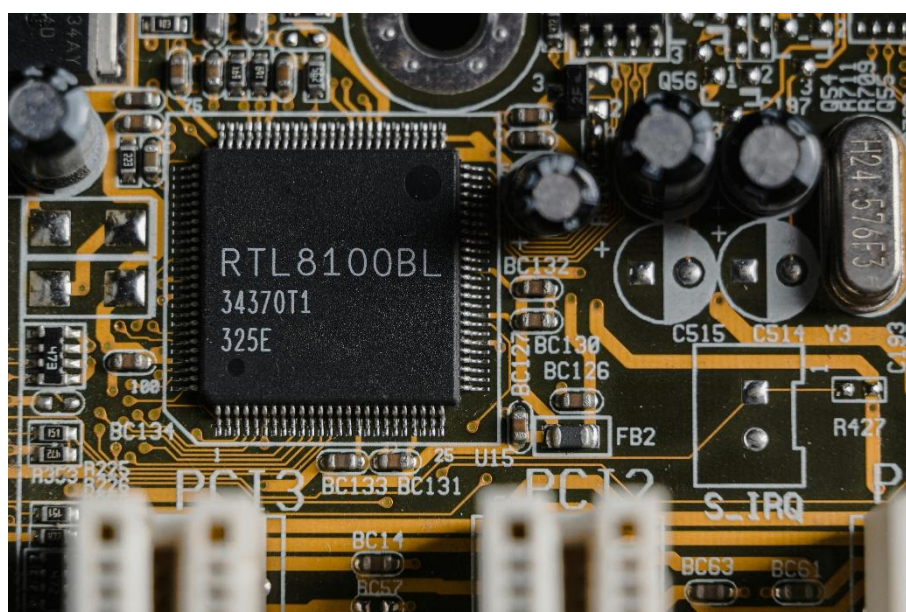


Towards electronic memories that also store energy

An ICMAB-CSIC research team has developed a material capable of both efficiently storing energy and retaining information, paving the way for lower-consumption electronic devices



Electronic device components | Tima Miroshnichenko, Pexels

Bellaterra (Spain), 30 April 2026 – A research team from the Institute of Materials Science of Barcelona (ICMAB-CSIC) has experimentally demonstrated a device in which information storage and energy storage can be integrated within a single physical structure. The work, published in the journal *Nano Energy*, presents a strategy that enables the material to efficiently recover energy without losing its memory functionality.

The group, led by Florencio Sánchez and Ignasi Fina, investigates materials for non-volatile memories. In a nutshell, these memories operate by accumulating negative (0) and positive (1) charges in materials capable of retaining them; in this way, the system does not need to continuously consume energy to preserve the stored information. “Ferroelectric materials exhibit spontaneous polarization; on their surface they accumulate 0s and 1s that can be switched with electrical pulses, which is why they are naturally attractive for use as memories,” explain the authors of the study.

Current non-volatile memory systems tend to consume large amounts of energy: on the one hand, they require significant energy to store information; on the other, they also heat up considerably, which extends the energy needed for cooling. In this context, the team explored a new way of addressing this problem: using the very materials employed as memory elements to recover part of the energy that is normally lost as heat.

Specifically, the researchers demonstrated that by combining ferroelectric hafnium oxide, a material already widely used in the microelectronics industry, with a very thin layer of barium titanate, it is possible to obtain a device that retains information while simultaneously storing

energy in an efficient and stable manner. According to Sánchez and Fina, such devices “could potentially reduce energy demand and provide greater autonomy.”

The experiments show that this strategy makes it possible to significantly improve the device's energy efficiency and its stability over time and after millions of operating cycles, all without compromising memory functionality.

This type of advance can have a direct impact on everyday life. As electronic devices become smaller, faster, and more numerous, their energy consumption becomes an increasingly relevant issue. Solutions that reduce energy losses and cooling requirements could contribute to more sustainable devices with a smaller energy footprint.

How to store energy and memory at the same time

To understand the discovery, one must imagine the operation of a chip as a system in which electricity flows in and out, and, to a great extent, gets lost along the way. In today's chips, every time information is written or modified, part of the electrical energy is inevitably dissipated as heat. This energy cannot be recovered.

“Ferroelectric capacitors are used in conventional memories. The discovery of ferroelectric behaviour in hafnium oxide, a material compatible with industrial processes, is opening the door to memories with much higher capacity. This is because previously used materials were complex, which limited the fabrication of high-density devices. However, the possibility of using these devices simultaneously to store information and energy is new and represents a research strategy of great interest,” explain Fina and Sánchez. It was already known that capacitors can store electrostatic energy, but the materials typically optimized for this function did not allow information storage.

What the researchers have demonstrated is that, with the appropriate materials, part of this energy can be stored temporarily, in a manner similar to a capacitor, without erasing the information contained in the material. This is possible because ferroelectric materials exhibit different responses to an electric field: one associated with information, which is stable, and another, more elastic response related to energy, which can be recovered.

Towards the development of more energy-efficient chips

Modern microelectronics is moving toward increasingly dense and powerful devices, but this progress carries a growing energy cost. In conventional chips, memory, capacitors, and energy-management systems are separate elements. This fragmentation leads to energy losses in the form of heat and limits the overall efficiency of systems, particularly as they scale in size and complexity.

Although the work is still at the fundamental research stage, the results point to clear potential applications. In the long term, this type of device could contribute to the development of chips that consume less energy.

Moreover, these materials are already of interest to the semiconductor industry. This facilitates the eventual transfer of these concepts to real-world applications. Integrating

memory and energy-management functions into a single physical structure could reduce the number of components required in a chip and improve its overall efficiency.

Sánchez and Fina have long been in contact with this type of industry: “Ferroelectric materials are far more energy-efficient than other alternatives currently in use, (...) and all companies involved in electronic device development have research lines focused on this material.”

Reference article

Leveraging the integration of perovskite BaTiO₃ on ferroelectric fluorite HfO₂ to enhance energy storage cyclability and efficiency

Dong, W., Magén, C., Zou, J., Quintana, A., Bachelet, R., Saint-Girons, G., Silva, J. P., Sánchez, F., & Fina, I.

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