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Editorial

Optical and Electrical Properties of Low-Dimensional Crystalline Materials

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Low-dimensional materials have experienced a real revolution in both the technological and research fields in recent decades. Their unique properties have opened up a new frontier in the pursuit of novel technological advancements. By confining matter to reduced dimensions, such as thin layers or even individual atomic planes, low-dimensional materials are able to exhibit remarkable physical, chemical, and electronic properties that differ significantly from their bulk counterparts. This allows for the tailoring and engineering of their properties by simply controlling their geometrical parameters.

Low-dimensional materials encompass a diverse range of systems, including two-dimensional (2D) materials such as graphene, transition metal dichalcogenides (TMDs), and hexagonal boron nitride (h-BN); as well as one-dimensional (1D) nanowires (NWs) and zero-dimensional (0D) quantum dots.

What distinguishes low-dimensional materials from their bulk equivalents is their pronounced confinement effects, where the motion of electrons, phonons, photons, and many other particles becomes restricted in one or more dimensions. This confinement leads to intriguing phenomena such as strong electron–electron interactions, confined states, or altered electronic band structures, paving the way for groundbreaking applications across various disciplines. From nanoelectronics and optoelectronics to energy storage, material science, or biomedical applications, low-dimensional materials have demonstrated immense potential in revolutionizing our technological landscape.

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The unique electrical and optical properties of low-dimensional materials have been reviewed by Pura et al. [1]. This review covers all the possible dimensionalities: 2D, 1D, and 0D materials, with special emphasis on 2D and 1D materials, using the dependence of the physical properties with the different confined dimensions of each material as a common thread. In the 2D materials section, the authors review the electrical and optical properties of graphene and its derivatives, TMDs, h-BN, 2D oxides, and other interesting materials within this category. Regarding the section on NWs, both semiconductor and metallic NWs are presented separately. The properties of semiconductor NWs are introduced in consonance with their applications in optoelectronics, light emission, sensing, or photovoltaics. On the other hand, metallic NWs are shown to excel in electrical conductivity performance, optical transparency, or plasmonic response, with many applications in transparent conductive electrodes and sensing.

Several original contributions studied the optical and electrical properties of different low-dimensional materials. The effect of different gate insulators in MoSe2-based metal–insulator–semiconductor field-effect transistors (MIS-FETs) has been investigated by Abderrahmane et al. [2]. They studied the effect of using SiN and SiO_2 as gate insulators in this kind of device. In conclusion, SiN appears to be a good alternative to the more common choice of SiO_2, especially for optoelectronic devices such as high-speed photodetectors.

Salih et al. also studied the use of Zn(Al)O-mixed metal oxide (MMO) films for their use as transparent conductive oxides (TCOs) [3]. The observed optical transmittance of the post-processed MMO films revealed considerable transparency, with values ranging between 85% to 95%. This indicates a potential application of the deposited MMO film for TCO-based optoelectronic applications.

The optical properties of nanostructured CdO thin films and their dependence on the annealing time have been investigated by Kadhim et al. [4]. The annealed films are observed to present a homogeneous surface in the form of spherical nanoparticles with an average particle size of 46–80 nm. The optical characterization showed that the transmittance was in the range of 63–73% and the energy gap was in the range of 2.56–2.61 eV. The authors also found that the transmittance increased with the annealing time, while the energy band gap decreased.

Finally, Szewczyk et al. studied the thermal properties of detonated nanodiamond ceramics at low temperatures [5]. They examined the effect of the modification of the sintering conditions on the thermal transport properties. The thermal conductivity was reported to reach an improvement up to a factor of 3 at room temperature between different sintering temperatures. The analysis of the low-temperature behavior of the thermal conductivity indicated a strong influence of grain boundaries on phonon scattering processes.

This Special Issue on "Optical and Electrical Properties of Low-Dimensional Crystalline Materials" presents a state-of-the-art review of the topic, and, at the same time, exhibits many relevant contributions to different research areas.

Conflicts of Interest: The authors declare no conflict of interest.

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