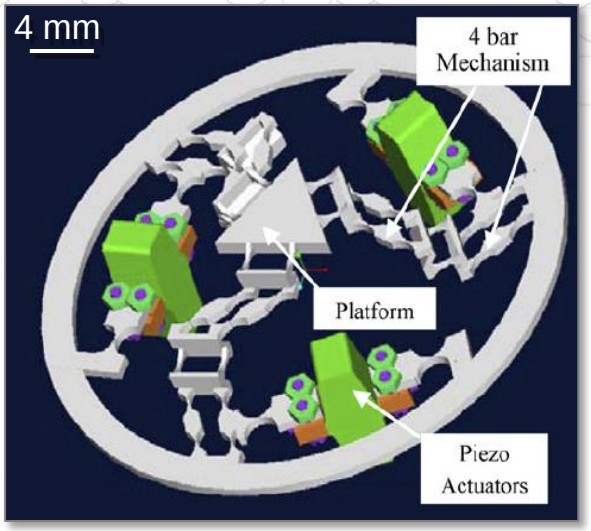
1. Context

• We need to put the systems that guide the laser inside larynx

• By the reduced space, it is necessary to use micromechanical systems

These are designed in accordance with:

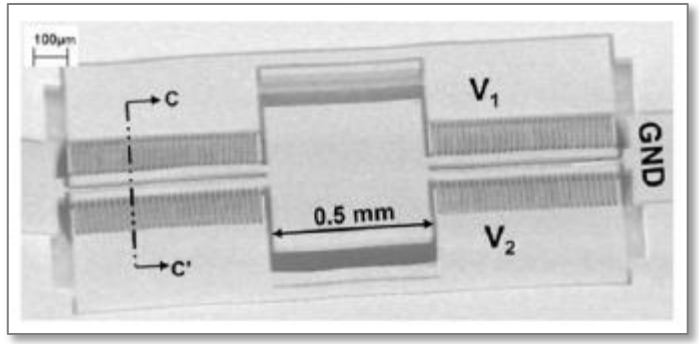
- ❖ Requirements of the task
- ❖ The constraints of the micro world



Platfond XY- Qing Yao 2008
University of Illinois at Urbana-Champaign

To build micromechanical systems:

- ➢ Micro-actuators
- ➢ Compliant structures



Micromirror - Milanovic 2004

2. Micro-actuators

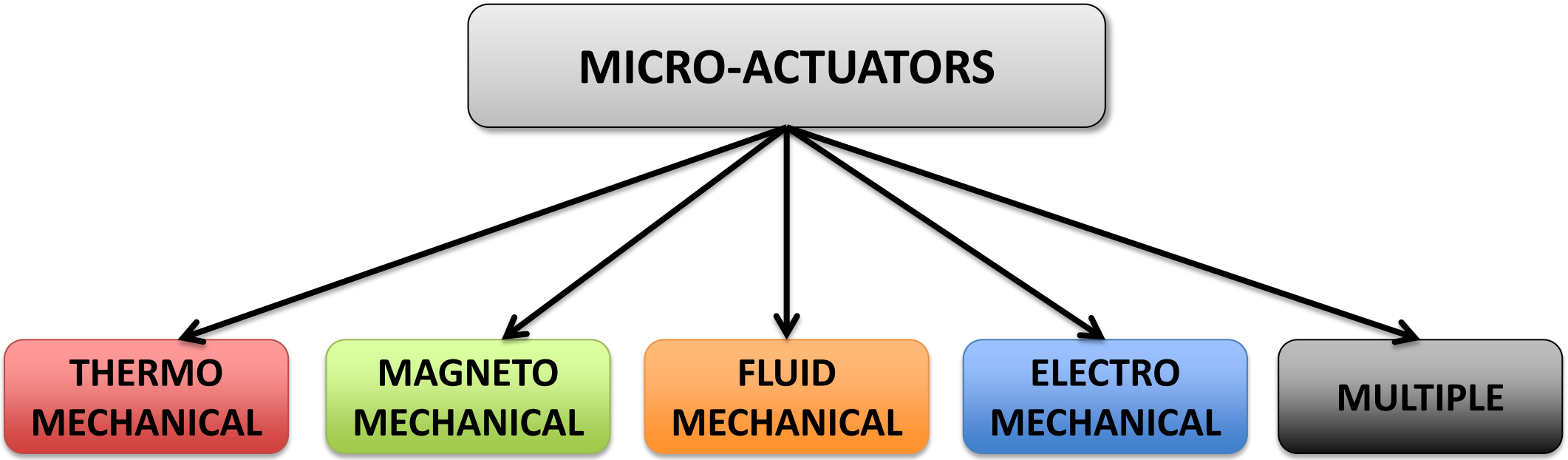
- Micro-actuators are vital in generating movements in micromechanical systems

