Digest of Tech. Papers *The 9th Conf. on Solid State Devices, Tokyo*

B—4—2

MIS Silicon Solar Cells

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Interest in the MIS structure for solar energy conversion originally arose when it was found that a thin insulating layer (< 30 Å) between the metal and semiconductor acted to increase the open circuit voltages of Schottky solar cells [1]. Subsequently it was shown that a suitably designed MIS solar cell is electronically equivalent to a p-n junction cell and therefore should be capable of similar efficiencies [2].

We have studied the properties of the MIS solar cells using silicon with thin thermal oxides as the insulating layers. For 10Ω cm p-type substrates, our cells have open circuit voltages between 530 mV and 550 mV at solar short circuit current densities, while our records for 1Ω cm and 0.1Ω cm material are 618 mV and 612 mV respectively, all measurements being made at 20-23°C. These values are extremely high when compared to those of p-n junction cells of these base resistivities

We have also shown that it is possible to use a different type of MIS contact to form the ohmic back contact to the cell. Specific contact resistances less than 1Ω cm^2 are readily obtained with such contacts. This has led to the development of the MISIM solar cell. The structure is formed by oxidising both sides of a silicon wafer and depositing, for p-type wafers, a thin metal layer of low work function on to the top of the wafer and a thicker layer of metal of high work function onto the back. A contact grid and antireflection coating are added to the top of the cell. For n-type wafers, the work functions of the front and back metals are reversed.

An analysis of the MISIM structure shows that it has an efficiency advantage over the normal MIS cell with sintered back contact, similar to that which would be obtained with a "back surface field". However, our main interest in the structure arises because it is easy to fabricate. As in the p-n junction case, the effect of a back surface field is minimal at the low substrate resistivities optimal for terrestrial energy conversion. The very simple fabrication procedure eliminates several of the processing steps required in p-n junction cell fabrication. It also allows devices to be made on substrate material where p-n junction formation is difficult. This makes the structure of great interest for the low cost substrates which are essential for large scale terrestrial use of solar cells in the future.

We have successfully produced large area (4-12 cm^2) MISIM devices with properties essentially those of p-n junctions using both p-type and n-type substrates. Based on present results, we expect to be able to produce such large area devices of 12% efficiency by the end of 1977. Work is scheduled to commence in 1978 on the fabrication of a 1 kW demonstration array based on single crystal silicon substrates.

References

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