Research Highlights

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Atomically Thin Perovskites Boost for Future Electronics

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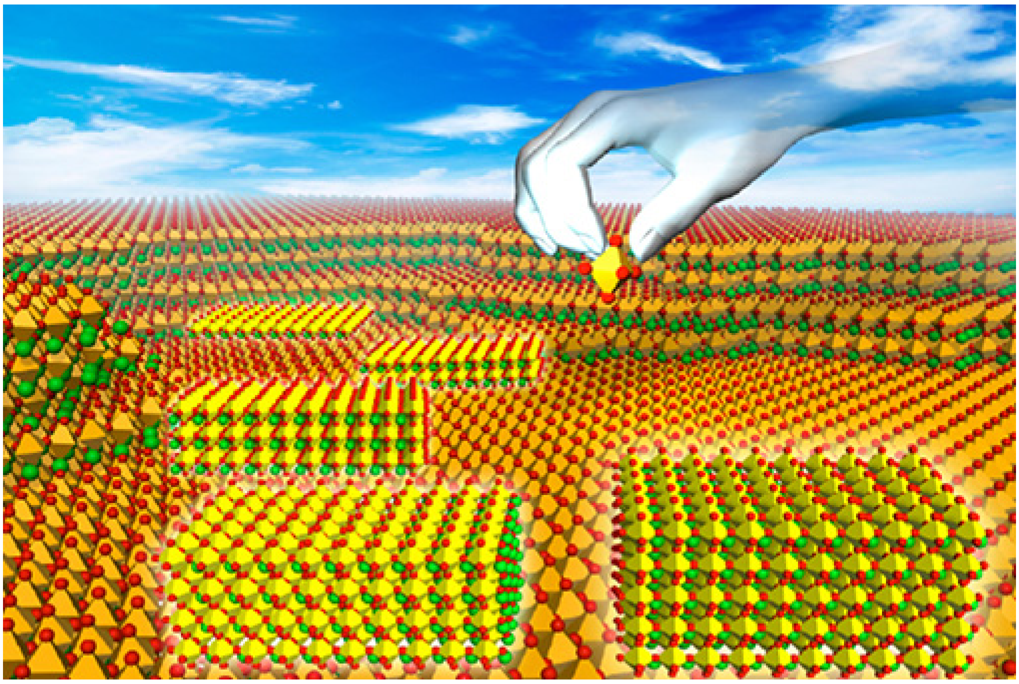
WPI-MANA has developed the world's highest performance dielectric nanofilms using atomically thin perovskites. This technology may revolutionize the next-generation of electronics.



This research was conducted by a WPI-MANA research group led by Principal Investigator Minoru Osada and Director Takayoshi Sasaki of WPI-MANA at NIMS. Electronic devices are getting smaller all the time, but there is a limit to how small they can get using current materials and technology. High-κ dielectric materials may be the key for developing electronic devices of the future.

Minoru Osada and colleagues created high-performance dielectric nanofilms using 2D perovskite nanosheets ($Ca_2Na_{m-3}Nb_mO_{3m+1}$; m = 3–6) as building blocks. Perovskite oxides offer tremendous potential for controlling their rich variety of electronic properties including high-κ dielectric and ferroelectric.

The researchers demonstrated the targeted synthesis of nanofilms composed of 2D perovskite nanosheets in a unit-cell-upon-unit-cell manner. In this unique system, perovskite nanosheets enable precise control over the thickness of the perovskite layers in increments of ~0.4 nm (one perovskite unit) by changing m, and such atomic layer engineering enhances the high-κ dielectric response and local ferroelectric instability. The m = 6 member ($Ca_2Na_3Nb_6O_{19}$) attained the highest dielectric constant, ε_r = ~470, ever realized in all known dielectrics in the ultrathin region of less than 10 nm.

Perovskite nanosheets are of technological importance for exploring high-κ dielectrics in 2D materials, which have great potential in electronic applications such as memories, capacitors, and gate devices. Notably, perovskite nanosheets afforded high capacitances by relying on high-κ values at a molecular thickness. $Ca_2Na_3Nb_6O_{19}$ exhibited an unprecedented capacitance density of approximately 203 μF cm^{-2}, which is about three orders of magnitude greater than that of currently available ceramic condensers, opening a route to ultra-scaled high-density capacitors.

These results provide a strategy for achieving 2D high-κ dielectrics/ferroelectrics for use in ultra-scaled electronics and post-graphene technology.

Reference

"Atomic Layer Engineering of High-κ Ferroelectricity in 2D Perovskites"
Bao-Wen Li, Minoru Osada, Yoon-Hyun Kim, Yasuo Ebina, Kosho Akatsuka, and Takayoshi Sasaki
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