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POINT CONTACT SILICON SOLAR CELLS

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The point contact cell has recently demonstrated 22 percent conversion efficiency at one sun and 27.5 percent at 100 suns. This cell derives its high efficiency from a synergistic combination of:

- Light trapping between a texturized top surface and a reflective bottom,
- Thin, high resistivity, high lifetime base,
- Small point contact diffusions, alternating between n-type and p-type in a polka-dot pattern on the bottom, and
- Surface passivation on all surfaces between contact regions.

The following figures are described below:

Figure 1: Light trapping is caused by the diffuse nature of scattering from a texturized surface. If a photon is not absorbed upon reaching the back surface it is reflected of the back surface reflector. If it is still not absorbed by time it reaches the top there is a very high probability (about 88 percent) that it will be beyond the angle for total internal reflection and hence will be reflected back into the cell.

Figure 2: For high ifficiency it is necessary to reduce recombination as much as possible. This is to provide for:

- Collecting as large a fraction of the photo-generated carriers as possible,
- Generating as large a voltage (which goes exponentially in the p-n product) as possible, and
- Producing as much conductivity modulation in the base, and hence reducing base voltage drop, as much as possible. The point contact cell reduces recombination by passivating the surfaces with SiO_2, using high lifetime float-zone silicon, and reducing the metal-semiconductor contact fraction through the point contact scheme.

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Figure 3: A three dimensional model has been developed to explore the potential of the cell and optimize the design. Important findings are:

- The contact spacing must be rather small to prevent excessive losses through base spreading resistance at the contact diffusions,
- The cell must be thin, in the 60 to 100 μm range,
- The base lifetime must be over 500 μsec,
- The surface recombination velocity must be less than 10 cm/sec, and
- The cell is capable of efficiencies of around 29 percent at 27 °C if the above conditions are met.

Figure 4: This figure shows the structure of the test cells currently being made.

Figure 5: This table illustrates the importance of texturizing for improving the short circuit current. Salient one sun parameters are shown.

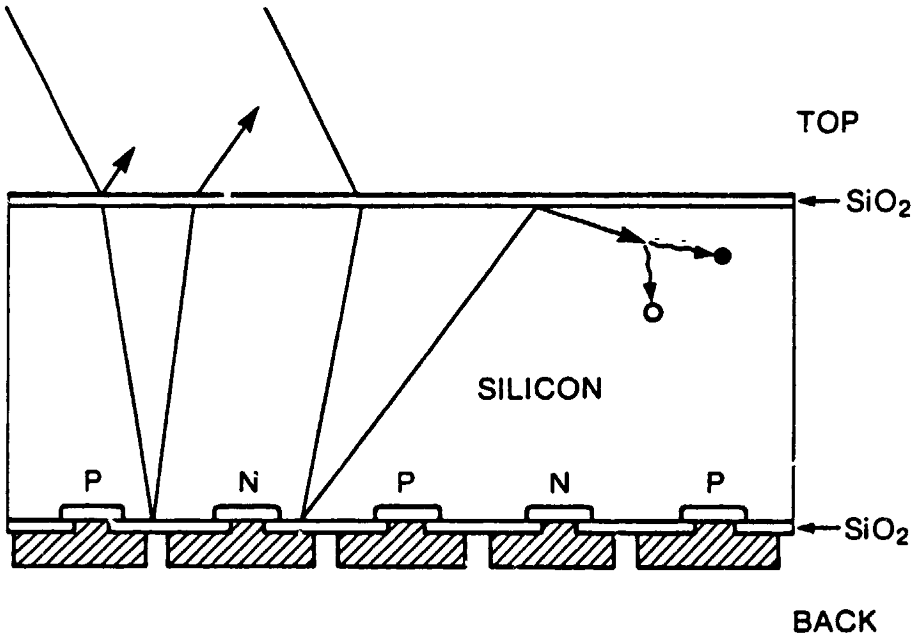
Figure 6: The spectral responsivity of a texturized and untexturized cell is shown. At shorter wavelengths the texturizing has reduced the reflectivity, resulting in improved response. Near the bandgap, however, the response has been dramatically increased due to light trapping.

Figure 7: The internal quantum efficiency is essentially unity until near the bandgap, where competing absorption mechanisms, such as absorption in the back surface mirror, become comparable to photoabsorption.

