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Preparation and Characterization of Hydrogenated Amorphous Boron Thin Films and Thin Film Solar Cells Produced By Glow Discharge Decomposition Methods

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INTRODUCTION

The energy gap of unhydrogenated amorphous boron is approximately 1.35 ev and therefore the theoretical maximum efficiency for amorphous boron solar cells is approximately 25%. However, in exact analogy with the situation previously existing for amorphous silicon, amorphous boron, without hydrogenation, has poor semiconducting properties due to defect states in the band gap. Large area amorphous boron films can be readily produced by either chemical vapor deposition or pyrolysis of diborane or boron tribromide. Such films do not contain more than minute quantities of hydrogen, however, due to the high (1000°C) pyrolysis temperatures required. The substrate temperature during glow discharge decomposition methods, however, can be independently controlled. The decompositon of diborane in a glow discharge has been used to dope amorphous silicon with boron. The decomposition of diborane and of boron tribromide in hydrogen to produce thin films can reasobably be expected to result in amorphous boron thin films containing substantial quantities of hydrogen. If the effect of hydrogen in amorphous boron is similar to that of hydrogen in silicon, then hydrogenated amorphous boron thin films resulting from glow discharge decomposition

of gaseous boron compounds could have very great potential as a solar cell material. Furthermore, although boron is only present to the extent of 0.001% of the earth's crust, the total metallic equivalent of boron production in the United States is approximately four hundred million pounds annually and the United States contains the largest known source of boron ores.

EXPERIMENTAL

Diborane (in hydrogen) has been obtained from two different suppliers (Linde and Scientific Gas Products). It is important that in obtaining diborane, some information be found concerning the date of manufacture of this gas since diborane is known to decompose as a function of temperature and time. For example, at 16°C, 10% of diborane will decompose in 100 days [1]. In our case, during storage at 27°C, substanitally all the diborane was observed to decompose in approximately 45 days, and a tank which initially, was used to produce substantial film deposits, after 45 days could produce essentially no deposit under the same glow discharge conditions.

Boron films produced by the glow discharge decomposition of diborane have now been shown to indeed contain hydrogen. The hydrogen content of these films was measured by the standard ASTM method (Standard E50-75).

Table 1 shows the results obtained for three separate films. From this Table 1, it can be seen that hydrogen contents of up to 34 atomic percent can be produced. We consider these results to be very encouraging.

PLANS

During the next reporting period we plan to characterize the nature of the hydrogen-boron bonds in these thin films by IR spectroscopy. Also, the resistivity of these films, as well as changes in resistivity as a function of hydrogen content, will be measured directly. This will be accomplished using an in situ vacuum oven and intermittently removing the annealed films to measure both resistivity and hydrogen content. An AC Hall effect machine is nearing completion and this will be used to look at carrier mobilities in these films.

TABLE 1

Sample	Film Mass (mg)	H_2 Mass (g)	H(a/o)
1	1.45	12.6	9.4
2	1.00	4.9	5.3
3	0.1	3.1	34.0
4	1.3	3.39	2.8
5	2.4	4.93	2.2
6	2.0	4.93	2.7
7	3.6	10.3	3.1

REFERENCES

1. Callery Chemical Co., Division of Mine Safety Appliances Co., Callery, PA. 16024, Report No. LCC-1024-JR-35.

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