Centre for Chronic Diseases & Disorders

Exploring novel multi-modal photonic techniques for live imaging of synaptic activity

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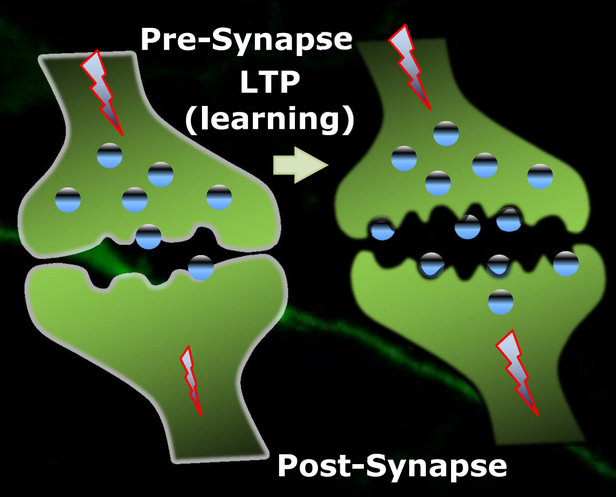
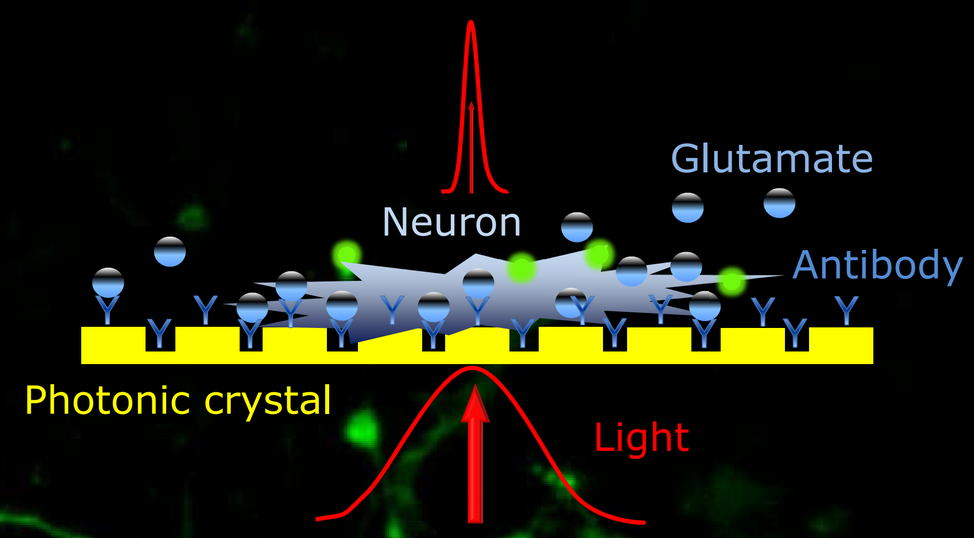
Objective: Endogenous observation of a chemical neurotransmitter released by active synapses during the course of learning by using a silicon-based photonic crystal biosensor

Background:

The fundamental cellular mechanisms of learning in the brain cause strengthening of synaptic connections between neurons following sensory stimuli. Learning-induced increases in synaptic activity are due to changes on both sides of the synapse: (I) enhanced neuro-transmitter (glutamate) release from the pre-synaptic cell and (II) enhanced detection of glutamate in the post-synaptic cell.



