OXIDE SEMICONDUCTORS

This special issue of the Journal of Materials Research contains articles that were accepted in response to an invitation for manuscripts.

Introduction

Guest Editors:

Steve Durbin
University at Buffalo, Buffalo, New York 14260

Tim Veal
University of Liverpool, Liverpool, L69 4ZF, United Kingdom

Marius Grundmann
Universität Leipzig, Leipzig D-04103, Germany

Jamie Phillips
University of Michigan, Ann Arbor, Michigan 48109

Although critically important in many electronic applications, oxides are still confined to playing mostly passive roles in actual devices. This state of affairs is set to change dramatically in the near future as a result of increased appreciation of the potential offered by a very large family of semiconductor materials based on oxides. Spanning a broad range of electrical and optical properties, oxide semiconductors are of interest for a number of device applications including detectors, solar cells, light emitters and both transparent and high speed transistors.[1] Most prominent of these is perhaps ZnO, an ultraviolet band gap semiconductor readily available as very high-quality bulk substrates. The subject of many review articles already,[2] it is readily synthesized by many techniques in both thin film and nanostructure form. A number of high-quality devices have already been fabricated from this semiconductor, including Schottky-based diodes[3,4] and transistors,[5,6] although achieving reproducible p-type material has been surprisingly challenging. Still, despite the fact that our understanding of the optical and electrical properties of this material has improved greatly over the past several years, there remain many open questions, particularly regarding both impurities and fundamental defects, as well as unusual polarity effects.[7]

Additional oxide semiconductors attracting interest for their device potential include CdO, In_2O_3, Ga_2O_3 and both SnO and SnO_2. Intriguingly, SnO tends to be p-type as-grown, whereas SnO_2 is known to have a strong tendency to be n-type, similar to ZnO, In_2O_3 and CdO. These compounds are also readily synthesized by a number of conventional deposition techniques including sputtering, pulsed laser deposition, chemical vapor deposition and molecular beam epitaxy, but do not yet benefit from high-quality bulk crystals suitable for substrates. Consequently, our understanding of these materials is limited, and better control of carrier concentration is an important goal. Rather than studying these materials in isolation, however, it is clear that a better approach is to improve our understanding of them as a family, and this should ultimately lead to devices with a broad range of applications. It is with this intention that we selected the papers which comprise this Focus Issue.

It is also worth noting that more recently, considerable attention is being given to thin film indium gallium zinc oxide– often referred to as IGZO – which is of significant interest for thin film transistors used in flat panel displays. This material can be compositionally tuned and is a serious rival to amorphous silicon, the traditional material of choice. Device performance is improving dramatically, driven by significant commercial interest, and it is likely that increased attention will be directed to developing a more detailed understanding of its fundamental properties and ultimate performance potential.

Finally, we would like to offer our sincere thanks to both the authors and reviewers of the many high-quality manuscripts submitted to this *JMR* Focus Issue on Oxide Semiconductors, as well as the efficient and talented editorial staff who were always willing to provide much appreciated assistance throughout the process.

REFERENCES

1. P.D.C. King and T.D. Veal: Topical Review: Conductivity in transparent oxide semiconductors. *J. Phys. Condens. Matter* **23**, 334214 (2011).
2. See, for example, Ü. Özgür, Ya. I. Alivov, C. Liu, A. Teke, M.A. Reshchikov, S. Doğan, V. Avrutin, S.-J. Cho, and H. Morkoç: A comprehensive review of ZnO materials and devices. *J. Appl. Phys.* **98**, 041301 (2005); C. Jagadish and S. Pearton, eds., *Zinc Oxide Bulk, Thin Films and Nanostructures*, 1st Edition. Elsevier Ltd., Boston, 2006.
3. C.A. Mead: Surface barriers on ZnSe and ZnO. *Phys. Lett.* **18**, 218 (1965).
4. M.W. Allen, S.M. Durbin, and J.B. Metson: Silver oxide Schottky contacts on n-type ZnO. *Appl. Phys. Lett.* **91**, 053512 (2007).
5. B. Bayraktaroglu, K. Leedy, and R. Neidhard: Microwave ZnO thin-film transistors. *IEEE Electron Dev. Lett.* **29**, 1024 (2008).
6. M. Grundmann, H. Frenzel, A. Lajn, M. Lorenz, F. Schein, and H. von Wenckstern: Transparent semiconducting oxides: Materials and devices. *Phys. Status Solidi A* **207**, 1437 (2010).
7. M.W. Allen, D.Y. Zemlyanov, G.I.N. Waterhouse, J.B. Metson, T.D. Veal, C.F. McConville, and S.M. Durbin: Polarity effects in the x-ray photoemission of ZnO and other wurtzite semiconductors. *Appl. Phys. Lett.* **98**, 101906 (2011).

DOI: 10.1557/jmr.2012.263

 © Materials Research Society 2012

https://doi.org/10.1557/jmr.2012.263 Published online by Cambridge University Press