THE FRONT SURFACE FIELD SOLAR CELL, A NEW CONCEPT

Oldwig von Roos and Bruce Anspaugh
Jet Propulsion Laboratory, California Institute of Technology

The "front surface field" (FSF) solar cell design is shown in Figure 1. It consists of a wafer of P type silicon containing a P-N junction on the rear surface and a P^+ layer on the front surface. The junction consists of interdigitated strips of N^+ material and ohmic contacts at the rear surface. There are no current collection grids nor busbars on the front surface, allowing current collection and cell contacting on the rear surface only. This design is similar to the tandem junction cell (1). In the case of the FSF cell however, the built in electric fields of both the N^+-P and of the P^+-P junctions point in the same direction, reinforcing each other and therefore facilitating the minority carrier (electron) current collection at the N^+-P depletion layer edge. Furthermore, the blue response of the cell is greatly enhanced since the free carriers generated close to the front surface are driven toward the N^+-P junction by the built in electric field.

Theoretical calculations of the FSF cell spectral response verify the above conjectures. The calculations, patterned after Wolf's work (2), basically consist of solving the continuity equations with boundary conditions appropriate to the FSF cell geometry. The P^+ layer was assumed to be $3\mu m$ thick, exponentially doped with a surface acceptor concentration of 1000 times that of the bulk. Allowance was made for the change in mobility through the P^+ region and the surface recombination velocity was taken as 10^6 cm/sec. Carrier generation in the N^+ material was neglected since it is only important for $\lambda > 1$ μm near the band edge. Figure 2 shows the results of the calculation. Here the spectral response SR(λ), neglecting surface reflectance, is plotted versus wavelength λ for 3 different cases. The broken curve shows the SR without the front surface field. The solid curve is the SR of the same cell with the addition of the P^+ layer and the open circles represent Hovel's calculated values (3) for the SR of a back surface field (BSF) cell of the same dimensions and approximately equal physical parameters (bulk diffusion length, etc.). It is clear that the FSF cell and the BSF cell are quite comparable as far as SR is concerned, and both are superior to a cell with a rear junction only (even though the bulk diffusion length is assumed to be twice as large as the cell thickness). When one considers that these calculations do not account for the loss of active area due to front ohmic contacts, the FSF cell should have an advantage of 6 to 7% over conventional cell designs (all other things being equal). In addition, the FSF cell will have all the advantages of interconnect attachment and array assembly which accrue when the contacts are coplanar.

Details of this analysis and follow ups (I-V characteristics, efficiencies, etc.) will be published elsewhere.

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(1) S.Y. Chiang, B.G. Carbajal, and G.F. Wakefield, IEEE International Electron Devices Mtg, 603, Dec., 1977, Wash. D.C.

(2) M. Wolf, Proc. of IEEE, 51, 674 (May 1963).

(3) H.J. Hovel, Semiconductors and Semimetals, Vol. II, Academic Press, New York 1975, p. 33, Fig. 15.

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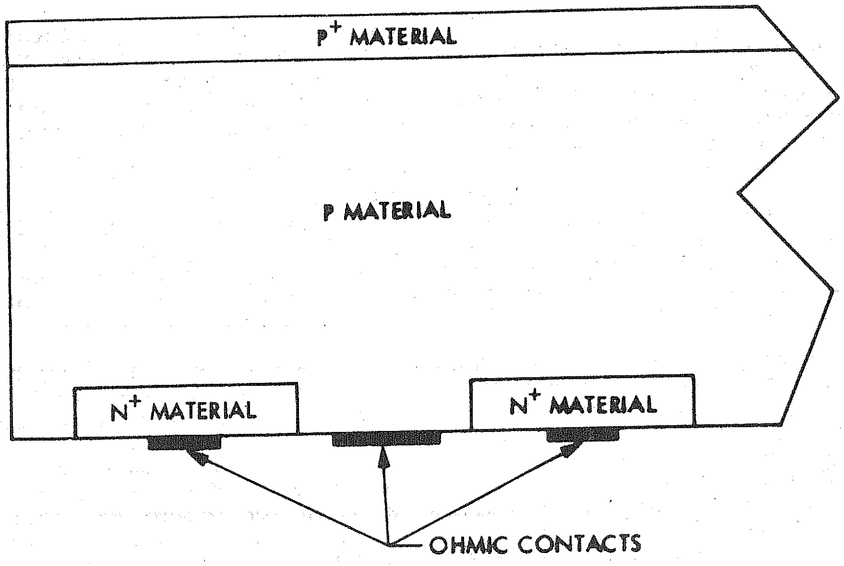

Figure 1. Cross-Section Through a FSF Cell

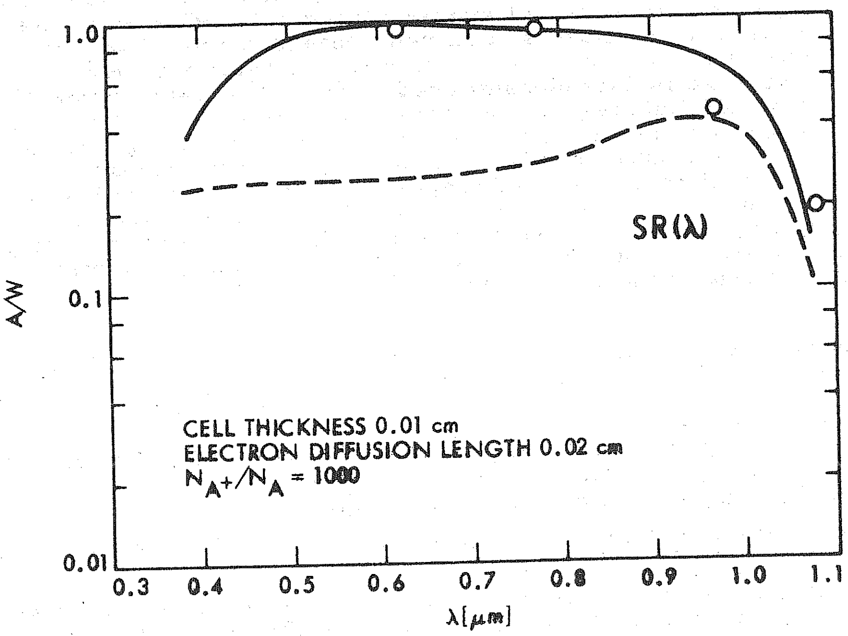

Figure 2. Spectral Response. Full Explanations in Text