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*Editorial*

# Metal Oxide Semiconductors for Electronic Applications

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The rapid expansion of the Internet of Things (IoT), wearable electronics, and smart surfaces has accelerated the development of transparent, flexible, and miniaturized electronic technologies. Meeting these demands requires functional materials that combine high electrical performance with scalable, low-cost fabrication processes. Among the available semiconductor platforms, metal oxides have emerged as particularly attractive candidates due to their excellent optoelectronic properties, chemical stability, and compatibility with large-area manufacturing [1]. The commercial success of indium–gallium–zinc oxide (IGZO) thin films in display backplane technology has further highlighted the technological potential of this material family [1,2].

Compared with conventional semiconductor materials, such as amorphous or polycrystalline silicon, as well as emerging materials such as graphene and two-dimensional transition metal dichalcogenides (TMDs), metal oxides offer several practical advantages. These include lower processing temperatures, good compositional and electrical uniformity over large areas, excellent reproducibility, and reduced fabrication costs. Furthermore, their intrinsic transparency and compatibility with flexible substrates make them highly suitable for emerging electronic applications [3].

In parallel with the advances achieved for thin films, metal oxide nanostructures have attracted increasing attention because of their unique size-dependent physical and chemical properties. Their large specific surface area, tunable morphology, and enhanced functional response provide opportunities for the design of high-performance electronic and sensing devices. Although significant challenges remain regarding their controlled integration into complex circuits and large-scale manufacturing, metal oxide nanostructures are expected to play a central role in the next generation of nanoscale electronic systems, offering improved device performance, higher integration density, and new multifunctional capabilities.

The field of metal oxide semiconductors continues to evolve rapidly, driven by the demands of next-generation electronics, energy systems, and transparent devices. This Special Issue brings together innovative research that highlights the progress in synthesis, modeling, and application of metal oxide materials, with a focus on their electrical, structural, and optical behaviors.

One of the key contributions in this issue explores the enhancement of current density in large-area electronics through an advanced architecture of amorphous indium–gallium–zinc-oxide (a-IGZO) transistors. A novel wrapping transistor configuration is proposed and evaluated via TCAD simulations, showing a remarkable improvement—doubling the current output compared to conventional source-gated transistors. This structural optimization not only delivers higher current densities but also results in well-defined saturation and pinch-off behavior, underlining its promise for scalable electronics [4].

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Another study delves into the fundamental physics of threshold voltage behavior in modern multiple-gate (MG) devices such as FinFETs, Ω-gate, and nanosheet MOSFETs. A unified ballistic transport model, grounded in quasi-3D scaling theory and realistic density of states, demonstrates how structural parameters like silicon thickness, gate oxide dimension, and a material's work function can mitigate voltage degradation. Among the devices analyzed, nanosheet MOSFETs showed the most resilience due to their unique electrostatic control, with P-FETs displaying higher thresholds as a result of the heavier hole effective mass [5].

In the realm of ultrawide-bandgap (UWBG) semiconductors, gallium oxyhydroxide (GaOOH) is explored not just as a precursor for $Ga_2O_3$ but as an active electronic material. Through first-principles density functional theory calculations, the doping potential of various impurities is assessed. The study reveals that silicon can serve as a shallow donor for n-type conduction, while magnesium and calcium are suitable for p-type doping. This capacity to tune carrier concentration, along with GaOOH's low-temperature synthesis capability, positions it as a compelling candidate for future transparent electronics [6].

Further addressing device stability, another contribution investigates the degradation of commercial metal oxide varistors (MOVs) under repeated switching surges. Using a combination of C–V characterization and statistical analysis, the work establishes a clear correlation between the number of surges and the reduction in grain barrier height, with distinct degradation profiles observed across manufacturers. Linear regression models quantify this effect, offering a predictive framework for evaluating MOV reliability under real-world transient conditions [7].

Finally, lanthanum manganite (LMO) thin films are studied in relation to their structural and optoelectronic evolution under thermal annealing. Co-sputtered LMO films undergo significant changes in transparency and capacitance with increasing annealing temperature, indicating a strong coupling between crystallinity and functional properties. A transition from amorphous to polycrystalline structure leads to varied electrical behaviors, and a light-induced photocurrent response is observed in annealed samples, suggesting potential for photoresponsive devices [8].

Together, these contributions illustrate the breadth and depth of ongoing research in the metal oxide semiconductor domain. From transistor performance enhancement and device physics modeling to transparent electronics and surge protection, these studies not only deepen our understanding of material behavior but also pave the way for future technological breakthroughs.

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