- These are selected by evaluating the following functionalities:

  - ❑ Input energy
  - ❑ Power consumption
  - ❑ Amplitude of deformation
  - ❑ Micro-actuator dimensions
  - ❑ Technology - easy of use
  - ❑ Repeatability and Bandwidth
  - ❑ Force and torque to be developed
  - ❑ Stiffness
  - ❑ Cost
  - ❑ Biocompatibility

2. Micro-actuators

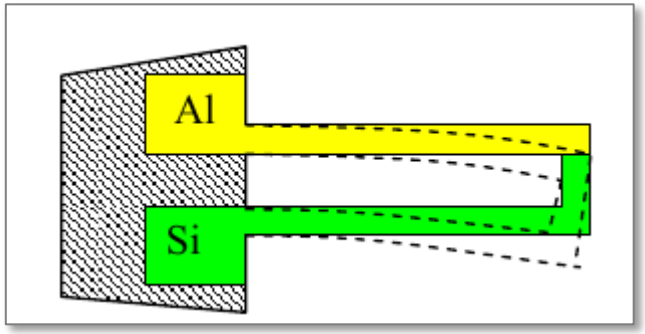
Classification of micro-actuators based on the supplied input energy



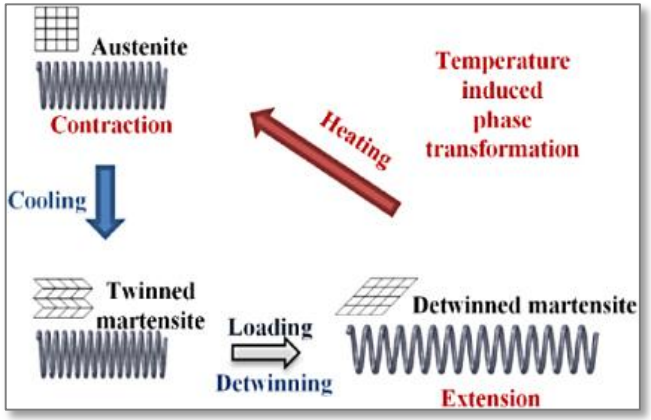
2. Micro-actuators

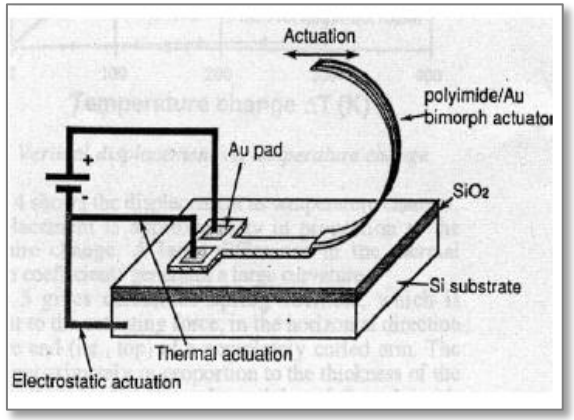
Thermo-mechanical actuators:

1) Micro-actuators obtained by thermal expansion of a solid **(displacement)**



2) Shape Memory Alloy Micro-actuators (SMA) **(deformation)**





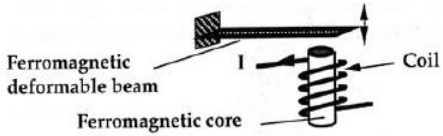
- ✗ ❑ Input energy
- ✗ ❑ Power consumption
- ✓ ❑ Amplitude of deformation
- ✓ ❑ Micro-actuator dimensions
- ✓ ❑ Technology ease of use
- ✗ ❑ Repeatability
- ✗ ❑ Bandwidth
- ✗ ❑ Force and torque
- ✓ ❑ Stiffness
- ✓ ❑ Cost
- ✓ ❑ Biocompatibility

