Cyborg insects, neural dust and other things:

building interfaces between the synthetic and the multicellular

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ABSTRACT

As the computation and communication circuits we build radically miniaturize (i.e. become so low power that 1 pJ is sufficient to bang out a bit of information over a wireless transceiver; become so small that 500 μm^2 of thinned CMOS can hold a reasonable sensor front-end and digital engine), the barrier to introducing all sorts of interfaces and control loops into organisms will lower radically. Put another way, the rapid pace of computation and communication miniaturization is swiftly blurring the line between the technological base that created us and the technological based we've created. This talk will provide an overview of recent work in the Maharbiz lab that touches on this concern. Some of this will cover our ongoing exploration of the remote control of insects in free flight via implantable radio-equipped miniature neural stimulating systems and more recent work in next generation mammalian neural interfaces for brain machine interface (BMI) applications, including neural dust.

We have recently demonstrated a number of miniaturized neural interfaces and systems. We demonstrated the first example of the remote control of insects in free flight via an implantable radio-equipped miniature neural stimulating system [1-4]. The pronotum mounted system consisted of neural stimulators, muscular stimulators, a radio transceiver-equipped microcontroller and a microbattery. Subsequently, we have focused on systems for interfacing to insect sensory organs [7]; I will present work showing how ocellar stimulation via a miniaturized system can result in strong changes in insect flight responses.

More recently, we've demonstrated flexible multielectrode arrays for applications ranging from high density electrophysiology on insect sensory organs [7] to mammalian microelectrocorticography [5-6]. These designs include flexible 256-electrode arrays for micro-electrocorticography (µECoG) with an electrode pitch of 500 µm. Our µECoG grid is a flexible five-layer parylene MEMS device (two layers of platinum insulated by three layers of parylene) featuring plasma-etched vias and a monolithically integrated parylene cable which is compression-bonded to a fan-out board using anisotropic conductive film (ACF) technology. Additionally, indium tin oxide (ITO) µECoG's were developed for use in simultaneous neural recording and optical interfacing/imaging [5]. Lastly, I will discuss more recent work on high density implantable neural probes and ultra-small tetherless interfaces (neural dust) [8].

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