Strategies for the Design and Fabrication of Improved Transparent Conducting Oxide Thin Films via the use of In-situ Growth Monitoring and the Exploitation of Photonic Band Gap Materials

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For a photovoltaic device based on an already optimised active photo absorber medium it is arguable that improvements in device efficiency can only be made via the optimisation of the associated components of the device. One such component is the transparent conducting oxide (TCO) that is used to provide electrical conductivity through the device and to permit the passage of light into the absorbing medium. Chemical vapour deposition (CVD) is a useful method for the production of such TCO layers since it is a relatively fast and cheap process, while varying the parameters employed often allows one to tune film morphology and in some case crystallinity. As such it is apparent that understanding how these CVD processes actually work could provide the means of optimising the growth and properties of the resulting TCO films. In the first part of this presentation results for the use of IR spectroscopic methods for the study of the growth of SnO_2 films on glass will be presented. It will be demonstrated that near-IR diode laser spectroscopy is a powerful method for the study of such reactions as illustrated for the precursor system $SnCl_4$ and H_2O. In addition, broad band FTIR spectroscopy has been used to study the growth of SnO_2 from the alternative precursor combination $(CH_3)_2SnCl_2$ and O_2.
Although not strictly relevant to the discussion of TCO materials, additional data will then be presented for the growth of the novel thermochromic material VO_2 from both VCl_4/H_2O and vanadyl acetoacetonate ($VO(acac)_2$), since we have also performed detailed spectroscopic studies of these growth systems using FTIR methods. These data are used to illustrate the methodology whereby individual reacting species may be identified and correlated within an otherwise complex system.
Finally, reference will be made to the emerging field of the use of photonic band gap (PBG) materials to produce improved photovoltaic systems. We present data for the growth of doped ZnO *inside* photonic band gap materials based on synthetic opals, which are synthesised and assembled in our laboratories. We demonstrate that under the correct conditions of PBG fabrication and modification of the photonic stop band by careful choice of infill levels, it is possible to design a material where the passage of photons through the film is significantly enhanced as compared to a non PBG system.