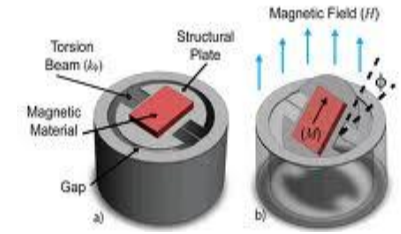
2. Micro-actuators

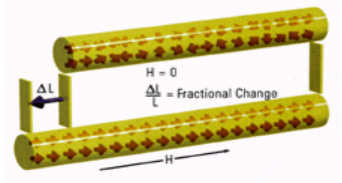
Magneto-mechanical actuators:

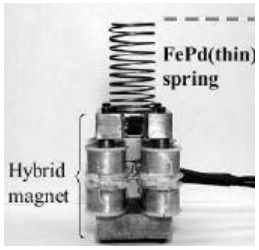
Magneto mechanical

- **MAGNETIC** — Displacement
- **MAGNETO STRICTIVE** — Deformation
- **MAGNETIC SMA** — Deformation
- **MAGNETIC FLUID** — Displacement









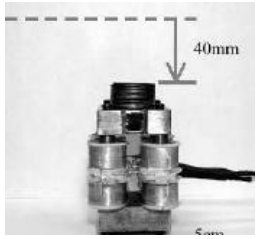


Image courtecy: Ferrotec

- ✗ ❑ Input energy
- ✗ ❑ Power consumption
- ✓ ❑ Amplitude of deformation
- ✓ ❑ Micro-actuator dimensions
- ✓ ❑ Technology ease of use
- ✓ ❑ Repeatability
- ✗ ❑ Bandwidth
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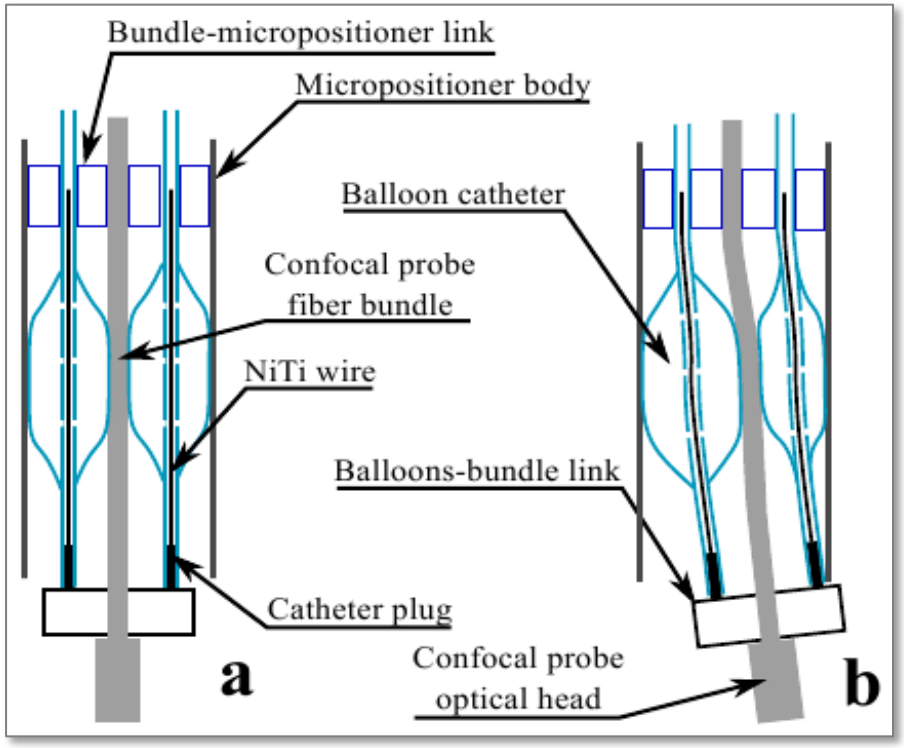
- ✓ ❑ Cost
- ✗ ❑ Biocompatibility

2. Micro-actuators

Fluid-mechanical actuators:



