高等学校“专业综合改革试点”项目

太阳能热利用技术丛书

太阳能专业英文文献选读

郝昕 编

清华大学出版社

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内容简介

本书作为“太阳能热利用技术丛书”之一，是教育部专业综合改革试点研究成果。本书共分为11章，涉及太阳能光伏、光热方向的理论研究与技术应用等内容。每章分为选摘专业文献、词汇与解析、专业文献延伸阅读、问题等四部分，力求明确本章节的学习目标与任务，激发读者的问题意识，反映文献的研究内容、逻辑思路、研究方法，引导读者掌握太阳能专业的核心概念与基本理论点，提升相关专业的理论分析与研究能力。本书既是太阳能专业的学术读物，又是专业英语的学习教材，适合用作高等院校太阳能专业专科，本科及研究生的专业英语教材。

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丛书序言

能源是人类社会赖以生存和发展的物质基础。纵观人类社会发展的历史，人类文明的每一次重大进步都伴随着能源的改进和更替，能源的开发利用极大地推进了世界经济和人类社会的发展。进入21世纪后，全球经济快速发展和人口不断增长，使得一次能源消费量不断增加。人们在物质生活和精神生活不断提高的同时，也越来越感受到大规模使用化石能源带来的严重后果：资源日益枯竭，生态环境不断受到威胁，还诱发了不少国与国之间、地区之间的政治经济纠纷，甚至冲突和战争。因此，人类必须寻求清洁、安全、可靠的新能源和可再生能源。

太阳能是开发和利用新能源与可再生能源的重要内容。太阳能具有资源丰富，取之不尽、用之不竭，处处均可开发利用，无须开采和运输，无污染等特点。因此，太阳能的开发利用有着巨大的市场前景。我国是太阳能资源十分丰富的国家之一，2/3的地区年辐射总量大于5020MJ/m^2，年日照时数在2200小时以上。尤其是大西北，太阳能的开发利用有巨大的潜力。

太阳能光热利用是太阳能热利用的一种基本方式。太阳能低温热利用产生的是热水，象征产品是太阳能热水器、商用的太阳能热水系统和工业用的太阳能热水系统；太阳能中温热利用产生的是热能，是太阳能热利用未来10～20年内主要的发展方向；太阳能高温热利用产生的是热电，主要作用于“政府”公共工程以及商业领域，是未来太阳能热利用的最高阶段，也将成为替代常规能源的主要途径。

清华大学出版社和德州学院顺应时代需要，组织联系一批学者和太阳能光热企业技术人员，出版了这套“太阳能热利用技术丛书”。本套丛书共七本，从太阳能热利用概述到热水系统设计、施工管理，再到专

业英文文献，体系完整。每本书在编写时，思路清晰，内容丰富充实，不仅有理论介绍，更有大量翔实的案例，既具有很强的实用价值，又具有较高的学术价值。本套丛书不仅可以作为能源类太阳能相关领域的专业图书和教材，还可以作为太阳能相关企业工程技术人员的专业培训用书和参考书。

我们期待本套丛书的出版发行，并希望它能在太阳能光热的研究开发与应用进程中作出应有的贡献。

是以为序。

贾铁鹰

2013 年 7 月

前言

《太阳能专业英文文献选读》作为高等院校太阳能专业的专业英语教材，兼顾了教学和科研等不同层次读者的要求，既适合用作高等院校太阳能专业专科、本科及研究生的专业英语教材，也可作为相关专业教师理论研究的重要文献参考。

该书共分为11章。每章分为四个部分：一是专业文献英文原文，所有文章均为英文原文著作，内容涉及光伏、光热方面理论研究与技术应用，具体涵盖了太阳能光伏发展趋势、非晶硅薄膜太阳能电池研究与应用、太阳能集热器应用技术、太阳能利用热光转换技术等方面内容；二是词汇与解析，选取每篇专业文献中的关键词与生词，对太阳能领域内的专业术语进行标注与解释，力求通过对关键词与生词的解读，使学生初步掌握本章的核心概念与基本理论点；三是专业文献延伸阅读，明确延伸阅读的具体学习要求，列出相关文章名称，并注明文章出处，引导学生在延伸阅读中丰富知识体系，开拓理论视野；四是问题思考，列出相关理论问题，引导学生进一步深入思考，激发学习兴趣，提升理论分析与研究能力。各个章节衔接紧密，力求在学科的理论知识、研究方法与研究思想三者之间保持平衡，引导读者进一步了解与把握该专业的基本理论知识和核心研究范式。

