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Presentation Abstract

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Abstract: Interfacing artificial functional materials and living neuronal tissues is at the forefront of bio-nanotechnology. Attempts so far have been based on micro-scale processing of metals, inorganic semiconductors as electrodes or photoactive layers in biased devices, and more recently, nano-materials have been investigated. However, in spite of extensive research, the communication between biological tissues and artificial sensors is still a challenge. Constraints exist in the complexity of the fabrication processes and the mechanical properties of the implanted sensing/recording elements (poor flexibility and biocompatibility) that could elicit deleterious tissue reactions such as inflammation and gliosis. In addition, electrodes have fixed geometries that limit the location in space of the stimulus, and electrical currents are often detrimental to the overall system. In this respect, organic soft matter has potential in terms of flexibility, favorable mechanical properties and biological affinity. The use of semiconducting polymers has been reported in mechanical actuators for precise delivery of neurotransmitters, and in biosensors, such as pH and glucose sensors, where their ability to support mixed ionic/electronic charge transport was fully exploited. Conversely, organic polymers have been tested as coatings of conventional electrodes in direct neuronal interfaces for recording and stimulating neuronal activity, whereas the exploitation of their appealing optoelectronic features has never been considered for neuronal communication and photo-manipulation devices. Here, we document a new communication protocol between organic semiconductors and neuronal cells, showing photo-stimulation of neuronal activity. We report the functional interfacing of an organic semiconductor with a network of cultured primary neurons and successfully demonstrate the physiological stimulation of neuronal cells in a network by shaping visible light pulses at the polymer/electrolyte interface. In contrast with metal or silicon interfaces, our approach works without any externally applied electric field and with minimal heat dissipation, favorably addressing the thermal issues, which are extremely relevant in an efficient biological interface. Moreover, the use of soft matter provides some advantages in terms of mechanical properties, since it enables the fabrication of light, thin and flexible devices, better suited to interaction with a biological environment. In perspective, this new approach to the optical stimulation of neurons may stimulate further work towards the development of an artificial retina based on organic materials.

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