- ✓ ❑ Input energy
- ✓ ❑ Power consumption
- ✓ ❑ Amplitude of deformation
- ✗ ❑ Micro-actuator dimensions
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- ✗ ❑ Repeatability
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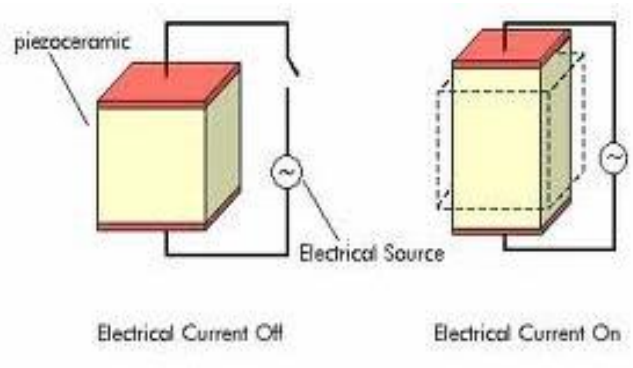
- ~ ❑ Force and torque
- ✗ ❑ Stiffness
- ✓ ❑ Cost
- ✓ ❑ Biocompatibility

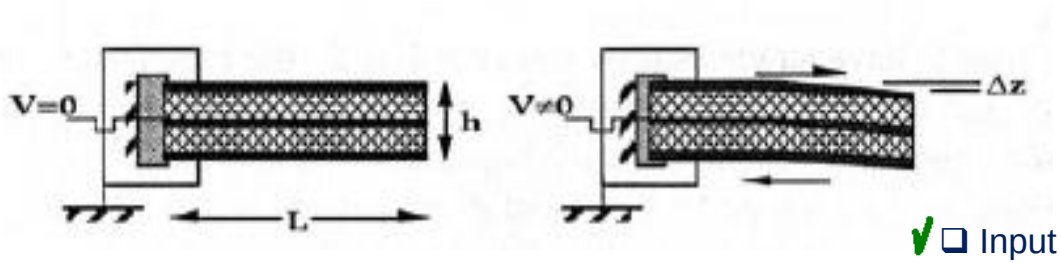
Rosa et al. Laparoscopic Optical Biopsies: In vivo Robotized Mosaicing with Probe-based Confocal Endomicroscopy -- IROS 2011 pp 1339 - 1345

2. Micro-actuators

Electro-mechanical actuators:

1)Piezoelectric Micro-actuator **(Deformation)**





- ✓ ❑ Input energy
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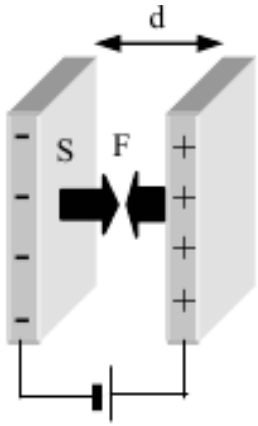
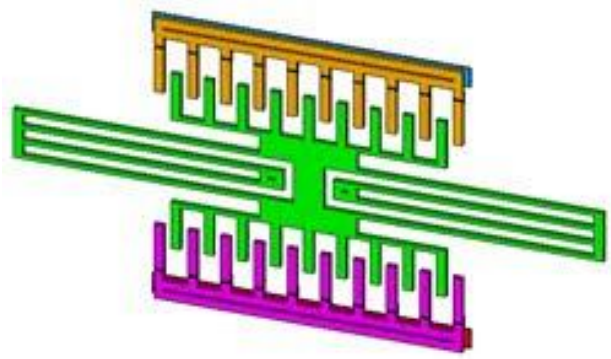
2)Electrostatic Micro-actuator **(Displacement)**



