

## PREFACE

*Thus daily were my sympathies enlarged,  
And thus the common range of visible things  
Grew dear to me: already I began  
To love the sun, a Boy I lov'd the sun,  
Not as I since have lov'd him, as a pledge  
And surety of our earthly life, a light  
Which while we view we feel we are alive;  
But, for this cause, that I had seen him lay  
His beauty on the morning hills, had seen  
The western mountain touch his setting orb,  
In many a thoughtless hour, when, from excess  
Of happiness, my blood appear'd to flow  
With its own pleasure, and I breath'd with joy.*

William Wordsworth, *The Prelude: Book 2: School-Time*, 1805.

More solar energy falls on the Earth's surface every day than the total amount of energy the world's population would consume in 16 years at present rates of utilisation. To harness this potential to provide reliable and economic carbon-free sources of electricity and fuels remains a challenge, even in current times of high energy prices and action to mitigate climate change. However, there are encouraging signs. The annual global market for photovoltaic (PV) modules was valued at US\$12.9bn in 2007 and is predicted to grow by 15% compound per annum. Although crystalline silicon  $p-n$  junction cells still dominate this market, a new generation of photovoltaic and photoelectrochemical devices is emerging to challenge them, many based on the unique properties of matter at the nanoscale.

It is this new generation of solar photon conversion devices that are covered in this book. They are less highly developed than those described in Volumes 1 and 2 of this series, but their promise is at least as great. That promise is two-fold: on the one hand highly efficient devices with sophisticated architectures in which the Shockley–Queisser limit on efficiency is finally overcome, and on the other very low-cost plastic or organic-based devices that are cheap enough to be disposable.

The leitmotifs of these devices include bespoke dye sensitisers, space-quantised nanoscale structures that enable hot carrier or multiple exciton generation, molecular and solid-state junction architectures that lead to efficient exciton dissociation and charge separation, and charge collection by percolation through porous or mesoscale phases. Another common theme underlying the devices discussed in this book is the

orthogonalisation of the pathways for photon absorption and carrier collection. Contrast the classical silicon solar cell, in which the two pathways are parallel with an ETA or bulk heterojunction cell, in which they are orthogonal. In the silicon cell, the base layer has to be sufficiently thick to absorb incoming photons, so minority carrier diffusion lengths have to be (and are) as long as 200–500  $\mu\text{m}$ , placing great demands on materials quality. In an ETA or bulk heterojunction cell, the junction architecture allows efficiencies of over 5% to be achieved with exciton or charge carrier diffusion lengths that are as much as one million times shorter, and materials of much lower electronic quality suffice.

Photocatalysis is closely related to photoelectrochemistry, and the fundamentals of both disciplines are covered in this volume. Their applications to photoelectrolysis and other solar fuel-forming or waste-destroying photochemical and photoelectrochemical processes will form the main subject matter of the fourth and final volume in this book series.

To satisfy the global need for carbon-free energy, the fields of photovoltaics and photoelectrochemistry must continue to develop. The key to progress lies in the quality of the fundamental research being conducted in this area. It is worrying that global funding streams for research to develop advanced solar photon conversion technologies remain fragile despite the concerted and powerful case for a ‘Manhattan project’ effort to do so made by the international scientific community during a special conference in 2005 on basic research needs for solar energy utilisation promoted by the US Department of Energy’s Office of Science, Basic Energy Sciences Division. However, commercialisation of some of these devices is beginning, and a January 2008 report from BCC Research predicts that the market for nanostructured thin films and silicon and dye-sensitised solar cells is set to grow at more than 50% per annum through to 2013 as the technology matures.

Our warmest appreciation goes to our fifteen authors, who between them have provided so rich a picture of the scientific frontiers they are exploring. We also thank Alexandra Anghel, Carol Burling, Barrie Clark and Stuart Honan for their editorial assistance, David Ginley, John Kelly and Reshef Tenne for providing information, James Bolton for his early input into some of the material in Chapters 1 and 4, the staff of World Scientific Press who expertly drew many of the diagrams, and Lenore Betts, Lizzie Bennett and Katie Lydon of IC Press for guiding us along the winding road to publication.

Mary D. Archer  
Arthur J. Nozik

March 2008