計畫編號：BE04-00

計畫名稱：可再生能源材料之先進製程技術

計畫主持人：李篤中

計畫摘要(中)：

有效利用可再生能源是現代社會可持續發展的關鍵，國際能源局定義可再生能源為”由風力、太陽光、海洋、水力、生物質、及地熱產生之電力及熱能 及其他可再生來源產生之生物燃料及氫氣”。有效利用可再生能源需要高效之能源採集儲存及輸運系統，對如台灣這種開發中國家而言是技術及財政上之沉重負擔，而可以高效採集及儲存間歇性可再生能源之能源材料是發展有效利用可再生能源之關鍵。本計畫將討論可再生能源材料之先進製程技術，包括(子計畫一)前端高效率太陽能矽晶材料生長技術；(子計畫二)新穎高分子太陽能材料及其元件製程最適化；(子計畫三)生物能源材料之先進製程技術；(子計畫四)高功能電化學元件材料之先進製程；(子計畫五)無鹽系統內的電動力學現象。

本團隊成員皆為相關領域之優秀研究人員，在 2002-2007 間共發表 414 篇 SCI 期刊論文，並被引用 1907 次。支持本計畫之執行將可幫助本團隊研究成果更上層樓，並保持在可再生能源領域之領先地位。

計畫摘要(英)：

Efficient utilization of renewable energy sources enlightens the sustainability of our modern society. International Energy Agency (IEA) defined Renewable energy as “is… electricity and heat generated from solar, wind, ocean, hydropower, biomass, geothermal resources, and biofuels and hydrogen derived from renewable resources.” Wide application of renewable energy requires its efficient collection, storage, and transportation, which poses technical and financial barriers for developing countries like Taiwan. Energy materials capable of collecting and storing at high efficiency the intermittently available renewable energies are key elements in the development of renewable energy process technology. This Excellence Research Project aims at contributing to cutting-edge research on advanced processing technologies of energy materials, with especially focus on the advanced

crystal fabrication processes of silicon materials for silicon solar cell (sub-project 1), the processing technologies of innovative polymer-based (poly(3-hexylthiophene)(P3HT)/PCBM system) solar cell (sub-project 2), the processing of high-efficiency bioenergy materials for conversion of biomass to bioenergy (sub-project 3), development of high-performance component materials for Li-ion battery applications (sub-project 4), and fundamental studies of eletrokinetic phenomena realizing the transport processes in the so-developed devices (sub-project 5).

The team members are experienced researchers in related fields, publishing a total of 414 SCI papers and receiving 1907 citations in period of 2002-2007. Full support of this project definitely will help the team moving into the new horizon and maintaining the leading-role performance in the renewable energy processing fields.

計畫編號：BE04-01

計畫名稱：高效率太陽能矽晶材料與電池的先進製程研究

計畫主持人：藍崇文

計畫摘要(中)：

太陽能發電原理為電池吸收太陽光後轉換成為電能。雖然太陽能在三十年前就已經開始發展，但是直到近五年來由於新技術的建立，太陽能產業開始以每年 35%的速度成長。2006 年時太陽能已到達 2.5GWp 的產能，而其中矽晶仍然為太陽能的主流，具有 85%的市場佔有率。目前太陽能發電成本仍然高達每瓦約 100 元，因此未來太陽能科技的發展重點為減少生產成本及提高發電效率，目標在 2015 年時將發電成本壓縮到每瓦 33 元以下。本計畫研究目的為研發高效率低成本之太陽能電池，研究重點共可分為三部分，第一部分為使用控制晶向之多晶子晶來作柴氏法多晶提拉，第二部分為晶向控制化的多晶鑄造生長，第三部分為黑色太陽能電池製作技術。黑色太陽能的製造方法為在矽晶表面製作一層奈米等級的蝕刻表面，使得晶片表面可以達到最小的光反射。另一個改進方式則是可以利用原子層層積技術來進行晶片表面鈍化，這是目前已知可用來降低表面載子再結合速率的有效方式。

除了實驗技術的研究改進之外，本計畫也使用相場模擬來進行晶體生長及晶向生長機制的理論分析。計畫中將建立 3-D 的相場模式來進行多晶矽生長模擬計算，此外光電與元件的電腦模擬也有助於奈米