$F=KV/d^2$

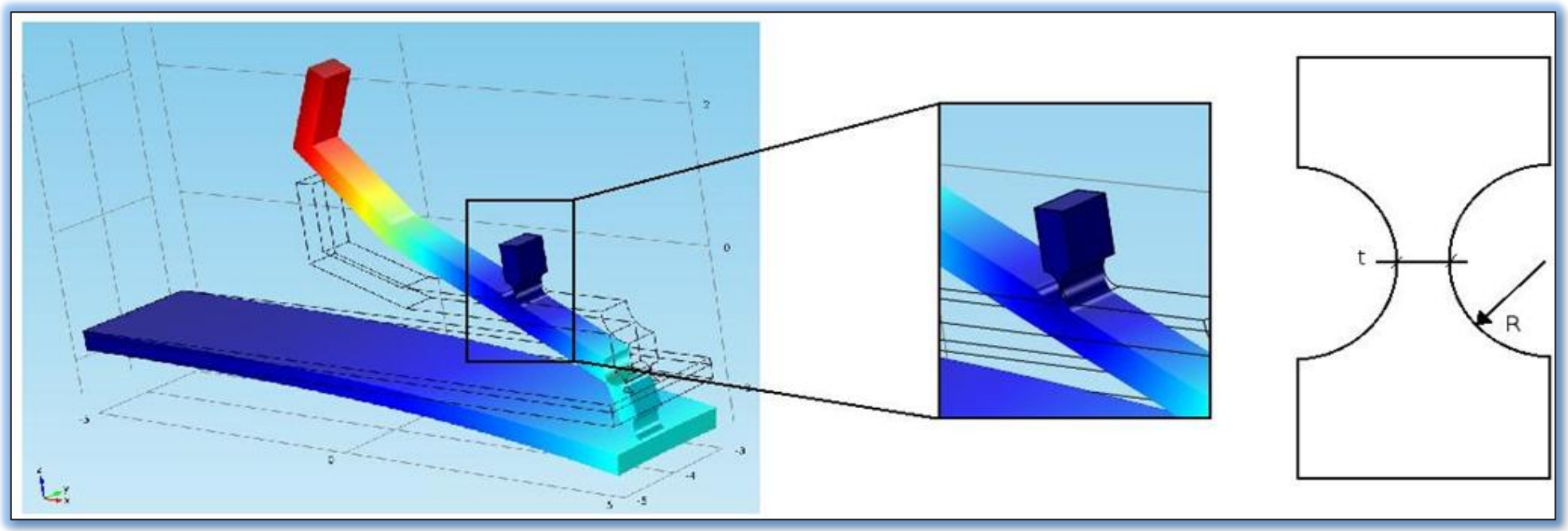


3. Compliant structures

- Micro-actuators are responsible for generating displacements
- Compliant structures are responsible for the transmission of these displacements
- Main proprieties and capabilities:
  - ✓ Frictionless
  - ✓ No lubrication is required
  - ✓ No Backlash due to mechanical clearances
  - ✓ Compatible with micro-scale
  - ✓ Easy to fabricate
  - ✓ almost no maintenance

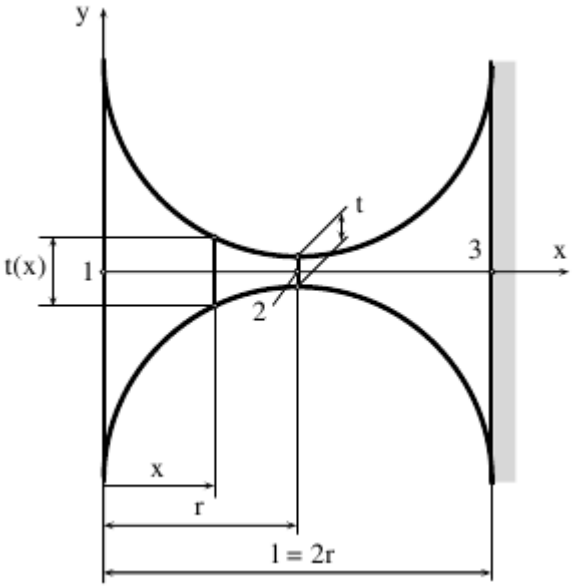
3. Compliant structures

Flexible hinge - usability:



Simulation using Comsol

3. Compliant structures



$$t(x) = t + 2[r - \sqrt{x(2r - x)}]$$

Hook's law

$$\begin{Bmatrix} \{u_1^{ip}\} \\ \{u_1^{op}\} \end{Bmatrix} = \begin{bmatrix} [C_1^{ip}] & 0 \\ 0 & [C_1^{op}] \end{bmatrix} \begin{Bmatrix} \{L_1^{ip}\} \\ \{L_1^{op}\} \end{Bmatrix}$$

C matrix -→ by the Castigliano's second theorem

For SiO_2 (E=70e9 Pa G=0.17) and with loads of 0.05 N

t=20 μm r=150 μm $\rightarrow \theta = 45°$

*1 Lobontiu book: Compliant Mechanisms Design Flexure Hinges

*2 Y. Koseki et al. Kinematic Analysis of translation 3-DOF micro Parallel Mechanism Using Matrix Method – IROS 2000 (pp 786 - 792)

4. Summary

- To build micromechanical systems we need:
  - ✓Micro-actuators
  - ✓Compliant Structures

- Piezoelectric micro-actuator has been chosen:
  - ✓by its functionalities
  - ✓by background in Femto-st

- Compliant structures are calculated in according to the capacity of the micro fabrication

THANK YOU ☺