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Optically transparent p-type oxide and oxychalcogenide semiconductors

Statement of the Problem: It is a great challenge to develop an oxide or oxychalcogenide material that is p-type conducting and also transparent to visible light. Transparent semiconductors oxides have many very important applications. A material that visible light can pass through requires that the material has a wide band gap of above 3 eV. However, such a wide band gap makes the material insulating due to the difficulty for electrons to jump from valence band to conduction band. Owing to the application needs, oxides have been intensively investigated as the potential transparent conductors (TCOs) and semiconductors (TCSs). To make a material electrical conducting as well as optically transparent, great efforts have been made since decades. Some TCOs and TSOs such as In_2O_3 incorporated with Sn (ITO) and ZnO doped with Al have been developed and applied as transparent electrodes in display panels for TV, computer screens and solar cells. However, these TCOs and TSOs are n-type. To make p-n junctions, p-type TCSs are also needed. In this presentation, both n-type and p-type semiconductors based on metal oxide and oxychalcogenide will be introduced, analyzed and discussed. One example is p-type ZnO and the p-n junction diode. Another example is the success in the p-type transparent oxychalcogenide LaCuOS. The intermediate product $CuLaO_2$ is synthesized via solid state reaction firstly, and then it is sulfurized at optimum temperature (860°C) to prepare LaCuOS without hazardous H_2S or CS_2 gas. The synthesized LaCuOS of high purity has a band gap of 3.1eV, gives a resistivity of 0.25 MΩ.cm and high Seebeck coefficient of +515μV/K. Moreover, it demonstrates great luminescence properties at room temperature. The success of this novel two-step synthesis method can be used flexibly with minor modifications to prepare other high performance oxychalcogenides.

Recent Publications

1. Zhang N and Gong H (2017) P-type transparent LaCuOS semiconductor synthesized via a novel two-step solid state reaction and sulfurization process. Ceramics International 43(8):6295–6302.
2. Shi D, Zhang L and Gong H (2017) Ni-Co oxide formation with Cu assisted method on Ni foam: Unexpected higher areal capacitance of inner layer with naturally formed nanotubes. J Power Sources 361:9–14.
3. Nie S, Sun J, Gong H, et al. (2016) Glucose-assisted reduction achieved transparent p-type cuprous oxide thin film by a solution method. EPL 115(3):37005.
4. Zhang L and Gong H (2016) Unexpected properties of gallium incorporated nickel oxide for electrochemical energy storage. Electrochimica ACTA 191:270–274.
5. Zhang L and Gong H (2015) Partial conversion of current collectors into nickel copper oxide electrode materials for high-performance energy storage devices. ACS Applied Materials & Interfaces 7(28):15277–15284.

Biography

Hao Gong completed his PhD from Delft University of Technology, the Netherlands. He is a Full Professor at Department of Materials Science and Technology, National University of Singapore. His research areas are electronic, functional, and sustainable energy materials thin films, nanostructures, heterostructures and devices. He has published more than 200 papers in reputed journals and has served as a Reviewer in more than 30 international journals including Nature Communications, Advanced Materials, Nano Letters, ACS Nano, JACS, etc. He is an Editorial Board Member of Scientific Reports, and Guest Editor of some special issues of a few journals. He has been Chairman for a few international conferences.

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