electronic materials

Editorial

Characterization of Electronic Materials

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Electronic materials are of great interest due to their potential to be applied in a broad range of important electronic devices including transistors, sensors, solar cells and others. To improve the electronic performance and development of new electronic materials for future technologies, it is of fundamental importance to understand the electronic processes in these materials and devices. For this reason, advanced characterization techniques and theoretical models are necessary to gain detailed knowledge regarding the properties of electronic materials.

This Special Issue has collected outstanding publications on advanced characterization studies of electronic materials. These publications will allow us to better understand the electronic properties of important semiconductors.

Silicon, as a well-known semiconductor, is required in thicker layers to ensure enough light is absorbed in solar cells. In contrast, gallium arsenide (GaAs) has high potential for use in solar cells as it provides high efficiency when thin layers are applied. Further advantages of GaAs-based solar cells include their good temperature coefficient and the possibility of multi-junction devices. Tomah Sogabe et al. studied the hot-carrier effect and hot-carrier dynamics in p-i-n junction GaAs solar cells [1]. Such hot-carrier solar cells have gained significant interest in recent years due to their high theoretical efficiency limit of over 80%. The authors simulated hot-carrier solar cells consisting of a specially designed GaAs device. Two models (the drift-diffusion model and the hydrodynamic energy transportation model) were compared and showed quasi-equivalence. Furthermore, an increase in the open-circuit voltage was observed by increasing the hot-carrier energy relaxation time. A detailed analysis was established for the spatial distribution of hot-carrier temperature and its relation to the electric field and three hot-carrier recombination processes.

Copper zinc tin sulfide semiconducting (CZTSSe) compounds are also promising candidates for use in next-generation solar cells as they also only require thin absorber layers due to their direct bandgap compared to silicon, which has an indirect bandgap. As it is difficult to control secondary phases and structural defects in the material, the efficiency of CZTSSe solar cells was shown to approach a limit of 12–13%. One important factor which affects the efficiency of CZTSSe is the copper content in the layer. For this reason, Volodymyr Dzhagan et al. studied the impact of the copper content on the structural and electrical properties of CZTS films [2]. The films were obtained through the "green" synthesis of colloidal CZTS nanocrystals, during which, the copper-to-tin ratio was varied. The impact of the copper content on important properties of the semiconductor was determined. Furthermore, thermal annealing improved the electrical conductivity of the films, which was mainly explained by the formation of a CuxS nanophase at the CZTS nanocrystal surface but also by the partial removal of ligands and improved structural perfection.

Another type of promising semiconductor for electronic devices is the 4H-SiC material. In comparison to other SiC polytypes, 4H-SiC shows the largest bandgap and high and isotropic charge carrier mobility. Its potential application fields include bipolar devices, quantum sensors and power electronics. However, due to the presence of electrically active deep level defects, its practical application has been limited so far. In their review, Ivana

Capan and Tomislav Brodar provided a comprehensive overview on common majority and minority charge carrier traps in n-type 4H-SiC materials [3]. The authors focused on characterization performed using different junction spectroscopy techniques and also provided the basic principles of these methods. The use of these techniques provided detailed insight into the role of charge carrier traps in n-type 4H-SiC materials.

Another important semiconductor for application in electronics is the transition metal oxide tungsten oxide (WO_3). The oxygen-deficient n-type WO_3 shows a wide bandgap with outstanding conductivity and high electron hall mobility. It is also a well-known active material in sensor devices. Madjid Arab et al. reported on the application of WO3 thin films in surface acoustic wave sensing (SAW) devices [4]. In general, SAW devices are used as chemical gas sensors to determine micromass changes, are easy to use and have highly sensitive characteristics. In their work, the authors discussed theoretical and experimental results regarding the elastic and acoustoelectric properties of WO3 thin films of different thicknesses supported on a Quartz resonator. The analysis of the results was supported by modeling the SAW devices using the finite element and boundary element methods. It was observed that the SAW electroacoustic responses to the gravimetric effect and acoustic loss depended on the film thickness. As the film thickness increased, the resonance frequency shifted to lower values. Furthermore, strong displacement fields with low acoustic losses of the SAW devices as a function of WO_3 thickness were reported.

The publications of this Special Issue offer comprehensive and new understanding into the key properties of electronic materials with important electronic applications and open doors towards the further development of novel semiconductors and corresponding technologies.

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