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Optical Bio-Sensing at the Brain-Machine Interface

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New developments toward creating a working 2-way communication between brains and machines offer exciting possibilities, yet are often limited simply by the basic bio-compatibility of the materials employed in their construction. Traditional electrical engineering semiconductors and metals are often quite poor choices for use in a real living wet biological environment, and much recent effort has been devoted to instead develop soft, squishy bio-polymer interface materials, that communicate via photons and not electrons. Inspired by the molecular mechanisms in our eyes that enable vision, photo-reversible azo visible dyes are incorporated into bio-polymers such as silk fibronin, to provide a stable dynamic transduction layer between live neural cells and optical fibres. Sensing neural activity locally and selectively is achieved spectro-scopically via subtle optical changes to the thin dye nano-layers at the fibre ends. Signalling back to a brain can be achieved by simple mechano-transduction via photo-mechanical layers, photo-chemical release of neurotransmitters from artificial vesicles embedded, or via light-reversible changes to surface energy and chemistry. Characterization of the structure and dynamics of these soft active nano-neuro-layers in situ is a key challenge, and results will be detailed from surface energy analysis, and 'underwater'Visible Ellipsometry, and Neutron Reflectometry techniques we have developed at McGill, and at Chalk River Laboratories.

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