Researchers create organic nanowire synaptic transistors that emulate the working principles of biological synapses

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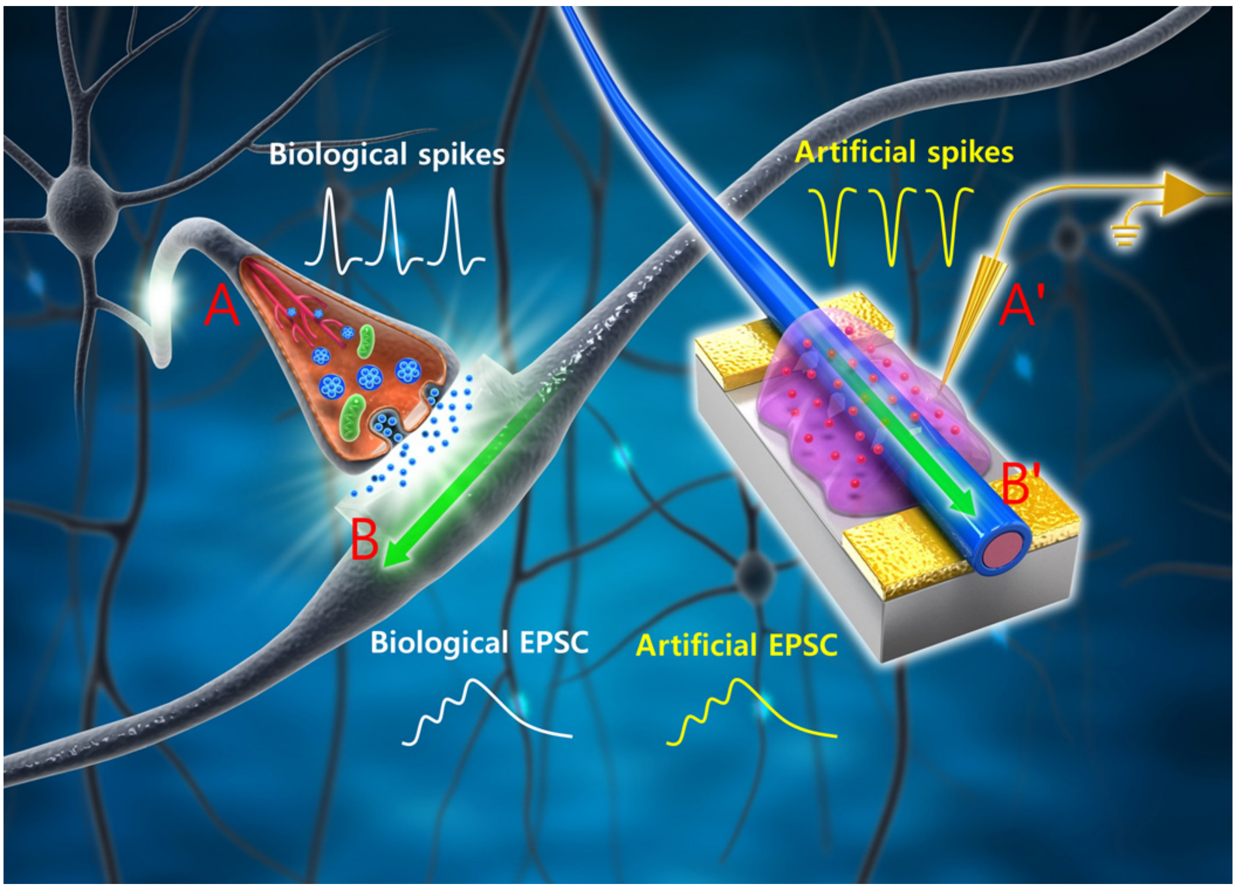

Schematic of biological neuronal network and an ONW ST that emulates a biological synapse. Credit: *Science Advances* (2016). DOI: 10.1126/sciadv.1501326

(Phys.org)—A team of researchers with the Pohang University of Science and Technology in Korea has created organic nanowire synaptic transistors that emulate the working principles of biological synapses. As they describe in their paper published in the journal *Science Advances*, the artificial synapses they have created use much smaller amounts of power than other devices developed thus far and rival that of their biological counterparts.

Scientists are taking multiple paths towards building next generation computers—some are fixated on finding a material to replace silicon, others are working towards building a quantum machine, while still others are busy trying to build something much more like the human mind. A hybrid system of sorts that has organic artificial parts meant to mimic those found in the brain. In this new effort, the team in Korea has reached a new milestone in creating an artificial synapse—one that has very nearly the same power requirements as those inside our skulls.

Up till now, artificial synapses have consumed far more power than human synapses, which researchers have calculated is on the order of 10 femtojoules each time a single one fires. The new synapse created by the team requires just 1.23 femtojoules per event—far lower than anything achieved thus far, and on par with their natural rival. Though it might seem the artificial creations are using less power, they do not perform the same functions just yet, so natural biology is still ahead. Plus there is the issue of transferring information from one neuron to another. The "wires" used by the human body are still much thinner than the metal kind still being used by scientists—still, researchers are gaining.

As part of this latest effort, the team placed 144 of their artificial synapses on a 4 inch wafer and connected them together in a two dimensional mesh with wires that were just 200 to 300 nanometers on average. The idea was to test the possibility of causing the synapses to fire (open or close) based on information coming from a wire, or being sent from other artificial neurons. Each synapse mimicked the natural kind in shape as well—they were long and thin and were made of two types of organic material that allowed for holding or releasing ions.

The new artificial synapses are one more step on the road towards a computer that works in ways very similar to the human brain, and most believe if we ever get there, the machines we create will be far more powerful than anything nature has ever produced.

More information: W. Xu et al. Organic core-sheath nanowire artificial synapses with femtojoule energy consumption, *Science Advances* (2016). DOI: 10.1126/sciadv.1501326

Abstract
Emulation of biological synapses is an important step toward construction of large-scale brain-inspired electronics. Despite remarkable progress in emulating synaptic functions, current synaptic devices still consume energy that is orders of magnitude greater than do biological synapses (~10 fJ per synaptic event). Reduction of energy consumption of artificial synapses remains a difficult challenge. We report organic nanowire (ONW) synaptic transistors (STs) that emulate the important working principles of a biological synapse. The ONWs emulate the morphology of nerve fibers. With a core-sheath–structured ONW active channel and a well-confined 300-nm channel length obtained using ONW lithography, ~1.23 fJ per synaptic event for individual ONW was attained, which rivals that of biological synapses. The ONW STs provide a significant step toward realizing low-energy–consuming artificial intelligent electronics and open new approaches to assembling soft neuromorphic systems with nanometer feature size.

Press release