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Research Highlights

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MANA Develops Ferroelectric-ferromagnetic Materials for Next-generation Electronics

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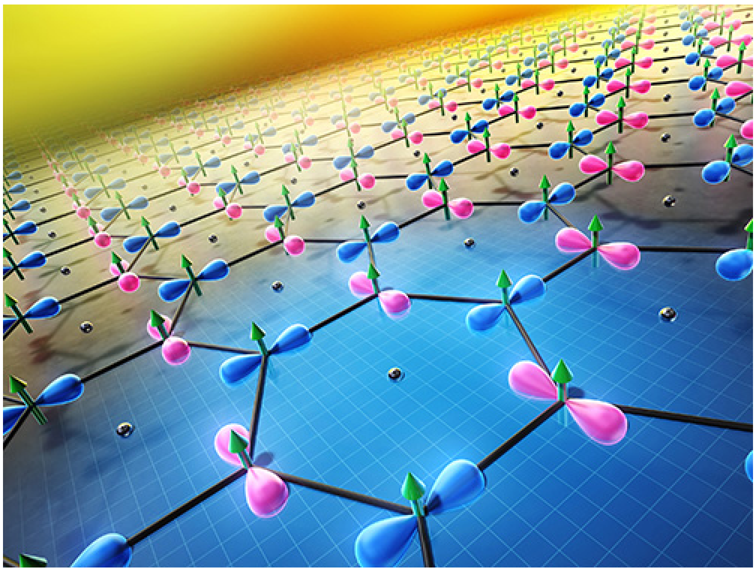
Researchers at the Research Center for Materials Nanoarchitectonics (MANA) have proposed a method to create ferroelectric-ferromagnetic materials, opening doors to advancing spintronics and memory devices.



In 1831, Michael Faraday discovered the fundamental connection between electricity and magnetism, demonstrating that a changing magnetic field induces electric current in a conductor.

In a recent study, MANA researchers have proposed a method for designing ferroelectric-ferromagnetic (FE-FM) materials, which exhibit both ferroelectric and ferromagnetic properties, enabling the manipulation of magnetic properties using electric fields and vice versa. Such materials are highly promising for spintronics and memory devices. The advantage of FE-FM materials, extremely rare in nature, is their ability to achieve the cross-control by relatively low electric and magnetic fields. The study, led by Principal Researcher Igor Solovyev from MANA, NIMS, included contributions from Dr. Ryota Ono from MANA, NIMS, and Dr. Sergey Nikolaev from the University of Osaka, Japan.

Ferroelectric materials possess a permanent electric polarization, usually arising from ion displacement in their crystalline lattice and resulting in the formation of charged electric dipoles, which align in the same direction. The key feature of ferromagnetic materials is the uncompensated magnetic moment produced by electron spins and orbital motion. Combining both properties in a single material is challenging since the ion displacement enabling ferroelectricity can disrupt the magnetic ordering needed for ferromagnetism. Similarly, the ferromagnetic alignment of magnetic moments is not sufficient for breaking the spatial inversion symmetry required for producing ferroelectricity.

The authors of the current study proposed that antiferro orbital ordering, driven by the Kugel-Khomskii mechanism, where electrons tend to occupy alternating orbitals, can promote both ferromagnetic interactions and break the inversion symmetry. When tested on VI_3, a van der Waals ferromagnet with a honeycomb structure, this ordering resulted in an FE-FM ground state.

"By properly arranging occupied atomic orbitals in a solid, one can make the material not only ferromagnetic but also ferroelectric," says Dr. Solovyev, highlighting the potential of this approach for developing next-generation electronic devices based on multiferroic materials and ferroelectric ferromagnets.

Reference

Journal	Physical Review B
Title	Ferromagnetic ferroelectricity due to the Kugel-Khomskii mechanism of the orbital ordering assisted by atomic Hund's second rule effects
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