在该书付梓出版之际，编者尤感欣慰。在编写过程中，德州学院副校长季桂起教授悉心指导，几次提出重要意见，亦得李永平教授、钟玲教授、孙如军教授等多位专家的大力支持与指点。在此，一并表示衷心感谢。

限于编者水平，该书难免有疏漏之处，恳请专家、同行和广大读者批评指正，以期进一步修订和完善。

编　者

2013年5月

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第1章

论太阳能光伏近期发展趋势

Ⅰ 选摘专业文献(Quoted article)

Recent developments in photovoltaics[1]

Abstract

The photovoltaic market is booming with over 30% per annum compounded growth over the last five years. The government-subsidised urban residential use of photovoltaics, particularly in Germany and Japan, is driving this sustained growth. Most of the solar cells being supplied to this market are "first generation" devices based on crystalline or multi-crystalline silicon wafers. "Second generation" thin-film solar cells based on amorphous silicon/hydrogen alloys or polycrystalline compound semiconductors are starting to appear on the market in increasing volume. Australian contributions in this area are the thin-film polycrystalline silicon-on-glass technology developed by Pacific Solar and the dye sensitised nanocrystalline titanium cells developed by Sustainable Technologies International. In these thin-film approaches, the major material cost component is usually the glass sheet onto which the film is deposited. After reviewing the present state of development of both cell and application technologies, the likely future development of photovoltaics is outlined.

1 Introduction

Although photovoltaics cells have been used since the 1950s in space craft, the interest in their terrestrial use was heightened by the oil embargoes of the early 1970s. Since then, a steadily growing terrestrial industry has developed which, in the past, has supplied cells mainly for remote area applications where conventional electricity is expensive (Green, 2000). However, the industry is now in an explosive period of growth where the subsidised urban residential use of photovoltaics is providing the main market. The industry has grown at a compounded rate of 30% per annum over the last five years, corresponding to a quadrupling of annual production over this period (Fig. 1).

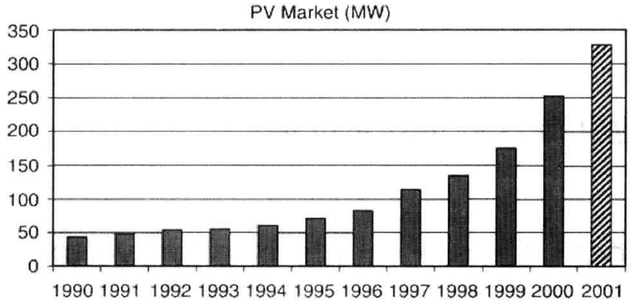

Fig. 1 Growth in PV module shipments (1999—2001).

The present healthy state of the industry is stimulating the fabrication of several large new manufacturing facilities and the commercialisation of new cell technologies. Although most of the product over the coming decade will be "first generation" silicon wafer based, it is thought likely that a "second generation" thin-film technology will make its mark during this period.

2 First generation technology

In the past, the overwhelming majority of cells have been fabricated using silicon wafers, as used in microelectronics, as the starting material and a screen printing technology for depositing the metal contact, giving the final cell structure shown in Fig. 2. The main attributes of this technology are the simplicity of applying the metal contact, which uses a process similar to printing patterns on T-shirts, as well as the availability of equipment for this purpose from the hybrid microelectronics industry (Green, 1995). The price for this simplicity is substantially lower cell performance than would otherwise be possible. This sacrifice is not particularly sensible given the material intensiveness of current solar cell manufacturing, with over 40% of the cost of the final product being attributable to the cost of the starting silicon wafer used in cell fabrication. The laser grooved, buried contact solar cell shown in Fig. 3 was developed at the University of New South Wales (UNSW) in the early 1980s as a way of transferring some of the groups laboratory improvements into commercial practice. The distinctive feature of this technology is the use of lasers to form deep grooves in the silicon cell surface.

