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Editorial

Metal Oxides: Crystal Structure, Synthesis and Characterization

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Solid metal oxides are widely recognized for their ubiquitous presence and multifaceted utility in everyday applications. These materials, including iron oxide, aluminum oxide, zinc oxide, and many more, play a pivotal role as pigments in paints, catalysts in chemical processes, abrasives in polishing compounds, and constituents in ceramics and glass formulations [1–3]. Furthermore, metal oxides are integral to the electronic industry, serving as essential components in the production of semiconductors. Moreover, their indispensable role extends to the medical field, where they find applications in various pharmaceutical and biomedical contexts. The broad spectrum of functionalities of metal oxides underscores their significance across diverse industries, exemplifying their pervasive impact on daily life [1].

Over the past decade, significant advancements in metal oxide research have led to breakthroughs in various fields. One of the most developed areas is energy storage and conversion, where metal oxide supercapacitors have improved the performance of pseudocapacitors. This development bridges the gap between batteries and capacitors by enhancing energy density without compromising power delivery [4]. Additionally, the topic of thermoelectric materials is also noteworthy. High-throughput methods have identified metal oxides with superior thermoelectric properties, which offer the potential for efficient energy conversion [5].Moreover, engineered metal oxides have emerged as promising electrocatalysts for the Hydrogen Evolution Reaction (HER), crucial for sustainable hydrogen production [6]. Perovskite-type metal oxides have shown potential as alternatives to noble metals in catalytic transfer hydrogenation reactions, offering cost-effective solutions [7].Innovations such as molten oxide electrolysis (MOE) have been developed to produce steel without CO_2 emissions. This process utilizes renewable electricity, significantly reducing the carbon footprint of steel production [8]. Additionally, advancements in solid-state batteries that incorporate metal oxides have resulted in higher energy densities and improved safety profiles, with companies such as TDK reporting notable progress in this area [9]. Furthermore, conducting polymer–metal oxide nanocomposites have applications as advanced supercapacitors, effectively combining the benefits of both components to enhance performance [10].Certainly, the examples mentioned represent merely a fraction of the extensive research undertaken on this subject.

Despite the considerable amount of research carried out in this particular field over the years, there are still numerous questions that remain unanswered, leaving many gaps in our understanding. Additionally, these gaps present ample opportunities for researchers and scientists to explore and develop new functionalities and properties associated with metal oxides. As a result of this ongoing quest for knowledge and innovation, this Special Issue is specifically dedicated to the exploration of metal oxides. This dedication will cover various aspects of these materials, including their synthesis processes, crystalline structures, and the diverse physical properties they exhibit. The Special Issue comprises nine research papers and one review, each of which makes substantial contributions to the field, encompassing a wide array of knowledge. The articles published herein predominantly focus on the synthesis, properties, and applications of various metal oxides at the nanoscale. Notable subjects include the following:

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- Iron oxides—optical and magnetic properties in mixed-mineral assemblies [11];
- $CuInS_2/TiO_2$ nanocomposites—mechanochemical synthesis and optoelectrical analysis [12];
- Ti/SBA-15 composites—chemical vapor deposition synthesis and structural analysis [13];
- ZnO particles—potential applications as resistive random-access memory (RRAM) [14];
- Vanadium oxides—metal-to-insulator transitions [15];
- Titanium(IV)-oxo complex in polymer matrix—enhancing photocatalytic and antimicrobial activity [16];
- Al_2O_3 polymorphs—phase transformations and thermal expansion for high-temperature optimization [17];
- Cubic ZrO_2—oxygen vacancy dynamics and electronic properties [18];
- $Ce_{1-x}Zr_xO_2$ Nanoparticles—structural and catalytic characterization [19];
- CuO and ZnO nanowires—structural defects and the thermal conductivity via molecular dynamics simulations [20].

These articles provide valuable insights into the design and functional optimization of metal oxide nanomaterials for advanced technological applications.

As the Guest Editor for this Special Issue, I wish to extend my heartfelt appreciation to all authors for their significant contributions of exceptional knowledge and for presenting their research findings. It has been a profound honor to serve as a member of the editorial team for the *Crystals* journal.

Conflicts of Interest: The author declares no conflicts of interest.

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