

# Organic Neuromorphic Circuits for Neuromorphic Computing

**Flexible, biocompatible organic spiking neurons that mimic brain function for soft robotics, wearables, and brain-machine interfaces.**

Researchers at Purdue University have demonstrated a spiking neuron composed of a single integrate-and-fire Axon-Hillock-based somatic circuit complemented with two excitatory and two inhibitory Pulsed Current Source synaptic circuits. This circuit was implemented using physically flexible and biologically compatible organic electronics. This innovation addresses many of the problems associated with other computer architecture and hardware. Von Neumann computer architecture is designed to store data and instructions in the same memory space and with only one access path, meaning both cannot be accessed simultaneously. This results in a separation of memory and logic, and hence serial data processing and high energy consumption. Neuromorphic engineering, inspired by the structure and dynamics of the biological brain, describes the development of embodied AI systems to interact with the physical world and emulate neural computation with artificial neurons. Neuromorphic engineering hardware typically relies on silicon-based CMOS circuits, which suffer from issues like rigidity and high cost of fabrication. Organic electronics are a promising new route towards creating biocompatible neuromorphic hardware with properties such as physical flexibility, easy and low-cost fabrication, and emulation of synaptic and somatic behavior. However, they have thus far had slow response times, require an aqueous environment to work, and have poor long-term stability. Therefore, there is a need to develop an organic neuromorphic devices that are fully organic that allows for electrical spikes to replicate complex nonlinear brain behavior like frequency modulation or action potential generation.

Researchers at Purdue University have addressed these issues through their designed organic spiking neuron. The developed circuits allow for both the production of excitatory postsynaptic potential through the injection of pulsed current and inhibition of such potentials, and producing proportional post-somatic voltage spikes, thereby mimicking the neuronal functions found in the brain. The researchers also demonstrated a practical use of

**Technology ID**

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## **Category**

Artificial Intelligence & Machine Learning/AI Model Optimization & Acceleration Tools  
Semiconductors/Devices & Components

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such an embodied AI in a form of modulation of light intensity of an external system. The technology provides a promising foundation for energy-efficient, biocompatible neuromorphic systems and has applications in flexible, implantable, wearable brain-inspired electronics.

### **Technology Validation:**

- Demonstrates biologically relevant behaviors
- Characterization shows mechanical robustness and the ability for the embodied AI application to experience real-time learning in an ambient light control task

### **Advantages**

- Can create neuron outside of cleanroom environment, so more affordable accessible and scalable platform
- Can be physically flexible, thereby enabling soft and squishy applications with embedded intelligence

### **Applications**

- Flexible, implantable, wearable brain-inspired electronics like sensory processing technology, autonomous and soft robotics, and brain-machine interfaces

Related Publications (if none, delete this section)

-Mohammad Javad Mirshojaeian Hosseini et al 2022 Neuromorph. Comput. Eng. 2 034009

-Mohammad Javad Mirshojaeian Hosseini et al 2025 npj Flex Ele. under review doi.org/10.21203/rs.3.rs-7175066/v1

**TRL:** 3

### **Intellectual Property:**

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**Keywords:** artificial neurons, Biomedical Engineering, brain-inspired electronics, Electrical Engineering, embodied AI, neuromorphic engineering systems, organic electronics

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