Microsystems Based on the Biological Functions of Insects

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At our laboratory, we are studying on new machinery systems in an interdisciplinary research field between engineering and biology : micromachines, robotics and neuroethology. We are particularly interested in the creation of microsystems modeled on the biological functions of insects and micro-devices designed to help us learn more about biological functions. This article describes some of our main research projects.

Microsensors modeled on the biological functions of insects

We have developed a visual sensor modeled on the compound eyes of insects. Figure 1 shows the visual sensor system consisting of a micro-lens array, a photo-diode array, and an electrostatic microactuator. It is known that insects recognize objects with the aid of minute oscillations of the retina. The visual sensor produces the same effect as the oscillating retina of the insect by scanning the visual axis through oscillating slits operated by the actuator. Significantly, the sensor can be made no thicker than a sheet of paper, making it eminently suitable for the flexible visual devices of the future.

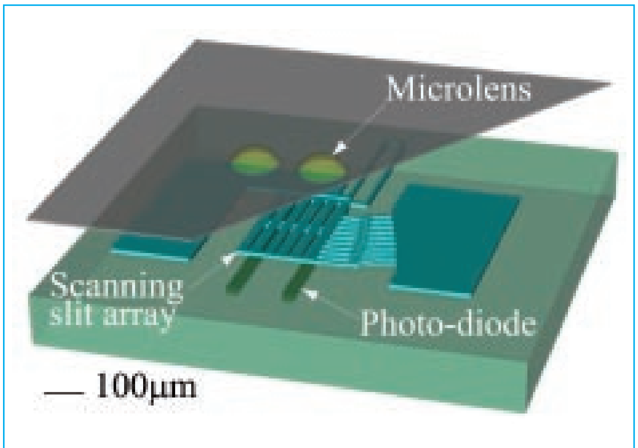

Fig. 1 Visual microsensor modeled on a compound eye

Crickets and cockroaches have thin sensory hairs on a pair of organs extending caudally from the abdomen. Air flow around the insect deflect the sensory hairs, generating mechanical distortion at the base of the hairs which is converted to neurosignals. Figure 2 shows the fabricated air flow sensor modeled directly on this principle. A metal wire is fixed to the center of a supporting cross-beam structure. Movement in the surrounding air causes the wire to bend, generating distortion at the fixed ends of the beams. The distortion is detected by semiconductor strain gauges. We are currently trying to integrate multiple sensors. Similar sensory hairs can be found inside human organs such as the semicircular canals of the inner ear. We are also developing a sensor based on this principle.

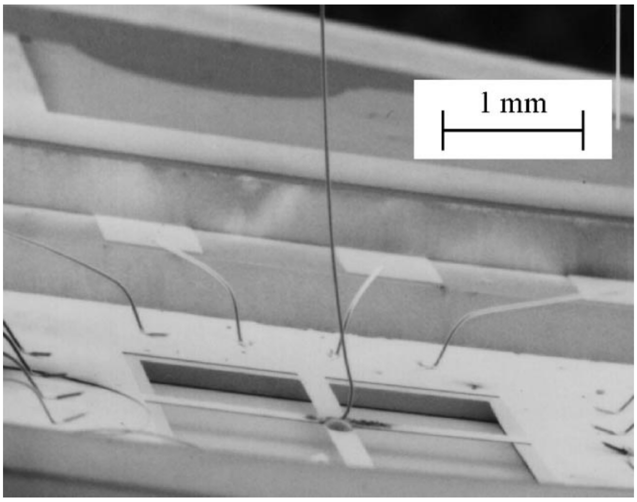

Fig.2 Flow velocity sensor modeled on sensory hairs

Micro-devices for recording biological signals

We are also studying micro-devices for measuring neuroelectric and myoelectric potential in living organisms. We have successfully measured changes in electrical potential on the surface of an insect nerve cord of approximately 100μm diameter by holding it in a micro-electrode clip made of thin-film shape memory alloy (see Figure 3). We are currently developing a wireless telemetry system for mounting on the actual insect that can transmit measurement data back from the electrode.

By integrating the various systems described above, we will be able to measure biological information from an insect without imposing any restriction on its movement or behavior. We are confident that this technology will significantly boost our understanding of the mechanisms underlying insect behavior.

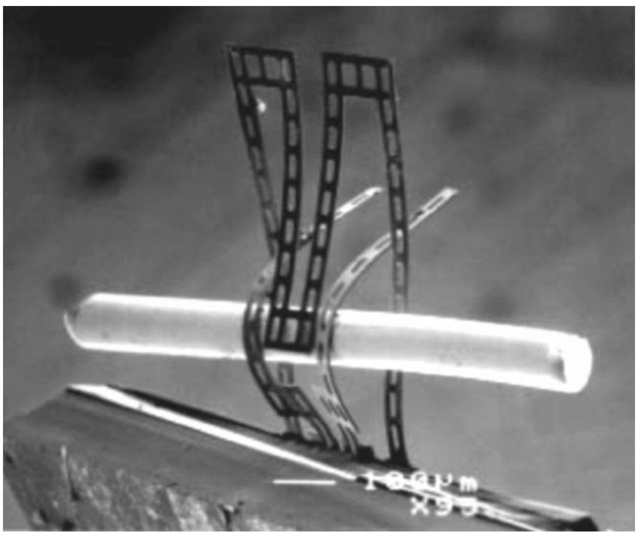

Fig. 3 Microelectrodes for insect neural recording