AN IMPROVED SILICON SOLAR CELL - THE VIOLET CELL*

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State-of-the-art silicon solar cells exhibit a poor quantum yield at short wavelengths, the typical response dropping sharply below 0.5 μm. As a result of independent extensive work at COMSAT Labs, the spectral response has been extended to wavelengths as short as 0.3 μm, significantly improving the solar cell current. The conversion efficiency has been further improved by an increased fill factor. The combined effect of short wavelength response and sharper I-V curve has resulted in an overall improvement in the conversion efficiency of about 30% relative to state-of-the-art cells for space applications. The improved solar cell is called the "Violet Cell."

In the course of this work it was found that recombination of photocarriers generated by blue-violet light is not controlled by front surface recombination. It has been found that the short wavelength response is limited by a highly damaged "dead layer" in the conventional cell, which has been nearly eliminated in the improved cell. The resulting loss of lateral conductivity required a very fine collection geometry; employing this fine geometry reduced the series resistance to 0.05 Ω. With the help of the dead-layer model, it has proved possible to preserve a high short wavelength response over the entire solar spectral range and to improve the diode I-V characteristics sufficiently so that they approach those of an ideal p-n junction diode. Figure 1 shows the actual quantum yield (for incident photons) for a typical Violet Cell. The improvements achieved in current and fill factor are highly resistant to penetrating ionizing radiation.

The average conversion efficiency of the Violet Cell in the present state of development is above 13%, specified with

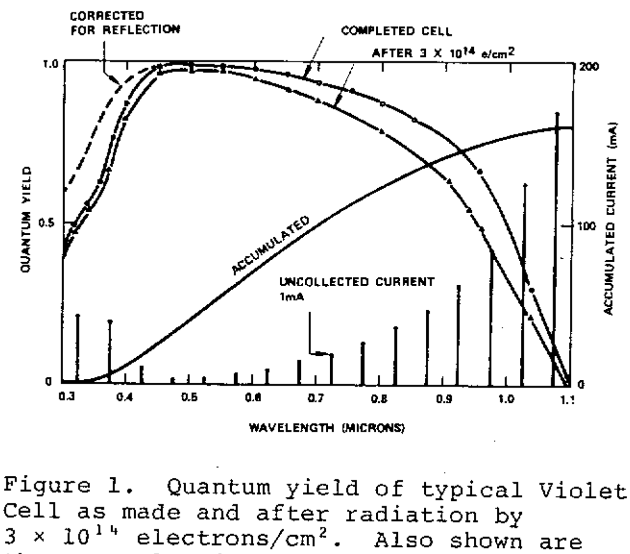

Figure 1. Quantum yield of typical Violet Cell as made and after radiation by 3×10^{14} electrons/cm^2. Also shown are the accumulated cell current and the current lost per 0.05 μm, both plotted as a function of wavelength.

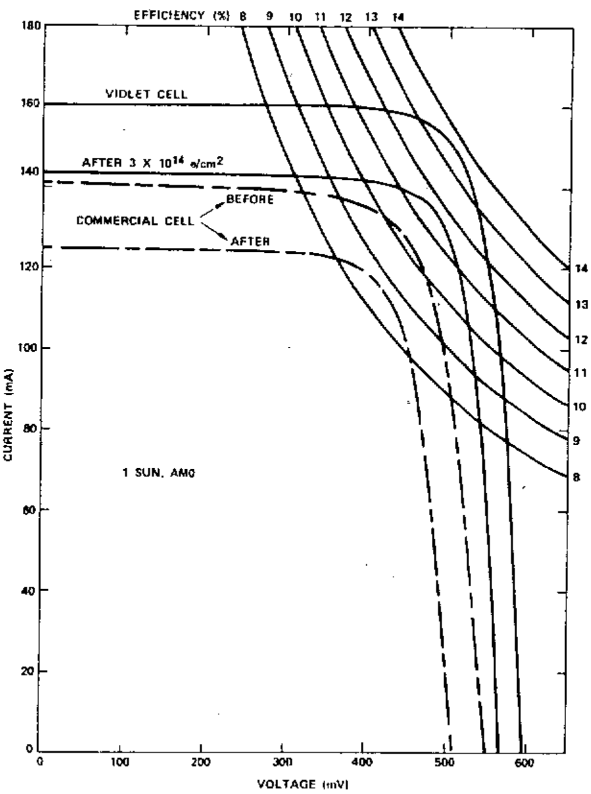

Figure 2. Typical I-V curves for both a Violet Cell and a commercial cell shown before and after irradiation by 3 × 14 e/cm^2. All curves taken with one sun illumination in AM zero.