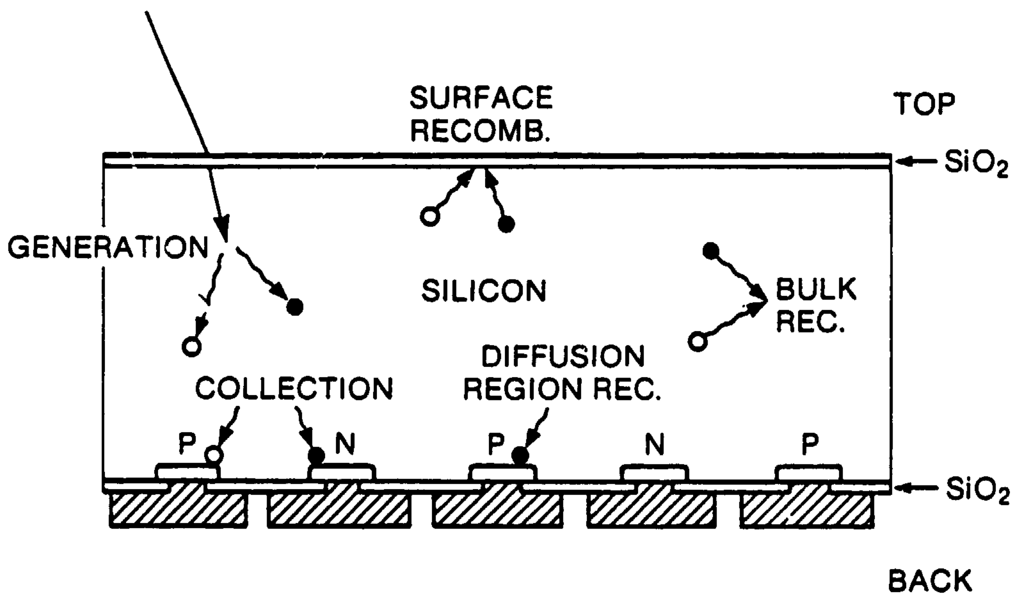
Figure 8: This slide shows the measured open circuit voltage and fill factor of a 113 μm texturized cell.

Figure 9: The measured efficiency of the cell from the previous slide is presented. The one sun efficiency is 22 %, increasing to 27.5 % at 100 suns. The major portion of the drop off above 100 suns is due to metal series resistance; however, a significant portion results from a decrease in internal quantum efficiency at high intensity due to Auger recombination in the dense electron-hole plasma generated by the light. A thinner cell will reduce this effect.

