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Amorphous-Si:H solar cells having a conversion efficiency of 10.5% by the separate chamber photo-CVD system

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High conversion efficiency a-Si:H solar cells were fabricated using a newly developed separate chamber photo-CVD system. The new system, which consists of three separate reaction chambers and one loading chamber as shown in Fig.1, reduces the contamination of the dopant elements as well as oxygen and nitrogen in the i-layer. The distributions of boron atoms in the cell fabricated by a separate chamber photo-CVD system and a single photo-CVD system are shown in Fig.2. The slope of the boron profile at the p/i interface of the separate chamber photo-CVD system is sharper than that of a single photo-CVD system. Furthermore, the concentration of boron in the i-layer is greatly reduced by a magnitude of $2x10^{15}cm^{-3}$. This boron concentration profile in the i-layer fabricated by the separate chamber photo-CVD system is lower than that in solar cells fabricated by a plasma-CVD system with three separate reaction chambers. Thus the effect of ion bombardment from the susceptor or the wall of the reaction chamber, present in a plasma-CVD system, is considerably avoided with the separate chamber photo-CVD system.

In this paper, a-Si:H solar cells with a glass/TCO/ p(SiC)in(μc)/metal structure were fabricated and their properties were examined. For a pin-type a-Si:H solar cell, the p-layer and p/i interface are very important for solar cell performance, especially when using a-SiC:H in the p-layer. In order to minimize the interface losses at the hetero-junction, a carbon graded layer was introduced at the p/i interface. Figure 3 shows the variation of the solar cell parameters with the changes of B_2H_6 to Si_2H_6 ratio in the p-layer. In the range of 3 to 4% of B_2H_6, over10% conversion efficiencies were constantly achieved, which indicated that the presence of B_2H_6 not only lowered the resistivity of the p-layer but also reduced the p/i interface states. Figure 4 shows the illuminated (AM-1,100mW/cm^2) I-V characteristics of the a-Si:H solar cell with the highest conversion efficiency of 10.5%.

In conclusion, we have fabricated solar cells using the newly developed separate chamber photo-CVD system. By minimizing the effect of the impurities in the i-layer and optimizing conditions at the p-layer and p/i interface, the high efficiency of 10.5% was achieved. The superior performance of the a-Si:H solar cells demonstrated that the separate chamber photo-CVD technique is a promising method for fabricating high quality a-Si:H solar cells.

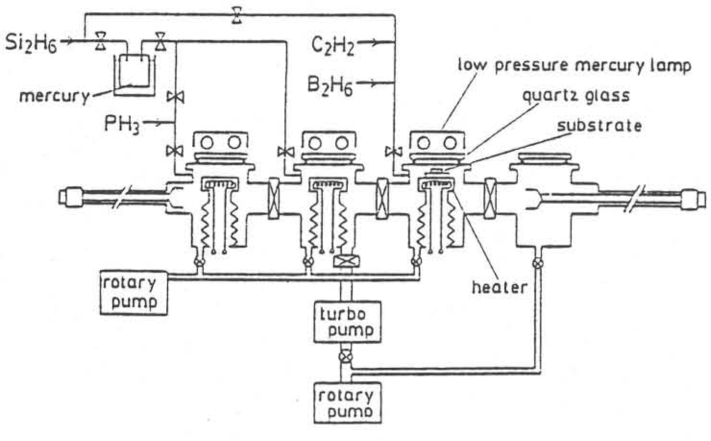

Fig.1 Schematic diagram of the separate chamber photo-CVD system

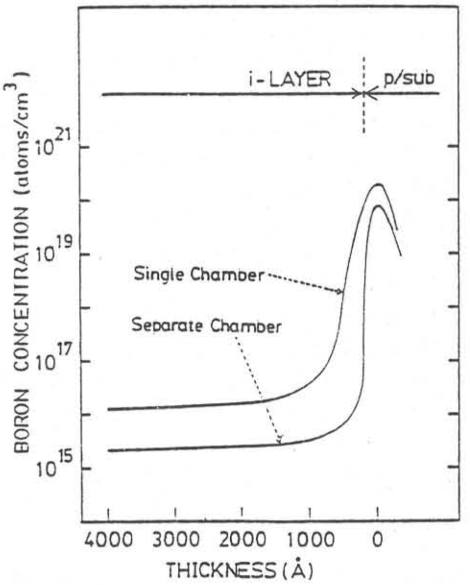

Fig.2 The distribution of boron atoms in the a-Si:H solar cell fabricated by photo-CVD

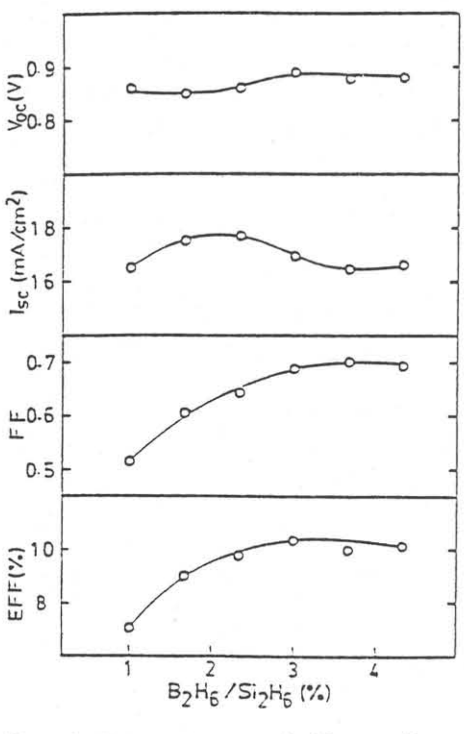

Fig.3 Variation of the solar cell parameters as a function of the B_2H_6 to Si_2H_6 ratio in the p-layer

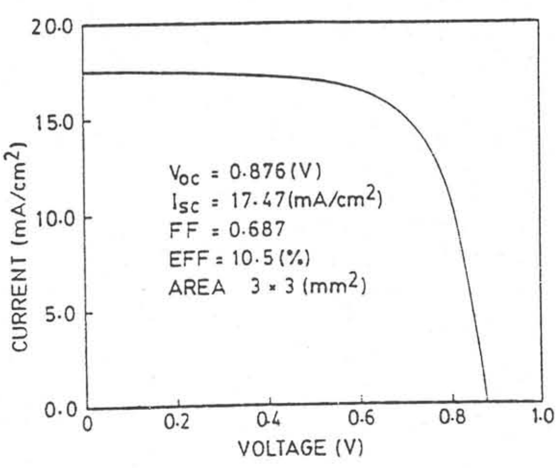

Fig.4 Illuminated I-V characteristics of the highest efficiency a-Si:H solar cell