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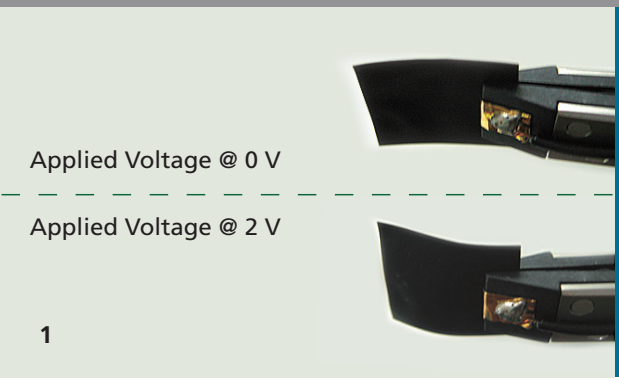

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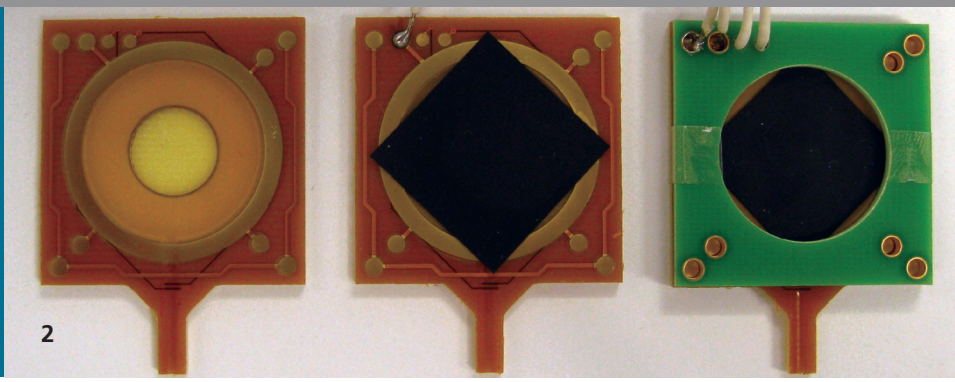

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1 Actuation of the three-layered CNT actuator (©AIST Kansai)
2 3 steps in manufacture (left to right): 1) Pipette with laser-cut membrane, 2) CNT actuator glued onto membrane and 3) with cover electrode.

JOINT APPLICATION DEVELOPMENT FOR NEW MATERIALS - PIPETTE WITH CNT ACTUATOR

Motivation

Carbon nanotube (CNT) actuators has always presented several advantages over materials currently in use – piezoceramics and shape memory alloys. They can offer higher work per cycle than previous actuator technologies and generate much higher mechanical strength. Additionally, CNTs require very low driving voltages for their operation what in many cases presents the major advantage. Another benefit is the direct conversion of electrical energy to mechanical energy followed by high actuation strain, high strength, high elastic modulus and low density. These features can be utilized in such applications as micropumps, molecular motors or nanorobots.

Among many research groups active in this field Fraunhofer IPA and AIST Kansai (Osaka, Japan) always belong to the innovative parties. AIST Kansai was the first organisation to publish the results on the development of so called "dry" carbon nanotube actuators, whereas Fraunhofer IPA was the first to disclose a functional model demonstrating applicability of those actuators on a macroscale in a device.

Now in order to strengthen the position of CNT actuator technology and fasten the transfer of scientific results into application development and market introduction both Institutes started the official cooperation in the field of electroactive polymers. The first development resulting from this cooperation is a miniaturized pipette in which the carbon nanotube actuator developed by AIST Kansai was integrated by Fraunhofer IPA with the help of FEM simulation and printed circuit board (PCB) manufacturing methods.

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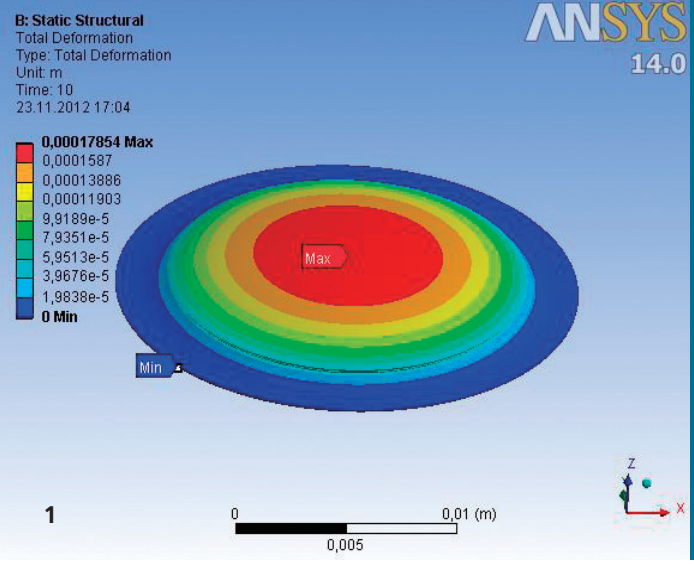
In cooperation with:

