3D FEM Model of Neuron Excitation Using an Organic Electrolytic Photocapacitor

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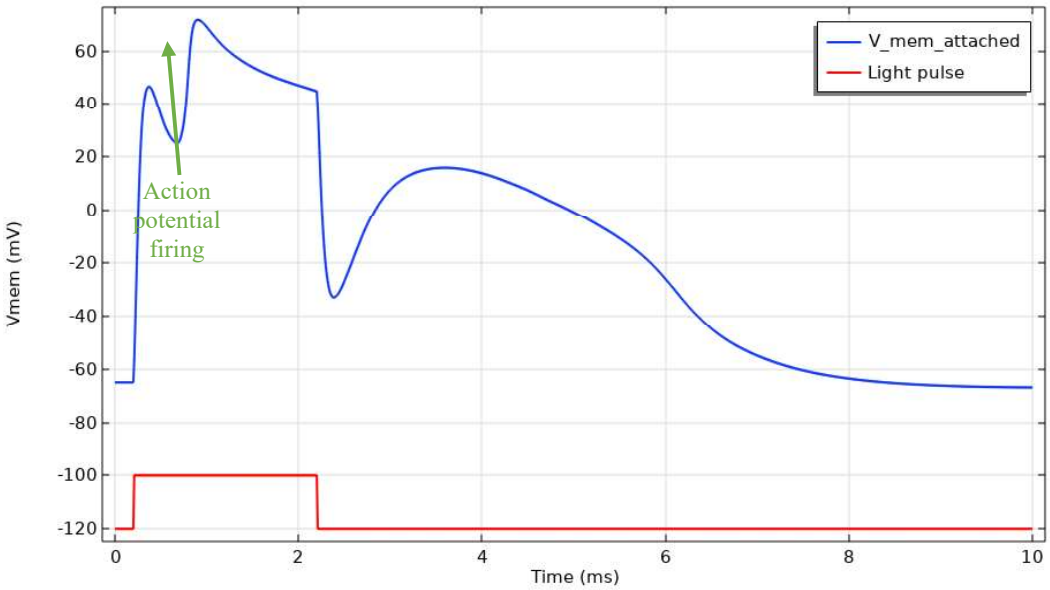
There are many parameters that can determine if a single neuron placed on top of the organic electrolytic photocapacitor (OEPC) can be successfully stimulated. We can divide those parameters into three categories: OEPC parameters such as maximum current density or voltage; interface parameters such as electrode geometry or neuron-electrode cleft distance; and neuron parameters characterized with neuron shape and ion channel conductivities. With so many variables it is crucial to understand the influence of each of those parameters to ultimately determine if the stimulation will be possible. For that purpose, we developed a complete 3D FEM model of capacitive photo-electrode and neuron in COMSOL Multiphysics. OEPC is characterized by its equivalent circuit model and contact electrical properties while neuron is modelled by solving Hodgkin–Huxley equations on the cell membrane with realistic ion channel distribution along the dendrites, axon and soma. Using our model, we can estimate the probability that the neuron is successfully stimulated in a particular experimental arrangement. Also, based on model predictions we can try to make improvements to the experimental setup in the most effective and viable way.



Membrane potential in one point of the attached membrane in time and the 2 ms stimulation pulse. Action potential firing can be seen on top of the stimulation artefact when the light is turned on and turned off.