Photo-Crosslinked Side-Chain Liquid-Crystalline Elastomers for Microsystems

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Microactuators are an essential component in technologies such as Microsystems or microdevices, and in applications that include artificial muscles, pumps, valves or switchers.[1] The properties of theses materials (actuation strain, reaction speed, density, driving voltage, consumed power), and the possibility of developing small dimension constructions with soft materials, are of high interest for industrial, medical and domestic uses.
Photo-crosslinkable side-chain liquid-crystalline polymers containing photo-reactive benzophenone cores have been synthesized in order to obtain the corresponding liquid-crystalline elastomers.[2-3] This synthetic strategy allows for the obtaining of thin elastomeric films and their integration in silicon based Microsystems for actuators and micromachines.[4]
A model microactuator was constructed (Figure 1) and its thermally controlled response analysed at different voltage rates (Figure 2), showing that the principle can be applied for technological applications: pumps, valves and switches. Such an actuator is suitable for slow, sensitive positioning and gripping movements. On applying an electrical power (voltage at different rates), the nematic-to-isotropic transition induces changes of the liquid-crystalline elastomer film length that causes strains up to 150% in the microdevice.
New machines are under construction, where movements are produced by mechanical forces caused by either changes in temperature (due to external voltage[5] or light) or by photo-isomerization (induced by light).

(1) Y. Bar-Cohen, *"Electroactive Polymer Actuators as Artificial Muscles: Reality, Potential, and Challenges"*, 2nd Ed., SPIE Press Monograph, **2004**, Vol. PM136

(2) A. Komp, J. Rühe, H. Finkelmann *Macromol. Rapid Commun.* **2005**, *26*, 813

(3) J. Schmidtke, S. Kniesel, H. Finkelmann *Macromolecules* **2005**, *38*, 1357

(4) M. Bründel, M. Stubenrauch, H. Wurmus, A. Sánchez-Ferrer *International Newsletter on Micro-Nano Integration* **2004**, *4*, 38

(5) T. Fischl, A. Albrecht, H. Wurmus, M. Hoffmann, M. Stubenrauch, A. Sánchez-Ferrer *Kunststoffe* **2006**, *96*, 30

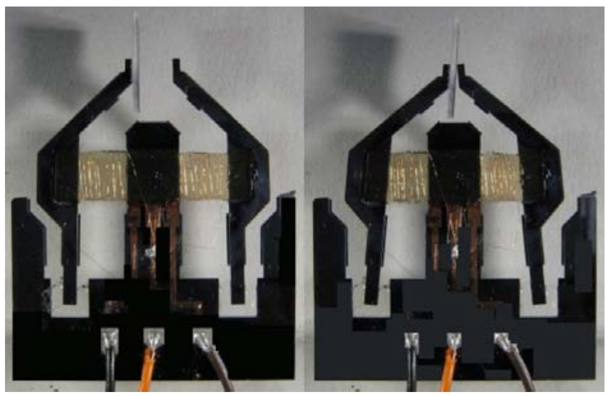

Figure 1. Open (left) and closed (right) liquid-crystalline elastomeric microgripper

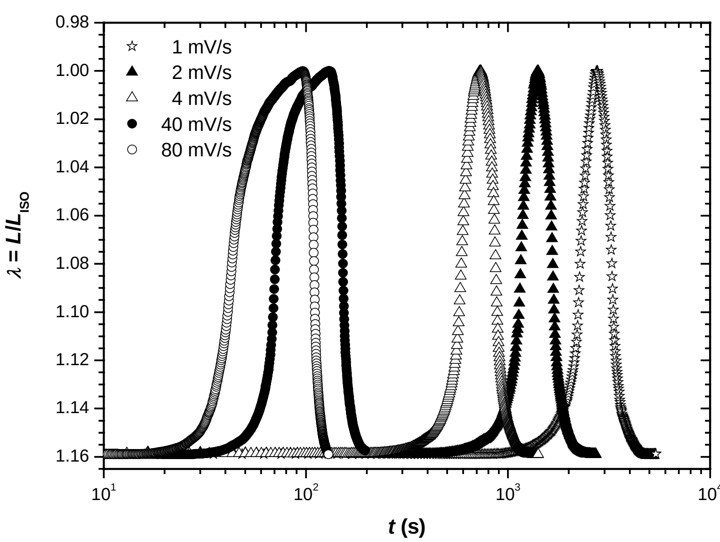

Figure 2. Thermal contraction-expansion (λ) vs. time at different voltage rates. The response time can be modulated from voltage rates of 1 mV/s (t_{max} = 46.1 min) to 80 mV/s (t_{max} = 1.6 min)