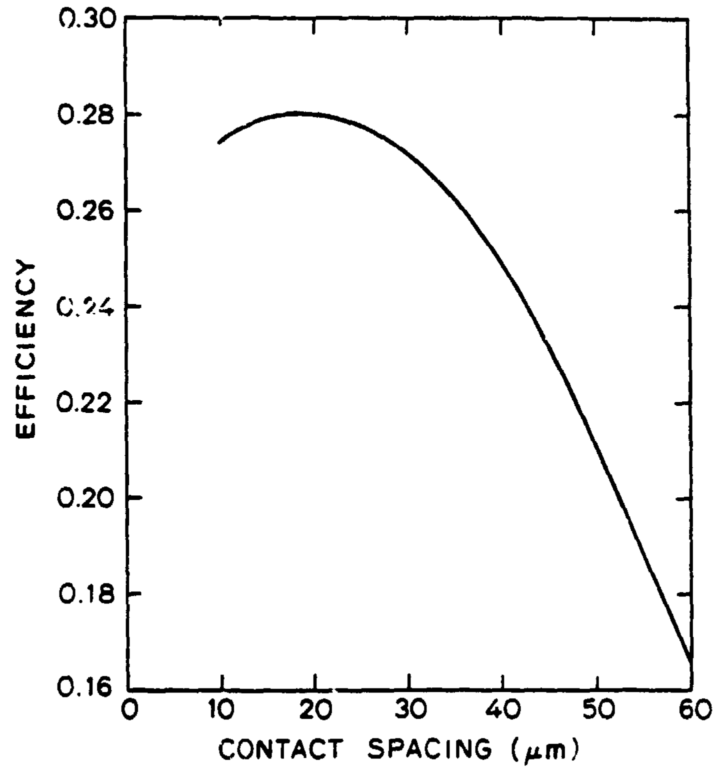
Light Trapping



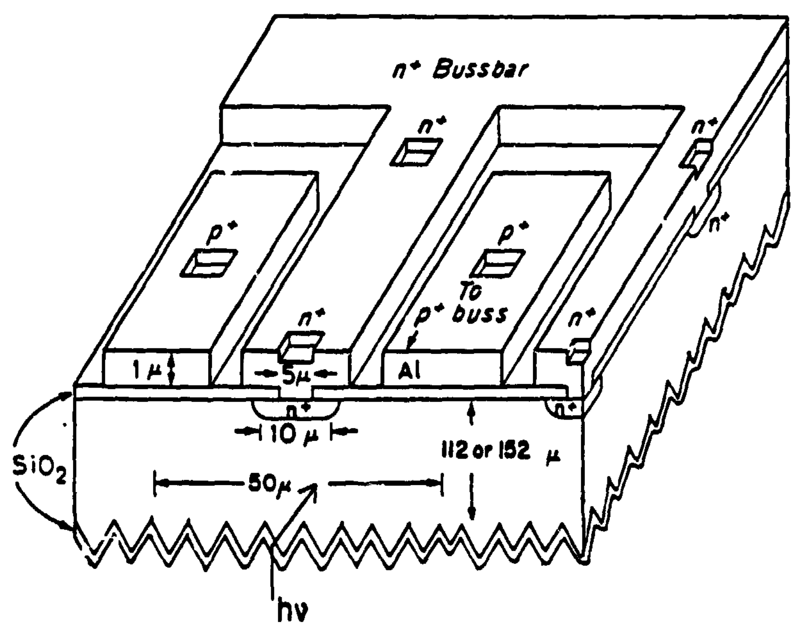
Collection and Recombination



Efficiency Versus Contact Spacing
Derived from Three-Dimensional Model



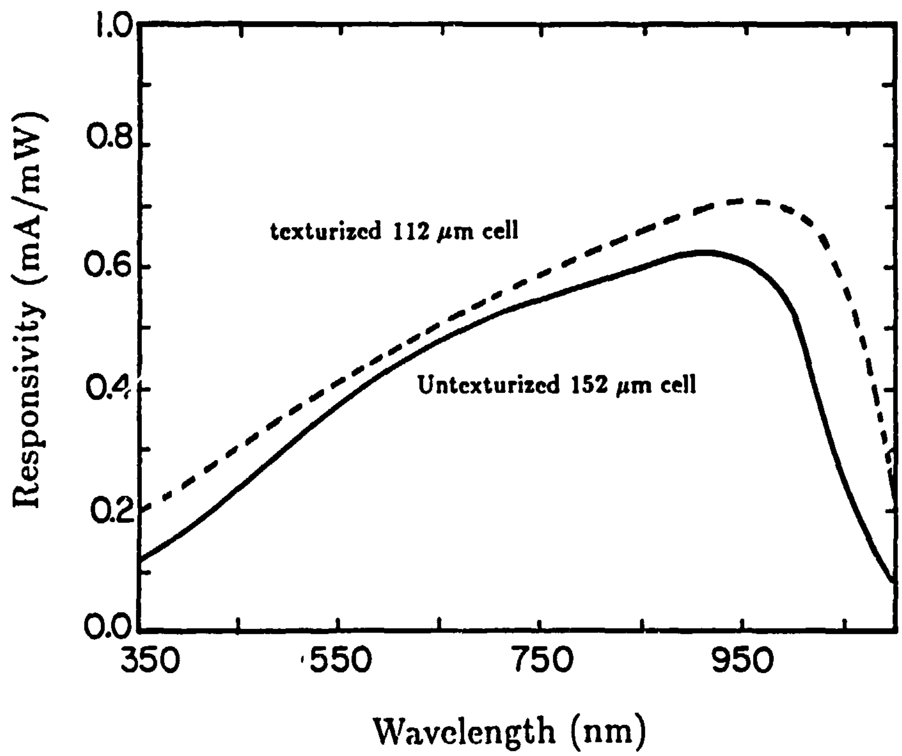
Structure of Test Cells Currently Being Made