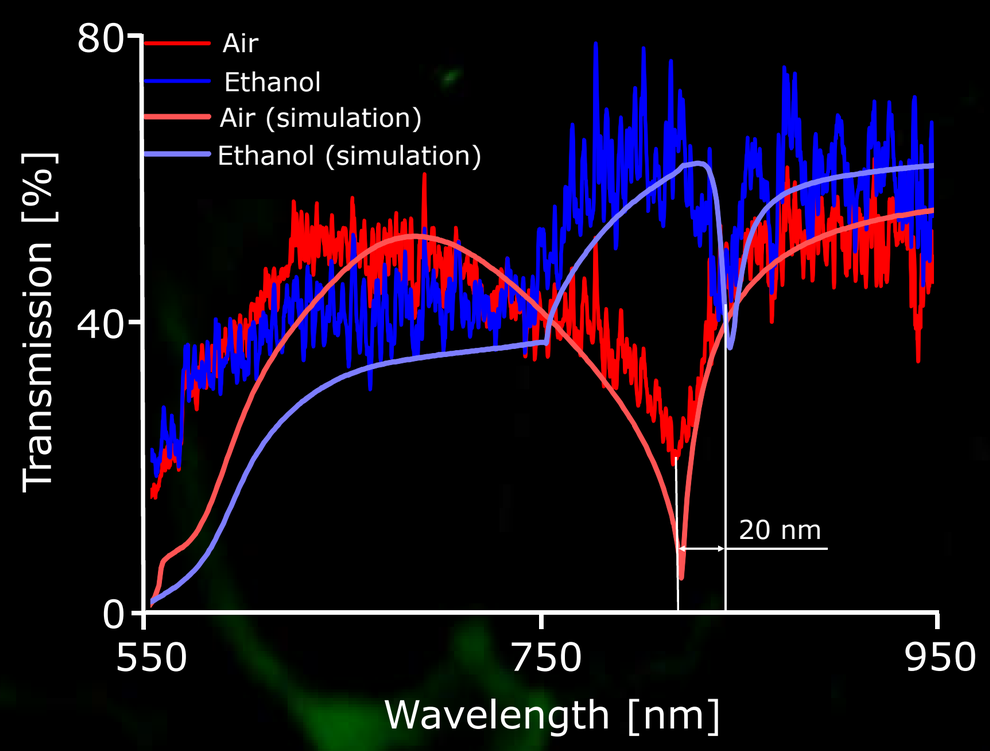


For detection of synaptic glutamate release, we utilise a photonic crystal surface that has been functionalised with anti-glutamate antibodies. The photonic crystal exhibits a resonance shift in wavelength in response to glutamate binding on the surface.

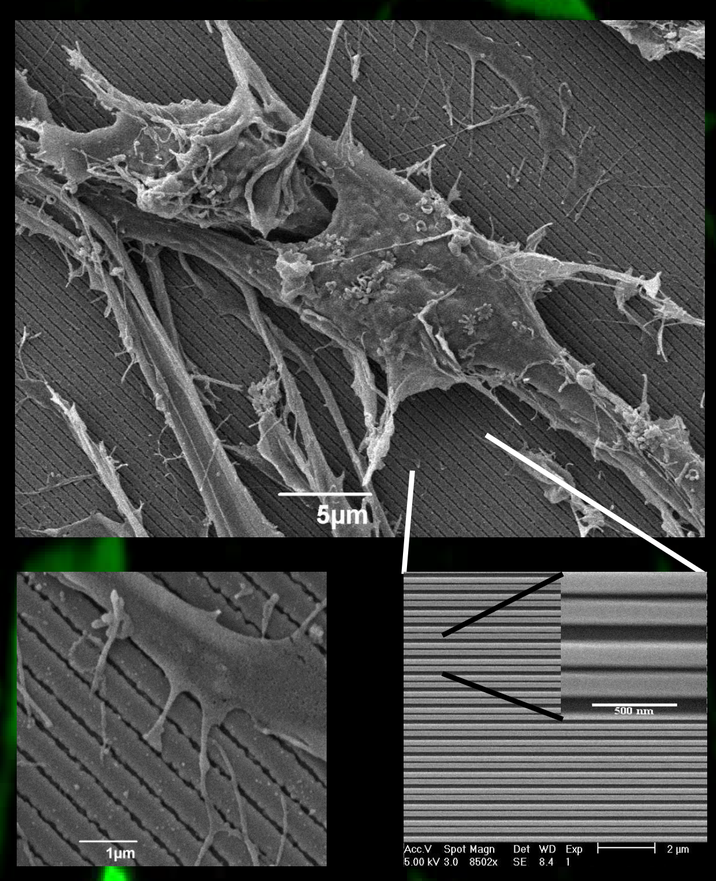
In combination with real-time imaging and expression of a fluorescent synaptic marker to visualise the location of all synapses, a map of the activity of individual synapses over time will be generated, allowing changes in synaptic activity to be monitored.

