Materials and Technologies for Soft Bioelectronic Interfaces

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Implanted bioelectronic interfaces are designed to exchange information between living tissues and electronic systems. Examples are deep brain stimulators, cochlear implants, spinal cord stimulators, and emerging neuroprosthetic systems aiming to restore functions lost through injury or disease. Central to this are electrode arrays. These components come into intimate contact with biological tissue and enable neural signals to cross the tissue–device boundary. Although electrode arrays used in current clinical practice are highly successful, important technological improvements are required.

I will describe the challenges of operating electrodes inside the body. One focus will be our efforts to formulate and process new electronic materials that more closely resemble biological tissues in their mechanical properties, hydration state, and bioactivity. Such materials may enable implanted electrodes with substantially improved biointegration. A second focus will be the opportunity to tailor electrode arrays to patient-specific anatomy and the particular niche of the nervous system being interfaced. We are addressing this through rapid prototyping (e.g., 3D printing) approaches.

Finally, I will consider whether neural interfaces can move beyond purely electrical communication. Are there other modalities that can support information exchange with the nervous system? I will discuss our efforts to create multimodal neural interfaces that combine electrical, biochemical, optical, and thermal information flows. The outlined approaches may broaden the scope and capabilities of future bioelectronic medicine therapies.