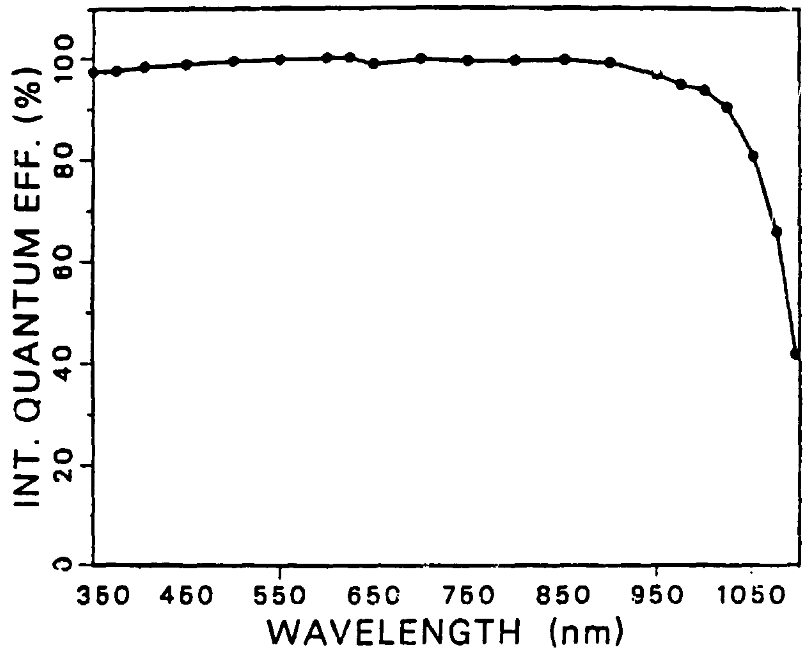
Importance of Texturizing for Improving the Short Circuit Current

One Sun Results AM1.5 100 mW/cm²								
Cell	Thickness	Texturized	Efficiency	V_{oc}	J_{sc}	V_{mp}	Fill Factor	Temp
11-3B	112 μm	Yes	22.2%	.681 V	41.5 mA/cm²	.582 V	.786	24 °C
11-1A	152	No	18.5%	.678	35.0	.570	.776	26

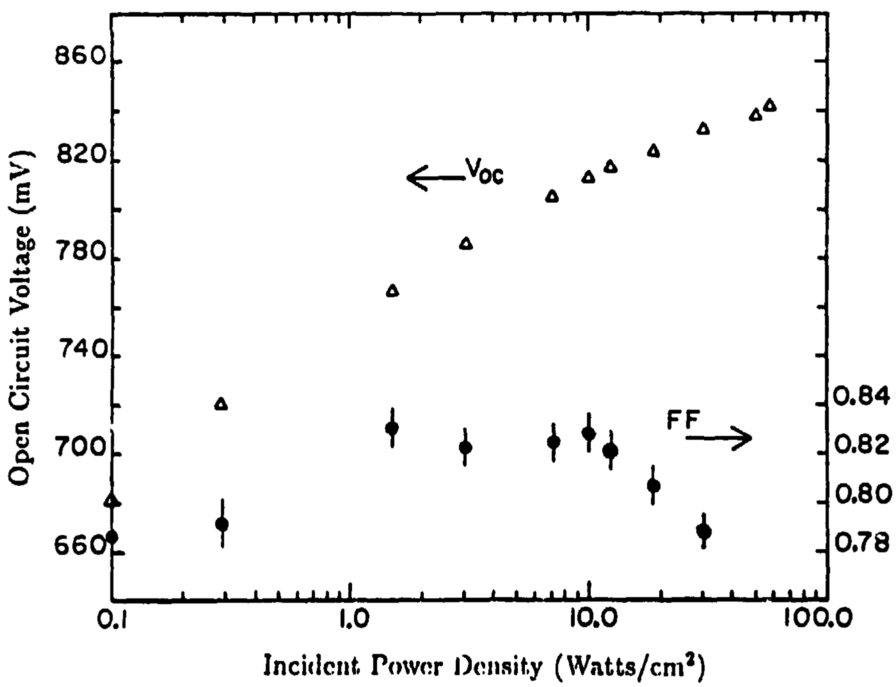
Spectral Responsitivity of a Texturized and Untexturized Cell



Internal Quantum Efficiency Versus Wavelength
(Stanford Point Contact Cell FT 11-3B)



Measured Open Circuit Voltage and Fill Factor
of a 113 μm Texturized Cell



Measured Efficiency of the Cell (from Figure 8)