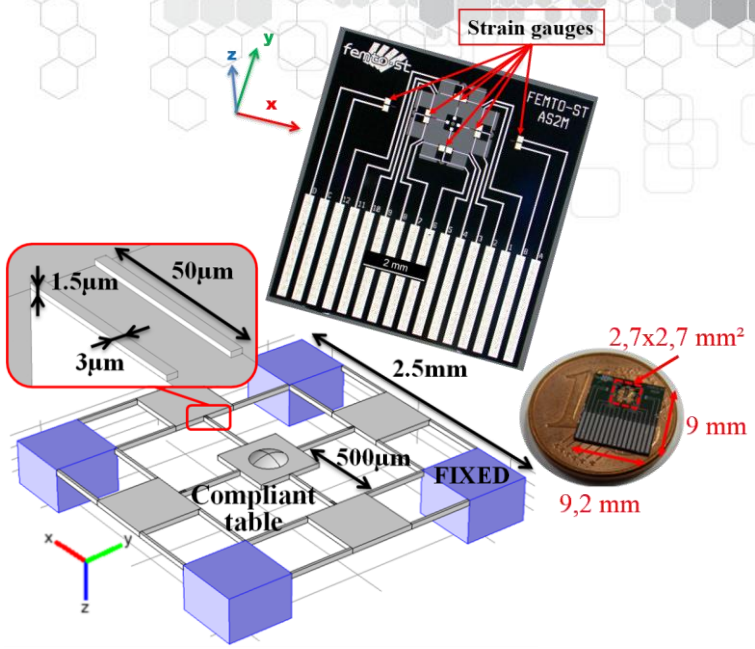
# Multi-axis MEMS force sensor for measuring friction components involved in dexterous micromanipulation

## Research framework

The objective is the development of a bulk multi-DOF MEMS microforce sensor for a new kind of nanotribometer enabling to characterize the finger/object contact involved in dexterous micromanipulation. At the nanoscale and for this particular application, two Degrees of Freedom nanotribometers are no longer adequate for studying and characterizing the contacts. Therefore, the MEMS sensor has to display a flexible structure which allows torsion moves in order to access to all the components of friction simultaneously, ie sliding, rolling, and spin motion, with high sensitivities and acceptable crosstalks, both in air and vacuum. The developed MEMS sensor is composed of a central platform with a fixed microball and surrounded by four compliant tables. Its sensing ability is based on piezoresistivity: four sets of piezoresistors are symmetrically distributed at the root of four central beams. First prototypes have been manufactured at MIMENTO in FEMTO-ST at Besançon on a five layers p-type Silicon on Insulator wafer (SOI), in order to obtain a compliant structure as perfect as possible.

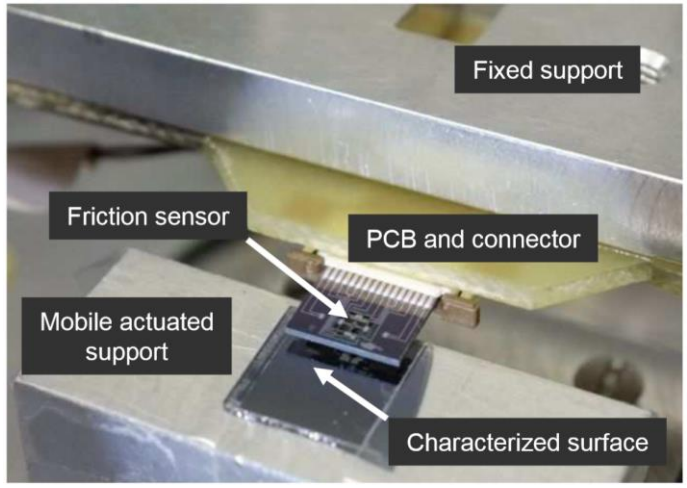



First sensor prototype

## Sensor characteristics (1)

Principle: compliant 6-DoF elastic structure with piezoresistive strain gauges.
Force measurement: Fz (normal force), Fx,y (tangential force corresponding to sliding), Mx,y (moments corresponding to rolling) and Cz (torque corresponding to spin motion).
Stiffness: Fx,y : ~4,10 kN/m ; Fz : ~2,31 kN/m.
Expected resolution: x,y < 1 µN ; z : ~1 µN. Max range: Fx,y : 30 mN; Fz : 20 mN.
Expected crosstalks: Fx,y/Mx,y < 1 %. First resonance frequency: x,y,z > 35 kHz.

(1) depend on the design and dimensions of the sensor.




Complete platform for multi-asperity friction characterization

**Major article:** Multi-axis MEMS force sensor for measuring friction components involved in dexterous micromanipulation: design and optimisation – M. Billot, X. Xu, J. Agnus, E. Piat, Ph. Stempflé – International Journal of Nanomanufacturing, vol. 11, no. 3/4, pp. 161–184, DOI: 10.1504/IJNM.2015.071924, 2015

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