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RECENT PROGRESS AND FUTURE PLANS FOR AMORPHOUS SILICON SOLAR CELLS IN CHINA*

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1. Introduction

China is a vast country where about 70% of the area has more than 2800 hours of sunshine per year. Harnessing the sun power is of vital importance. Moreover, in the villages, mountainous areas and pastoral land, for example Tibet and inner Mongolia, solar cells are needed as a power source for irrigation system and electrical appliances.

We started research on amorphous silicon (a-Si) solar cells in 1982, and followed Sanyo which first introduced the a-Si solar cells several years earlier. Research and development in a-Si solar cells in China has been undertaken in collaboration with institutes of Academy of Sciences and universities, i.e. Nankai University (in Tianjin); Research Institute of Ceramics (in Shanghai), Shandong University (in Jinan), as well as other institutions which have been involved in the national project and made contributions. The pioneer work had been done in the General Research Institutes for Non-Ferrous Metals (GRINM) and other universities from 198^ to 1985. The single-junction solar cell configuration is glass/SnO2/p layer/i layer/n layer/Al layer. It appeared that the best quality, a-Si materials, had been prepared by glow discharge method. The seventh Five Year Plan (from 1986 to 1991) for a-Si solar cells with a total funding of 15M yuan RMB had been supported by the State Planning Committee and the State Committee for Science and Technology. The typical processing technology at that stage for integrated-type a-Si solar cells included:

1. Clean glass;
2. Deposit TCO film by CVD;
3. Clean TCO film;
4. Deposit a-Si film by FCVD;
5. Laser-scribe a-Si film;
6. Deposit Al Layer by MS;
7. Test;
8. Bond power leads;
9. Packaging;
10. Final test.

All equipment in the prototype production line in GRINM had been designed and manufactured in China, which includes CVD, laserscribe, magnetic sputtering, plasma enhanced CVD. Deposition systems (see table 1) had also been compared in order to produce the large area a-Si film of high quality.

	No. of Chambres	Mode	Operation	No. of Wafers
a	3	high vacuum		1
b	7		continuous	1
c	6		continuous	1
d	3			multi
e	1			multi
f	1	photo-induced CVD		1
g	1	plasma CVD		1

Table 1. a-Si deposition systems used in experiments

2. Present Status

After the seventh Five Year Plan, the research on a-Si solar cells has reached a new level. The large area ITO deposition system has been devoted to supply the 30x30cm^2 ITO film with sheet resistance Ro<10Ω/□, transparency> 90% and nonuniformity <15%. a-Si/a-SiGe stacked junction solar cell has a total area of 1cm^2 and conversion efficiency of 11.2%. Some information on work on soft a-si solar cells had been obtained, which indicates that more efforts have to be made. Computer-controlled indoor and outdoor testing systems have been successfully operating and offering a series of data for studying the stability of the solar cells. The conversion efficiencies

of single junction cells are over 11% for 1x1cm^2, 8.6% for 10x10cm^2 and 7.9% for 20x20cm^2. The typical and average conversion efficiencies of 30x30cm^2 integrated-type cells approach 5.3% and 5% respectively. A prototype production line which has a capacity of over 30KW/Yr has been established in GRINM to fabricate 30x30cm^2 integrated-type a-Si solar cells. A 1KW a-Si solar cell power station which is the first one of this kind in China has been made operational. The national project on a-Si solar cells in the past five years has been jointly developed by industrial research bodies, universities and institutes of academy of sciences, and GRINM is a major industrial institute both in research and in application of the a-Si national project and will transfer the advanced design and processing technology to the solar cell plants. Besides, a joint venture by Harbin Electric Motor Plant and Chronar Corporation, is capable of producing 1MW/Yr, and main products 30x90cm^2 large area a-Si solar cells. In addition, another joint venture, which is located in Shenzhen, with a capacity of 1MW/Yr, has been set up and will be operational in 1992. Its major effort is directed to a-Si solar cells for electronic calculators and watches. The present average cost for 1 peak watt is about 35-40 yuan RMB.

3. Future Plans

1. High Quality

Conversion efficiency remains the major problem of a-Si solar cells. Controlling the opto-electronic properties of the i-layer and optimizing the interfacial concentration profiles are of importance. In order to improve the conversion efficiencies, over 9% for 10x10cm^2 cells and more than 8% for 30x30cm^2 cells are the main target for next five years.

2. Reliability

Further studies on the Staebler-Wronski effect which is detrimental to the performance of solar cells are needed. One way to solve this problem is to reduce the i-layer thickness and to add the buffer layers. The target degradation rate (after one year) should be within 12% for 10x10cm^2 and within 15% for 30x30cm^2 solar cells.

3. Large Area Cells

It is planned to establish design technology and production processes for 30x30cm^2 area cells whose conversion efficiency will be larger than 6%.

4. Stacked-junction Cells

Based on the small area stacked-junction technique, a-Si/poly Si, a-Si/SiGo, a-Si/a-Si/SiGo stacked-junction cells will be developed with higher conversion efficiencies and lower degradation rates.

5. Cost Reduction

Future production costs can be reduced to less than 20 to 25 yuan RMB/Wp for the production scale of 5MWp/Yr.

6. Application

For the next five years, application of a-Si solar cells to the calculators, watches, irrigation system and so on will be enormously wide.