Silicon Microneedle Technology for Implantable Sensors

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Our research group has developed practical methods for fabricating silicon microneedles and microprobes for bioassay applications, using integrated circuit and MEMS (microelectromechanical systems) processing steps. The needles and probes, which are comparable in cross-section to a human hair and several millimeters in length, are sharp, strong, flexible, and tough. They are capable of reliably penetrating human skin and other tissue as components of integrated silicon devices for painless microsampling and bioassay. These devices are modeled after the mosquito and other blood-sucking insects which use fine stylets for drawing blood from the microvasculature of the skin, and also contain sensors to expedite the feeding process. Silicon microneedle technology can be employed in devices for physiological measurements in several different ways, including taking discrete blood samples, continuous sampling, or painlessly inserting biosensors. Sub-microliter blood samples can be taken and analyzed in the silicon microdevice. Continuous sampling can be performed at blood flow rates of one to five microliters per hour with the bioassays carried out using ex vivo sensors. Biosensors can be integrated into the silicon microprobes and inserted painlessly with minimal tissue damage, and replaced without professional medical attention, to enable measurement with in vivo sensors. A variety of analytical techniques can be used. Thus far, methods for several chemical analytes have been developed employing both optical and electrochemical readout. Potentially, immunoassays and DNA assays could be performed using microchips integrated with the silicon needle. The devices are low cost disposables designed to operate for periods varying from one minute to ten thousand minutes (one week), thus avoiding many problems inherent in longer term implantation. Readout of the assays can be provided by a hand held instrument or the data can be transmitted to a nearby receiver by a telemetry chip packaged with the bioassay device. Applications include painless measurement of blood glucose concentration for control of diabetes, physiological status monitoring, and measurement of biological markers.

Key words:

microneedle	MEMS	silicon
biosensor	analyte	blood

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