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# Recent Advances in Amorphous Silicon Solar Cells

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The recent discovery of an existence of valency controllability in the glow discharge produced amorphous silicon (a-Si:H) by Spear and LeComber opens up a wide variety of the potential applications to the fields of both electronics and opto-electronics for the amorphous semiconductors. Particularly, an excellent photoconductive property with high optical absorption for the visible light and also thin film-large area producibility in this material match very timely with strong potential needs for the development of low cost solar cell as a new energy technology. Carlson and Wronski have reported firstly an a-Si:H Schottky barrier solar cell having a conversion efficiency as high as 5.5% in 1977. This high efficiency encouraged the field very much, more than several groups initiated Schottky type solar cell. As a second key step, Osaka University group developed a heteroface ITO/p-i-n junction cell having the efficiency of 4.5% in spring of 1978. The invention of this p-i-n junction structure with the succesive depositions of p, i, n layers enables us to develop the present technology for the integrated type large area solar cell with a considerably good mass-producibility. Since this event, remarkable progress has been seen in both basic physics and technologies in the amorphous solar cell fields.

In this paper, a review is given on the progress of the amorphous silicon solar cell technologies and the current state of the art in the field. First of all, some new knowledges on the basic properties of hydrogenated amorphous silicon (a-Si:H) and fluorinated amorphous silicon (a-Si:F:H) are summerized, and remarkable advantages of these new materials for low cost photovoltaic devices are pointed out and discussed in views of both device physics and manufacturability.

In the socond part, the device physics of the amorphous silicon solar cells and cell structure design concept are discussed. A new concept of the drift type photovoltaic effect in terms of the field dependent photocarrier generation process and carrier collection efficiency is introduced. Optimization of photovoltaic performance in p-i-n junction and inverted p-i-n junction devices is examined with some experimentally determined physical constants, and realistic limit of the conversion efficiencies in the p-i-n homojunction and heterojunction solar cells are also clarified.

In the third part of the paper, some new approaches and key technologies to improve solar cell performance with new amorphous materials such as a-SiC:H, μc-Si:H, a-SiGe:H and their heterojunction solar cells are introduced. A series of tremendous efforts to know the plasma deposition mechanism and to improve the film quality have been made with various approaches, such as the cross field method, effect of magnetic field and plasma emission spectroscopy.

In the final part of this paper, progress of the conversion efficiency in various types of amorphous silicon solar cells is surveyed and discussed. A recent feature of the industrialization of a-Si photovoltaic cells is also reviewed Figure 1 shows progress of a-Si solar cell efficiency and its prospect in the near future. As can be seen from these plots, more than 7% conversion efficiency for even 1 $cm^2$ area solar cells are reported by several groups, and for the 100 $cm^2$ cell area, about 5% efficiency technology has been accomplished in Japan. The top record of the efficiency is more than 8% for small area with a-SiC:H/a-Si:H heterojunction and a-Si:H/a-SiGe:H stacked solar cells.

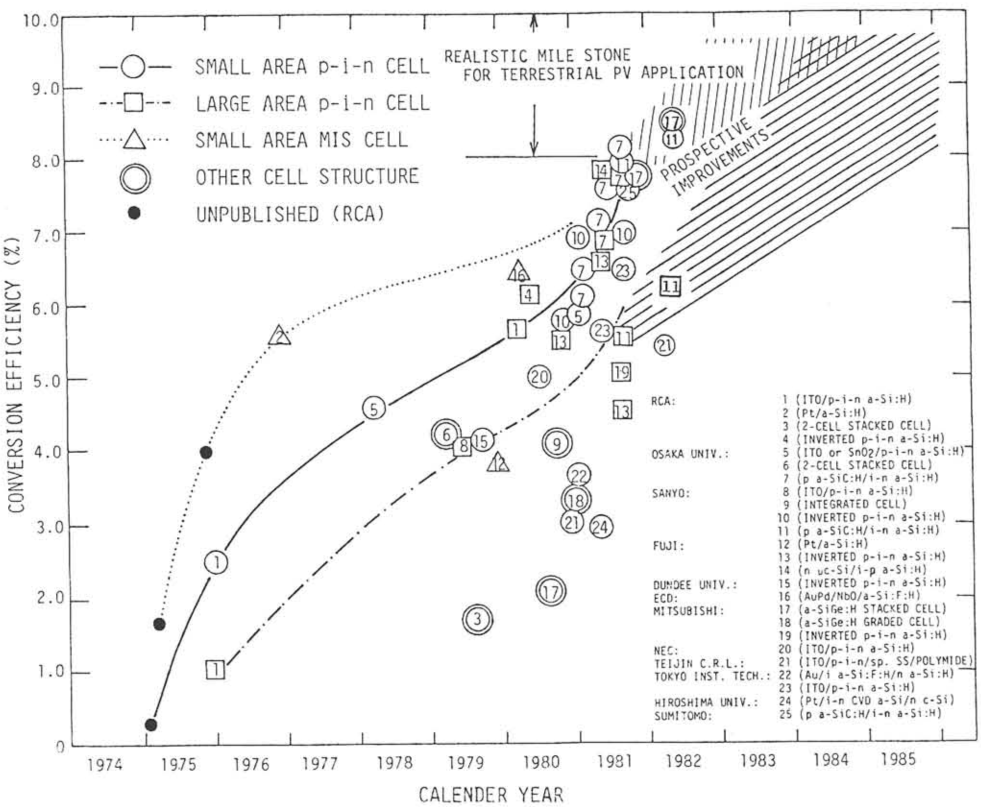


Fig.1 Progress of a-Si solar cell efficiency and its prospect in the near future. Solid line shows the efficiency of p-i-n type small area solar cells, the chain line is that for the same type large area solar cells and dotted line shows that of Schottky barrier solar cells.