Results:

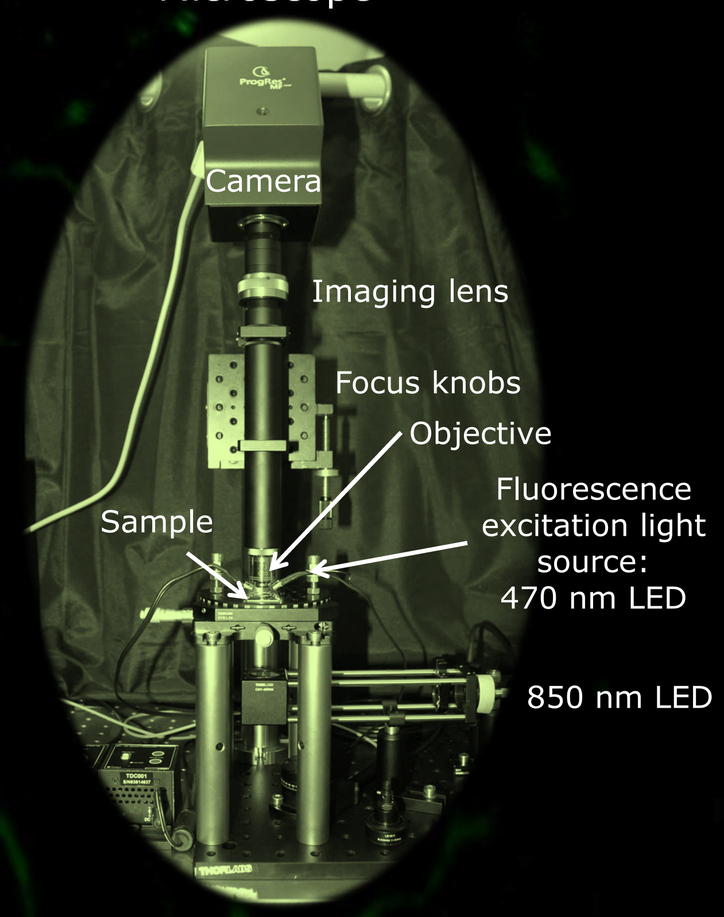
Refractive index change of a photonic crystal



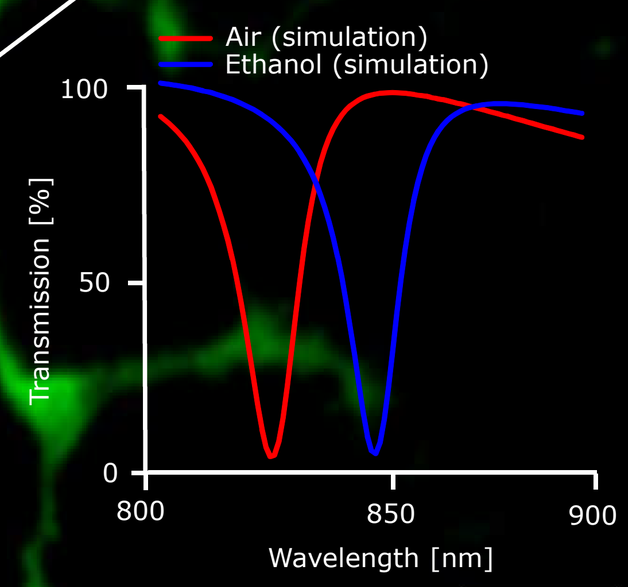
SEM image of neurons cultured on a photonic crystal surface



Microscope



Fluorescence image of a neuron



20 µm

Conclusion:

- Resonant photonic crystal biosensor for label-free monitoring of neuronal activity being developed
- Combination of fluorescence microscopy with resonant detection demonstrated
- Neuron growth on sensor surface demonstrated
- Shift in resonance observed

Outlook:

- Fabrication of an optimised photonic crystal
- Optimisation of fluorescence excitation
- Real-time and simultaneous measurement of glutamate release and activity of individual synapses by electrical field stimulation at ~0.1 Hz that mimics learning
- Provide a model for the future study of synaptic strengthening during learning

References: E.A. Lidstone et al., (2011) Analyst. 136(18); M.A. Cousin and G.J.O. Evans (2011) J. Physiol. 589

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