<Research Topics>

Development of Highly Efficient Materials-based AI Devices

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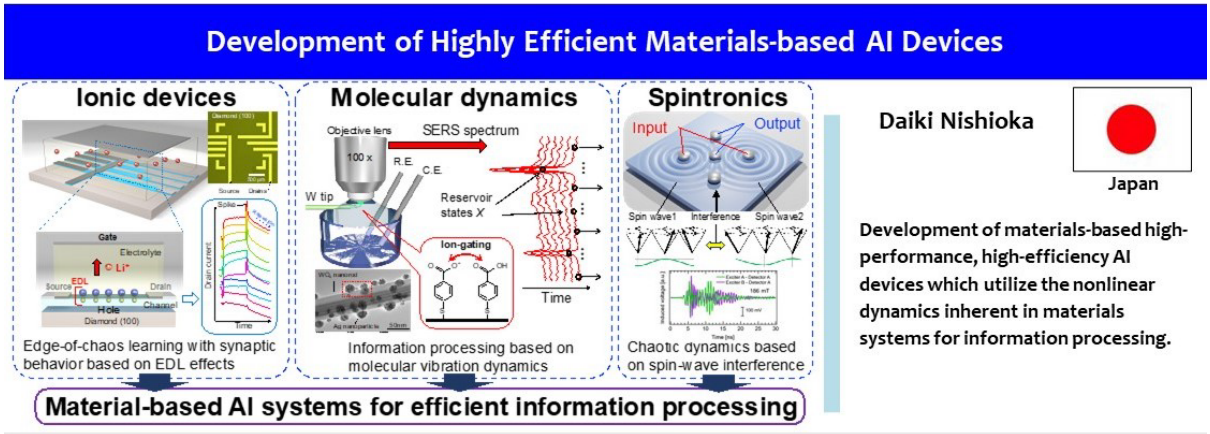

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In recent years, AI technology has made remarkable progress, surpassing human capabilities in certain tasks such as recognition. These advances are supported by technological innovations such as deep learning, which is based on learning large-scale network models and vast amounts of data. However, AI technologies that perform AI calculations that simulate brain functions on conventional computers face problems such as increased power consumption. Neuromorphic devices, which directly utilize the nonlinear dynamics inherent in physical systems for information processing, have been attracting attention in recent years as a potential solution to this problem. When inputs are applied to a physical system, the output response is often nonlinear and reflects the various dynamics occurring within the material. These dynamics provide functions such as nonlinear transformation of input information, short-term memory, and transfer to higher dimensional space, which are partially equivalent to the operations performed by neural networks. By utilizing these functions of materials for information processing, significant reductions in computational cost can be achieved because the operations can be performed in physical processes without the necessity of simulating complex neural circuits.

The key to realizing high-performance neuromorphic devices is to control nonlinear dynamics, as a computational resource, and to achieve complexity and consistency in information processing. As promising systems for this objective, I am developing neuromorphic devices such as artificial neural devices based on ionic devices, artificial neurons based on the vibrational dynamics of a few organic molecules, and artificial neural networks utilizing the chaotic nonlinear interference of spin waves in ferromagnetic materials. Furthermore, focusing on the physical process-based nature of neuromorphic devices, I also work on the development of material-based AI devices in which sensors and neuromorphic devices are seamlessly connected.

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