等級蝕刻表面的設計。

本計畫執行期限一共三年，經費預計需要 732 萬，每年 244 萬其中將建構 FTIR，Laser processing tool，跟 Inject printer，用作新結構新製程之用。計畫也將與工研院太陽能光電科技中心及中美矽晶公司合作，未來對於產業界的高品質多晶矽製造與高效能太陽能電池製作將有助益。

計畫摘要(英)：

Photovoltaics (PV) is solar electric power technology that converts sunlight directly into electricity. Although the research and development of PV technology have been over thirty years, the solar market growth was slow until recent years when due to the supports of various incentive programs, particularly in Japan and Europe, markets have grown by an average of more than 35% per year over last 5 years. In 2006 alone, more than 2.5 GWp PV modules were produced. Silicon solar cells are still the main stream, sharing more than 85% of the market. Nevertheless, the solar cell cost being about US$ 3/Wp is still too high, and the advanced processing technologies for low-cost and high-efficiency solar cells are necessary for the projected US$ 1/Wp by 2015. In this proposal, we will focus on three processing technologies that are critical for getting the low-cost and high-efficiency silicon solar cells. The first two proposed works are related to the crystal growth technologies including Czochralski pulling of polycrystalline silicon using a prearranged multiple-orientation seed and the grain control in silicon in directional solidification. The third one is proposed for the so-called black cells by fabricating nano-patterns on the silicon wafers, so that the light reflection on the surface can be minimized. Further improvement can be done by using the atomic layer deposition (ALD) for surface passivation, and this has been found effective in reducing surface recombination.

Beside the development of the advanced processing technologies, theoretical understanding of crystal growth and grain competing mechanisms will be carried out through phase field simulation. The three-dimensional phase field model for polycrystalline crystal growth will be developed. Optical simulation and device simulation will be considered for designing the nano-patterned solar cells.

The project is proposed for three years. Seven millions NT dollars are required including FTIR, laser, and in jet printer. In collaboration with the Photovoltaics Technology Center at ITRI and Sino-America Silicon Product Inc., the technologies developed for the high-quality polycrystalline solar ingots and the high-efficiency solar cells should be beneficial for the PV industry.

計畫編號：BE04-02

計畫名稱：新穎高分子太陽能材料及其元件製程最適化

計畫主持人：陳文章

計畫摘要(中)：

近年來，以高分子太陽能電池做為新穎性的替代能源受到廣泛的重視。然而，其光電轉換效率要能大於 10%且要有至少 10 年的生命周期，才有商業化的價值。欲達到此目標可有以下方針: (1)高分子必須具有高載子遷移效率 (大於 10-3 cm2/Vs); (2) 開發具有廣波域吸收的低能隙高分子材料; (3)主動層受體-施體電子能階最適化; (4)有序異質接面 (order Bulk Heterojunction)。目前研究以 P3HT 混摻 PCBM 的異質均相結構能達到最高的光電轉換效率約為 4-5%。此混摻系統除了本身具有高載子遷移率，且可藉由溶劑的選擇與後烤製程來調控一個較具規則性的形態，進而達到如此高的效率。而近期研究亦顯示新穎性高分子材料的開發、元件的封裝與製程的最適化皆能幫助提高光電轉換效率。

在本計畫中，我們提出了二個新穎性的系統更進一步提昇 P3HT/PcBM 系統之光電轉換效率及其長期穩定性: (1) P3HT 末端以具有高電洞傳導能力的 dendron 修飾並且混摻 PCBM ；(2) PCPDT 末端以具有高電洞傳導能力的 dendron 修飾並且混摻 PCBM。當 P3HT 與 PCPDT 末端以不同代(generation)的 hole-transporting dendron 來修飾時，不但可以調控主動層表面形態，還可以更進一步提升整體的載子遷移速率，即有效增加電子/電洞分離。除此之外，末端以 electroactive dendron 修飾的高分子，預期可以使原本的高分子半導體進一步降低其能帶隙，進而能更有效的利用太陽光。在元件製程上，我們也將利用溶劑的選擇(沸點、極性)與元件熱處理，調控主動層的表面形態。此外，我們亦將利用結合上述高分子系統；TiOx 插層及低能帶隙 PCPDT-acceptor 共聚物之串疊型太陽能電池(tandem solar cell)的技術，以期將效率達到 8-10%以上。最後將利用原子層沉積