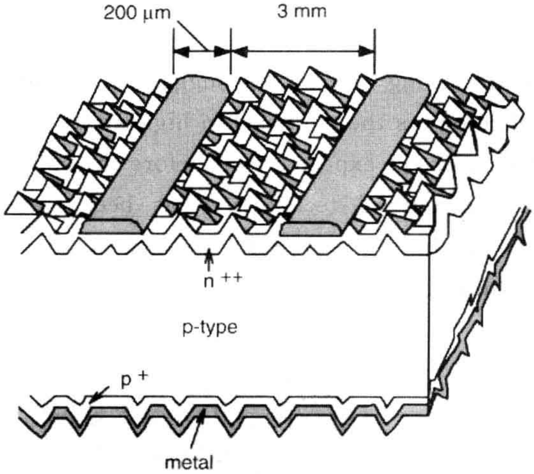

Fig. 2　Standard screen printed solar cell (Green, 1995).

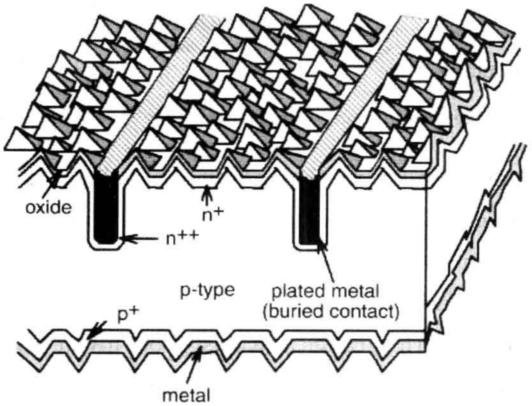

Fig. 3　UNSW buried contact solar cell.

Subsequently they can be used to define where the metal contact is deposited by electroless plating. This gives numerous performance advantages compared to the standard screen printing approach, by allowing the elegant incorporation of many of the performance enhancing features previously developed at UNSW (Green, 1995). Comparison of the output characteristics of the two technologies shows a 20%-30% performance advantage for the buried contact approach (BP Solar, 1991). Published manufacturing cost analyses by BP Solar also show that the product is no more expensive to produce per unit area, giving rise to a similar 20%-30% economic advantage based on the price per Watt of the final product. A recent major European Union study showed that the UNSW buried contact cell approach was the most economic silicon cell processing method yet suggested (Bruton et al., 1997). Over recent years, this technology is the one used in highest volume in Europe, with the $1 billion in accumulated sales expected well before the end of the decade.

Another recently introduced technology has been the HIT cell (Fig. 4) introduced by Sanyo which is a successful merger of that company's thin-film amorphous silicon technology and wafer-based technology.

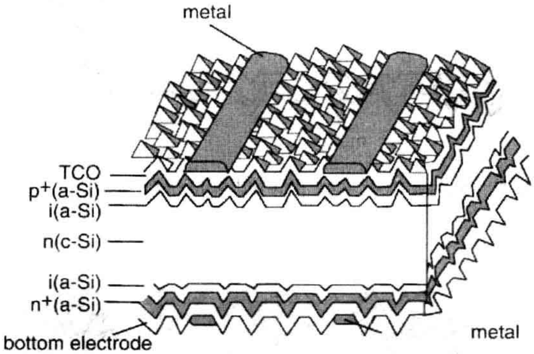

Fig. 4 Heterojunction with intrinsic thin-layer (HIT) cell.

Cell efficiencies are similar to the production values of buried contact cells, although module efficiency is higher due to denser packing in the module.

A survey of the manufacturer's nominal efficiency of a range of first generation commercial modules is shown in Fig. 5. Typical efficiency is in the 10%-15% range. Modules at the low end of this range are based on lower cost substrates such as silicon-on-ceramic ribbon or multicrystalline silicon, while those at the high end use the buried contact or HIT cell structure on single-crystalline wafers.

3 Second generation

The long-term future of photovoltaics is likely to be based on what is known as a "thin film" technology. In the thin-film approach, a thin layer of the photovoltaically