Abstract #906, 223rd ECS Meeting, © 2013 The Electrochemical Society

Epitaxial growth of visible to infra-red transparent conducting In_2O_3 nanodot dispersions and reversible charge storage as a Li-ion battery anode

M. Osiak[1], W. Khunsin[2], E. Armstrong[1], T. Kennedy[3,4], C. M. Sotomayor Torres[2], K. M. Ryan[3,4], and C. O'Dwyer[1,5]

[1] Applied Nanoscience Group, Department of Chemistry, University College Cork, Cork, Ireland
[2] Phononic and Photonic Nanostructures Group, Catalan Institute of Nanotechnology, Campus UAB, Edifici CM3, Bellaterra, 08193 (Barcelona) Spain
[3] Department of Chemical and Environmental Sciences, University of Limerick, Limerick, Ireland
[4] Materials and Surface Science Institute, University of Limerick, Limerick, Ireland
[5] Micro & Nanoelectronics Centre, Tyndall National Institute, Dyke Parade, Cork, Ireland

Indium oxide has become the subject of extensive studies in recent years due to its excellent electrical[1] and optical properties[2,3] as well as large theoretical lithium storage capacity[4] thus making them particularly attractive for use in thin film transistors[5], touch screens[6] and transparent contacts in solar cells[7]. Large theoretical lithium storage capacity also offers possibility for development of indium oxide based lithium-ion battery anodes. Recent demonstration[8] of transparent lithium ion battery has shown potential scope for development of see through charge storage materials, where touch screens, solar cells and batteries can coexists with transparent, or optically addressable form. Transparency can be provided by using miniscule quantities of materials, but to increase storage capacity, strategies to improve transparency while maximizing active material coverage of an electrode would be highly advantageous. One method to allow transparency in a battery is to reduce active material dimensions below their optical absorption length.

Here, In_2O_3 {111}-oriented crystalline nanodot dispersions were fabricated by MBE at an elevated temperature resulting in unique bimodal size dispersion. The growth of the nanodots and the surface coverage will be detailed and excellent IR and visible transparency will be demonstrated with reversible lithium storage. The orientation of the nanodots allows minimal lattice mismatch between the In_2O_3 and Si substrate. This helps to prevent interfacial weakening during lithiation, while co-insertion into the silicon substrate provides a degree of buffering of volumetric expansion occurring during electrochemical reactions of indium with lithium.

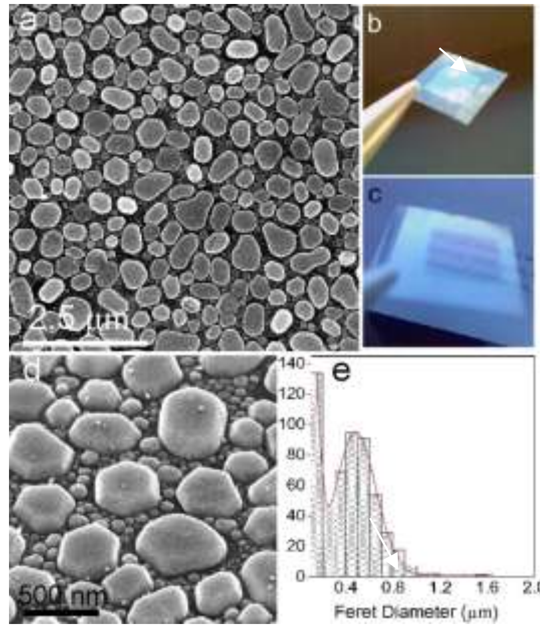

Fig. 1. (a) SEM image of In_2O_3 nanodots on silicon (b-c) Optical images of the In_2O_3 nanodots showing antireflection characteristics in the visible (d) Tilted SEM image of In_2O nanodots. (e) Size distribution histogram for In_2O_3 nanodot dispersion.

References

(1) H. Ohta, H. Hosono, *Mater. Today,* **3**, 42, (2004).
(2) C. H. Chiu, P. Yu, C. H. Chang, C. S. Yang, M. H. Hsu, H. C. Kuo, Ma Tsai, *Opt. Express.* **17**, 21250 (2009).
(3) C. O'Dwyer, M. Szachowicz, G. Visimberga, V. Lavayen, S. B. Newcomb, and C. M. Sotomayor Torres, *Nat. Nanotechnol.* **4**, 239 (2009).
(4) W. H. Ho, C. F. Li, H. C. Liu, S. K. Yen, *J. Power. Sources*, **175**, 897 (2008).
(5) P. C. Chen, G. Shen, H. Chen, Y. Ha, C. Wu, S. Sukcharoenchoke, Y. Fu, J. Liu, A. Facchetti, T. J. Marks, M. E. Thompson, C. Zhou, *ACS Nano*, **3**, 3383, (2009).
(6) Y. Y. Kee, S. S. Tan, T. K. Yong, C. H. Nee, S. S. Yap, T. Y. Tou, G. Sáfrán, Z. E. Horváth, J. P. Moscatello, Y. K. Yap, *Nanotechnology*, **23**, 025706, (2012).
(7) D. A. Rider, R. T. Tucker, B. J. Worfolk, K. M. Krause, A. Lalany, M. J. Brett, J. M. Buriak, K. D. Harris, *Nanotechnology*, **22**, 085706, (2011).
(8) Y. Yang, S. Jeong, L. Hu, H. Wu, S. W. Lee, Y. Cui, *Proc. Natl. Acad. Sci.* **108**, 13013, (2011).