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Research



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### From Bottleneck to Breakthrough: MANA Achieves New Computing Paradigm with Reconfigurable Logic Circuits

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Scientists from the Research Center for Materials Nanoarchitectonics (MANA) developed a reconfigurable logic circuit that switches functions with constant input voltages. This innovation opens doors to novel computing architectures.



Most computers today are based on the von Neumann architecture, where memory and processing are handled separately. The transfer of data between these two units causes a bottleneck, slowing down operations. In-memory computing aims to fix this issue by integrating logic directly into memory for faster and more power-efficient processing.

In a recent breakthrough, researchers from the Quantum Device Engineering Group at MANA, including group leader Yutaka Wakayama and Yoshitaka Shingaya, along with Junko Aimi from the Research Center for Macromolecules and Biomaterials, NIMS, developed electrically reconfigurable two-input logic circuits that can switch between different logic functions. These circuits also function as artificial synapses, which are crucial for advancing neuromorphic computing systems.

The circuit is based on a dual-gate antiambipolar transistor (AAT), constructed by stacking an n-type semiconductor and a p-type one. The AAT has a unique  $\Lambda$ -shaped response curve where the output current changes with the input gate voltages. By manipulating these gate voltages, specific current values corresponding to logic states "0" and "1" are produced. This allows the AAT to perform various logic functions depending on the chosen combination of gate voltages.

To maintain consistent input voltages while adjusting logic states, a zinc phthalocyanine core (ZnPc) is integrated into the AAT. ZnPc traps carrier charges, shifting the peak voltage position associated with

different logic functions. This enables the AAT to switch between logic states, such as from AND to OR and from NAND to NOR, under constant input voltages.

The device also functions like an artificial synapse. Adjusting the readout voltage modifies its synaptic response or current, similar to how brain synapses strengthen or weaken signals. As Dr. Wakayama highlights, "We have developed a non-von Neumann type device architecture by integrating the nonvolatile memory function with the dual-gate AAT, which is not achievable in conventional CMOS architectures."

## Reference

Journal	ACS Applied Materials & Interfaces
Title	Multifunctional In-Memory Logics Based on a Dual-Gate Antiambipolar Transistor toward Non-von Neumann Computing Architecture
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