Nanoscale Ferroelectrics for Advanced Electronics and Microwave Applications

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THE MOST RECENT DEVELOPments in research into ferroelectric materials, including those that are possibly compatible with CMOS technology, will make it possible to use the substances as widespread insulating-gate dielectrics in microprocessors and large-scale integrated circuits. As a matter of fact, growing demand for low-power and ultrafast high-frequency electronics, especially in view of future 6G and Internet of Things applications, is driving investigations toward devices operating at increasingly high frequencies by exploiting novel disruptive materials. In this framework, the most promising atomically thin 2D materials are represented by ferroelectrics at nanoscale, whose detailed characterization is becoming a crucial point.

A particular case involves hafnium oxide, whose ferroelectricity derives from a crystalline structure in the noncentrosymmetric orthorhombic phase that lacks oxygen. The absence of oxygen can be obtained with doping agents, for example, zirconium. Other effects, such as piezoelectric behavior and pyroelectric properties, are often studied in association with ferroelectric properties. Low-dimensional systems based on ferroelectric materials are expected to be particularly relevant for the next generation of microwave components and devices.

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Two featured articles in this special issue report recent developments in nanoferroelectrics. The first, written by Dragoman et al., presents a comprehensive review of emerging nanoscale ferroelectric materials in novel nanoelectronics devices, including phase shifters, phased antenna arrays, filters, field-effect transistors (FETs), ferroelectric tunneling junctions, memristors/memtransistors (neuromorphic nanoelectronics), and negative capacitance ferroelectric transistors. The second, authored by Das and Khan, discusses ferroelectricity in CMOS-compatible hafnium oxides and the revival of ferroelectric FET technology. In particular, the demonstrated ferroelectricity, low permittivity, high coercive field, environmentally friendly composition, and excellent CMOS compatibility in doped thin film hafnia is expected to unleash the promise of ferroelectric FETs.

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