(atomic layer deposition, ALD)元件封裝技術，使元件能維持較久的生命週期，而希望能達到最終商業化之標準。

計畫摘要(英)：

Polymer based solar cells have been recognized as new kinds of energy resources. The goal for the commercial applications of such solar cells are power conversion efficiency > 10% and at least 10 years of long term stability. There are several specific chemical structure or process requirements to achieve this goal: (1) polymer with high carrier mobility > 10-3 cm2/Vs; (2) enhance the solar energy absorption by low band gap polymers; (3) optimization of HOMO and LUMO energy levels between the donor/acceptor active layers; (4) order heterojunction structure. The polymer solar cell with the highest power conversion efficiency is poly(3-hexylthiophene)(P3HT)/PCBM system with 4-5%. Besides the high carrier mobilities of P3HT and PCBM, the processing solvent and post-thermal treatment to form order structures contributed to such high solar cell efficiency. In order to further enhance the efficiency, novel polymer structures are required to be developed. Furthermore, new process optimization and cell encapsulation are also essential.

In the proposed project, two new polymer systems are proposed to achieve this goal: (1) P3HT end-functionalized with hole transporting dendrons/ PCBM, (2) poly(cyclopentadithiophene) (PCPDT) end-functionalized with hole transporting dendrons/PCBM. The parent P3HT and PCPDT have relatively high hole mobility around 0.1~1 10-3 cm2/Vs. The end-functionalized different generation of dendrons could not only control the morphology and further enhance the carrier mobility higher than P3HT or PCPDT. Thus, the enhancement of the carrier separation efficiency is expected. Besides, smaller band gaps of the new end-functionalized polymers than the parent P3HT or PCPDT could be achieved by such end-functionalized electroactive dendrons. Process optimization through solvent (boiling point, polarity) or thermal treatment (multi-step curing for inducing the ordered structures) will be employed to control the morphology of active layer. The tandem cell approach (e.g., high band gap P3HT-dendron/TiOx/low band gap P3CPDT-acceptor)will also be used to enhance the efficiency to reach

8-10%. The atomic layer deposition technique will be developed to encapsulate the solar cell devices for enhancing their long-term stability.

計畫編號：BE04-04

計畫名稱：高功能電化學元件材料之先進製程

計畫主持人：吳乃立

計畫摘要(中)：

電化學能儲存裝置能夠將電能轉換成化學能，並儲存在化學製品中，且在需求時可逆的由化學能轉化成電能。這些裝置通常是永續能源擷取系統，例如太陽能電池、風車等裝置的重要元件之一。不同規模的太陽能或是風力轉換成的電力暫時地儲存在電池/超高電容中，並加以管理。發展更複雜且尺寸更小的電化學儲能裝置的驅動力在於對於可攜帶式電子產品的需求增加。儲能電容量、功率性能和安全考量是發展商業上可實行電化學技術的三大主題。在上述每個主題中，材料的議題都扮演了重要的角色。研發新的製程技術以製備新的材料能夠擁有高電容量、高充放電能力、高安全性且不會對環境造成污染，能夠在電化學能儲存技術方面有革命性的突破。此計畫將包含二個主要研究的主題，分別著重於高性能鋰離子電池新型負極材料與適用於鋰離子電池與染料敏化太陽能電池之全固態電解質之合成製程技術的研發，以期發展兼具高性能與環保與安全的先進電化學儲能裝置元件。

計畫摘要(英)：

Electrochemical energy storage devices convert electricity into chemical energy that is stored in chemicals and then release it via a reversible path upon demand. These devices are more than often key components to several sustainable energy-harvesting systems, such as solar cells and wind mills. Either the solar energy or wind power is converted into electricity, which is temporarily stored in and managed by battery systems of different scales. Ever increasing demand for portable electronic devices is another driving force to the development of sophisticated, small-scale electrochemical energy devices. Energy storage capacity, power capability and safety are three major topics for the development of commercially viable electrochemical technology. Material issue in turn plays important roles in each of these topics.

Development of new materials to facilitate high energy capacity, high power delivering capability, high safety, and environment benignity opens up the opportunity for revolutionizing the electrochemical energy-storage technology. This sub-project will include two major research topics that focus on developing processing methodologies to fabricate high-performance component materials for Li-ion battery applications. The topics include chemical processing of high-performance Si anode and synthesis of solid-state electrolytes suitable for both Li-ion batteries and Dye-sensitized solar cells (DSSCs).