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respect to total area. (With respect to active area, the corresponding efficiency is about 14%.) Figure 2 shows an actual I-V curve for a 2 x 2 cm cell. The increased efficiency has not been obtained by increasing the minority carrier lifetime with associated radiation sensitive red response. The operating efficiency after irradiation with 1 MeV electrons to 3×10^{14} e/cm^2 is 11.5%. The dramatic improvement over all fluences is illustrated in Fig. 3.

The Violet Cell in AM1 sunlight exhibits a conversion efficiency of about 16%.

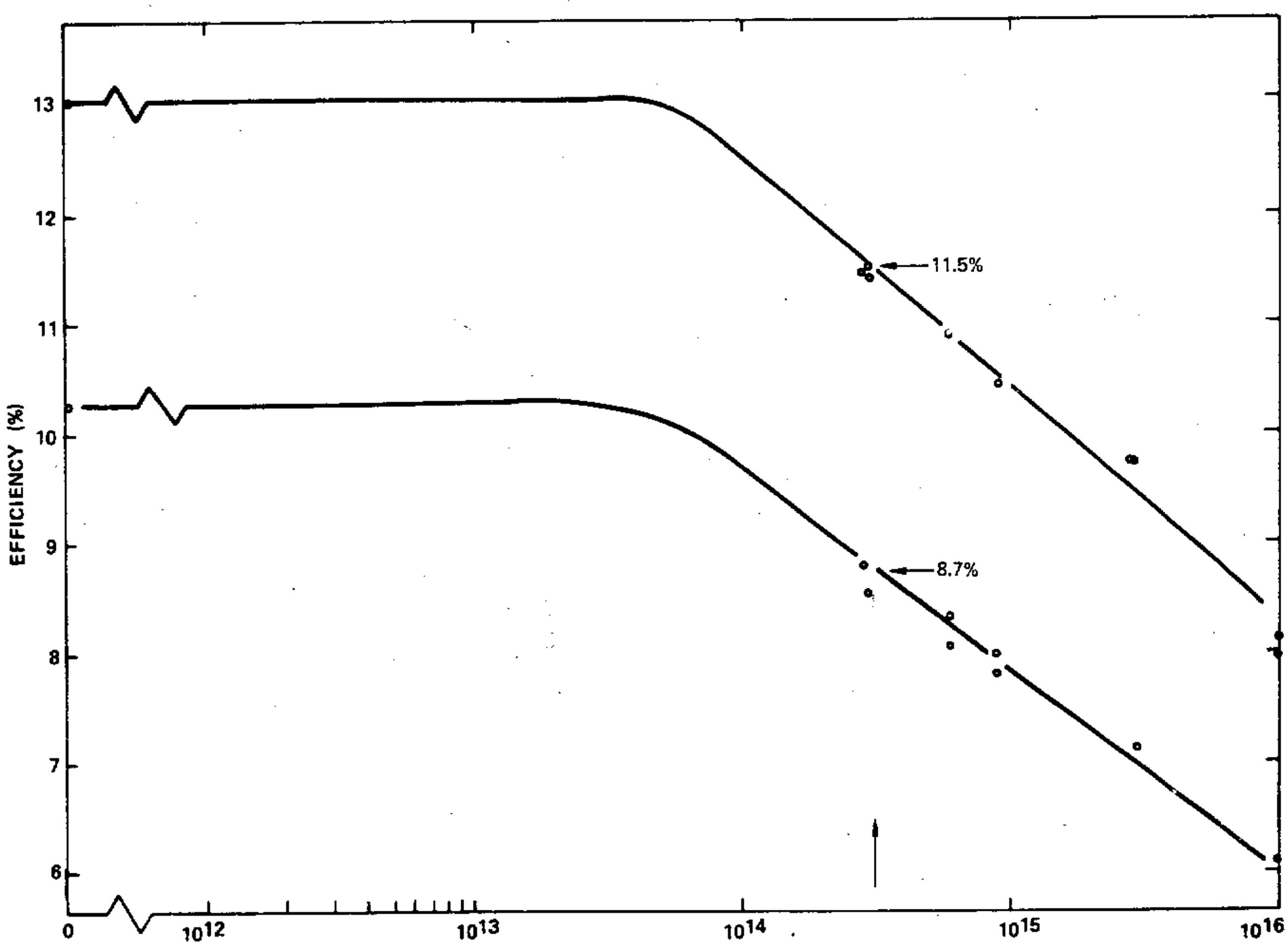

Figure 3. Violet Cell compared with commercial cell for radiation damage with 1 MeV electrons.