AIST



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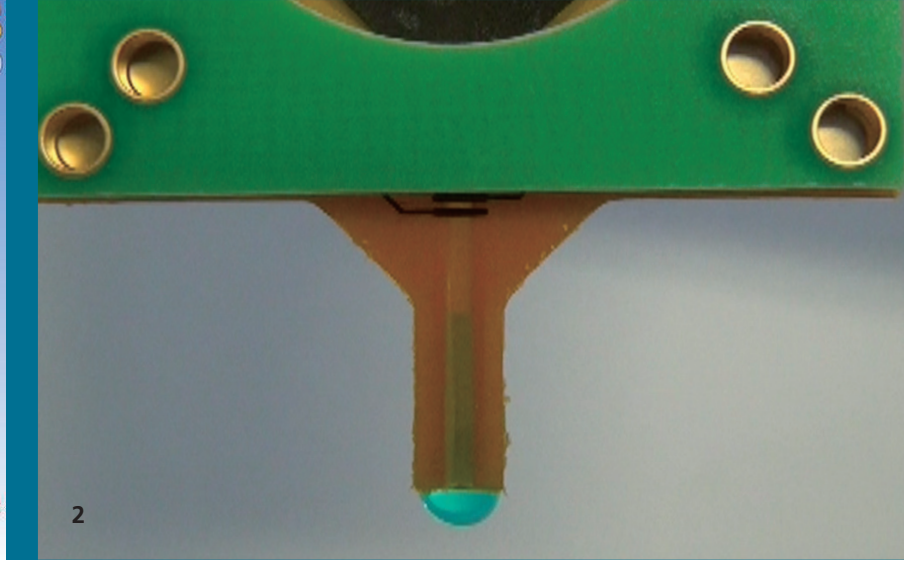

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Example - Pipette with CNT Actuator Our Approach

Automated dosing of small amounts of liquids involves normally quite large pipettes and motors for pipette actuation. Miniaturized pipettes can enable new areas, in which micro dosing is demanded.

Our approach is a direct integration of a bending CNT actuator into a PCB design, which enables a frictionless induction of movement onto a liquid. The driving electronics control the actuator with a low voltage and can be placed on the same PCB. The geometry of the pipette channel, the cavity as well as the membrane opening are generated by milling and laser cutting of standard PCB layers (stiff FR4 and flexible polyimide layers). The CNT actuator is glued on top of this layer stack. Gold electrodes ensure low contact resistance.

Features of our pipette are:

- Nominal fluid and actuation volume: 10 µl (up to 20 µl - single droplet)
- Channel length: 10 mm
- Channel width/height: 1 mm
- PCB integration with contact gold electrodes and electrodes inside the pipette channel to detect the fluid level resistively

Technical Data

- Driving voltage: 2 V
- Capacity: 0.23 F
- Peak current: 0.21 A
- Charging time (10 % to 90 %): 4.1 s

Benefits for Customers

The integration of carbon nanotube actuator technology into application of miniature pipette is in the first place beneficial in the field of micro dosing in medical or (bio-)chemical applications. The demonstrated model offers a compact and energy efficient system with advantage of precise dosing. In a next step, integration of many pipettes into microfluidic control systems offers further extension of current development, and will creation of the "Lab-on-a-PCB" systems for precise and controlled handling of small volumes of liquid. But that is just a beginning and the results of this first demonstration can be transferred to further fields of applications where the advantages of CNT actuators can be utilised for functions such as precise switching, positioning and manipulation.

Taking into consideration that this project was just a starting point in the cooperation between the AIST Kansai and Fraunhofer IPA, it is envisaged that the future activities will bring the transfer and integration of carbon nanotube actuator technology into further market sectors. With the greatest interest coming currently from the medical devices sector, the others are foreseen to follow in the future including such as smart fabrics, digital mechatronics and active vibration control systems. Furthermore, the combination of various functionalities such as actuation, energy storage and energy harvesting, is to be also addressed in the upcoming time.

The general purpose of the cooperation and the value that the partners offer to their customers is the development of materials and their processing towards improved and customised carbon nanotube actuators solutions. Moreover, considering the maturity of the technology the great focus will be given to the application and product development integrating carbon nanotube actuators.

The cooperation partners offer:

- Feasibility studies
- Development of functional models
- Development of demonstrators
- Prototype development

1 *FEM Simulation of CNT actuator and membrane deformation*

2 *Visualization of the pipette action. The CNT actuator pushes the liquid out of the channel to form a droplet.*