B−2−9 Window Effects of Amorphous Silicon Carbide on p-i-n a-Si Solar Cell

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Glow discharge produced amorphous silicon is actively investigated as one of the most promising low cost photovoltaic materials[1]. In a recent few years, a remarkable improvement of the conversion efficiency has been achieved by a great deal of R&D efforts, that is, 6.1% with the inverted p-i-n a-Si:H[2], 6.3% with a-Si:F:H MIS cell[3] and 7.14% with a-SiC:H/a-Si:H heterojunction cell[4] are worthy of notice.

The p-i-n heteroface solar cell is one of the best cell constructions and might provide better producibility, as well as being amenable to future mass production and design control when put into practical application[5]. However, this structure has a big defficiency that an optical absorption in the window side p-layer is large[6]. We have paid our attention on this point for suppression of loss components and improving the conversion efficiency. Recently, we found that substitutional impurity doping is possible and can provide control of electrical and electronic properties over a wide range in amorphous silicon carbide produced by the plasma decomposition of $[SiH_{4(1-X)}+CH_{4(X)}]$ gas mixture[4,7]. Utilizing this doped a-SiC:H as a wide band gap window material, we have developed a new type of a-SiC:H/a-Si:H heterojunction solar cell having more than 7.5% conversion efficiency.

Fig.1 shows the gaseous compositional dependence of the optical band gap and the photoconductivity(AM-1 100mW/cm^2) of undoped and boron doped a-SiC:H. As can be seen in this figure, optical band gap continueously increases as increase of methane fraction (X), but a sharp decrease of photoconductivity is observed in undoped a-SiC:H even with a small fraction of methane. In contrast with these, boron doped a-SiC:H exhibits a clear recovery of photoconductivity, and two or four orders larger magnitude photoconductivity can be seen.

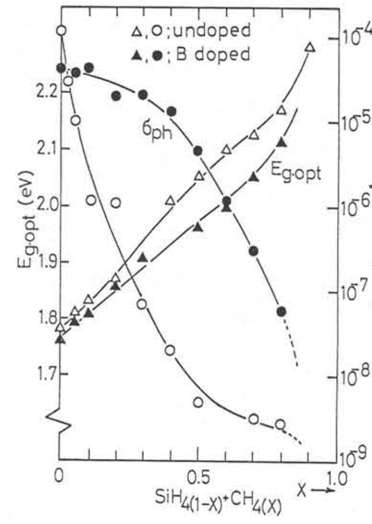

Fig.1 Optical band gap $E_{g\cdot opt}$ and AM-1 photoconductivity of undoped and boron doped a-SiC:H.

Utilizing these films as a p-side window material, we have examined the window effects of

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amorphous SiC:H on the performance of a-SiC:H/a-Si:H heterojunction solar cell.

Fig.2 shows photovoltaic properties of a-SiC:H/a-Si:H heterjunction solar cell as a function of $E_{g\cdot opt}$ of p-type a-SiC:H. As is seen in this figure, a remarkable improvement of both J_{sc} and V_{oc} is attained by increasing optical band gap of a-SiC:H. The increase of J_{sc} and V_{oc} are caused by the decrease of absorption in the p-layer and the increase of diffusion potential in the p-i-n junction, respectively. By further optimization of film properties, the conversion efficiency of this small area($3.3mm^2$) solar cell has been improved to be more than 7.5% as shown in Fig.3. To confirm the wide gap window effects, we compared this a-SiC:H/a-Si:H heterojunction solar cell with the ordinary p-i-n a-Si:H homojunction cell having a sensitive area of $3.3mm^2$ under AM-1($100mW/cm^2$) illumination. As is seen in Fig.3, a clear improvement has been seen in the cell performance, that is, about 22% in J_{sc}, 13.5% in V_{oc} and 32% in η. As for a large area($1.0cm^2$) solar cell, the conversion efficiency of 6.78% has been obtained with J_{sc}=12.95mA/cm^2, V_{oc}=0.866volts and FF=0.605.

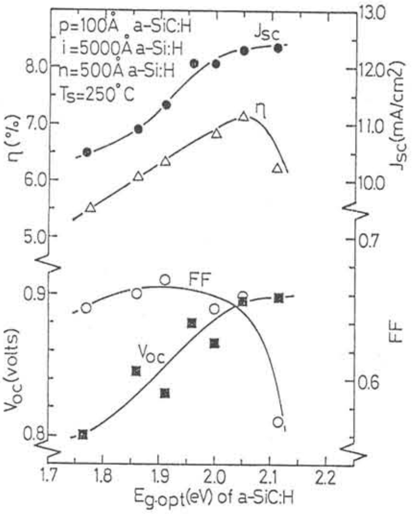

Fig.2 Photovoltaic properties of a-SiC:H/a-Si:H heterojunction solar cells as a function of optical band gap of p-type a-SiC:H.

In this paper, we will discuss in detail from the optical, electrical and optoelectronic properties of a-SiC:H along with a series of technical data on this new solar cell, and present further possibility of improvement of cell efficiency by optimization of material properties.

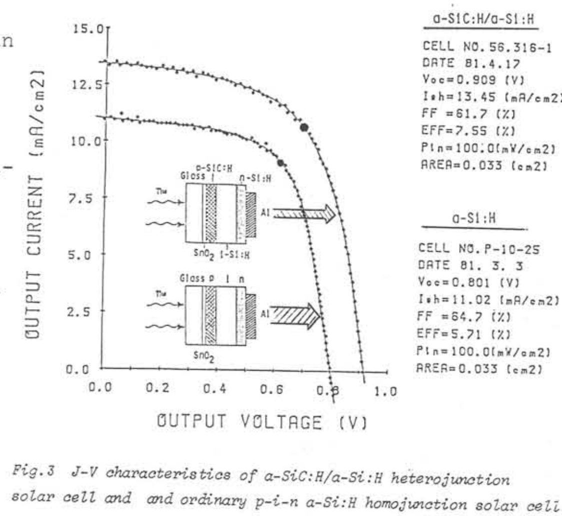

Fig.3 J-V characteristics of a-SiC:H/a-Si:H heterojunction solar cell and and ordinary p-i-n a-Si:H homojunction solar cell.

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