steps are taken as in the manufacture of mono-crystal cells except that a modified Czochralski process is employed allowing rectangular ingots to be cast rather than cylindrical ones formed. The cast ingots are less pure which reduces the finished cells efficiency slightly but the rectangular cross section enables the cells to be packed more densely into the panels without excessive trimming and waste of material. Poly-crystal cells have a distinctive large grain structure to them which forms as the ingots cool.

Both poly and mono-crystal cells generate an electrical potential of around 0.5 of a volt, so to be of practical use, cells are connected together in a series string (+ - + - + - etc) to obtain the required voltage. Standard crystalline panels consist of 30 to 36 cells so that a single panel can be used to charge 12 volt batteries. Panels may be connected in series and or parallel networks to achieve virtually any voltage and current requirement.

Crystalline panels are sensitive to heat, and to ensure adequate performance in hot outback conditions the full 36 cell panels should be chosen, especially for water pumping applications. Panels with less than 36 cells are more applicable to cooler environments . The 32 cell panels are normally marketed as *self regulating* battery chargers for use without an external voltage regulator. For marketing reasons, crystalline panels are rated at unrealistically low operating temperatures which can easily exceed sixty degrees Celsius in most parts of Australia during Summer. Under these conditions, power output can fall by over fifteen percent. This needs to be taken into account when designing systems around these type of panels.

Other disadvantages with crystal type panels are their fragility. Although toughened glass is used for the front, a stout blow in the wrong place will shatter it like a car windscreen, rendering the panel useless. Also, the cells are all arranged in a series string so that any shadowed cells drastically reduce output, similar to stepping on a hose. Finally, pricing will be the ultimate factor sending this type of technology into oblivion. It is not suitable for mass production on a scale necessary to ensure it's survival against it's successor, amorphous silicon.

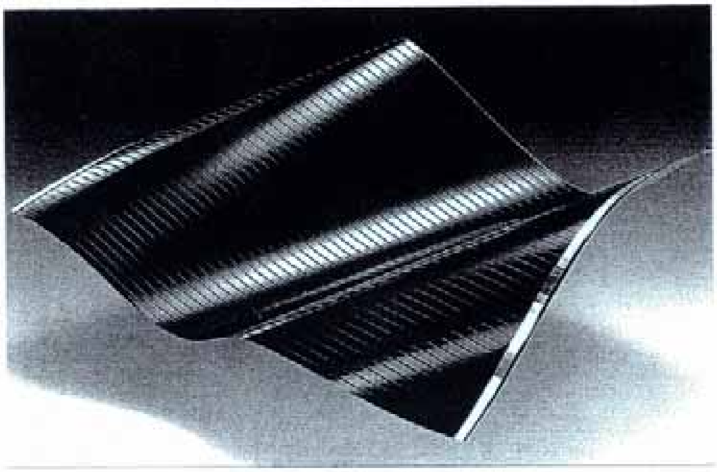

Fig 2.8 Amorphous silicon cells
"State of the art" triple junction, thin film cells..

Released in 1996, this revolutionary *Triple Junction* photo-voltaic material is everything the old crystalline technology could not deliver. Manufactured in a continuous roll to roll process (like newsprint) eminently suited to mass production, triple junction amorphous silicon solar panels are formed in layers upon a thin stainless steel sheet. A total of nine ultra thin layers of silicon alloy are sequentially applied in a seamless operation using advanced *Microwave-plasma-chemical-vapour-deposition technology*. The result is a unique tandem solar cell structure comprising three separate "P-N" junctions, each junction responding to a different wavelength of sunlight, blue, green and red. This spectrum splitting is the key to improved cell efficiency.

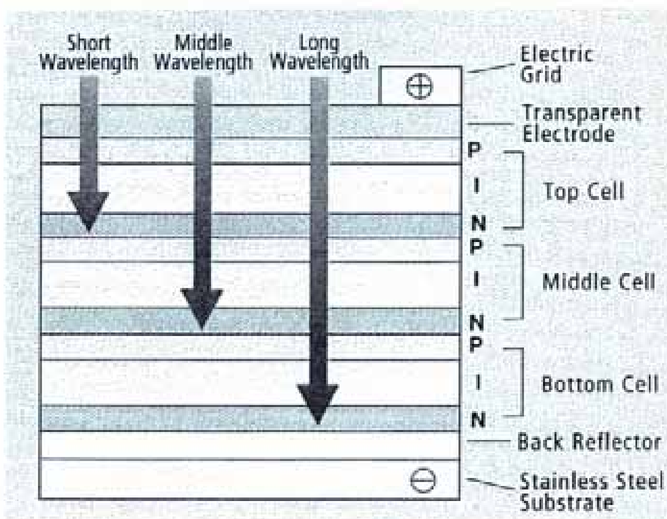

Fig 2.9 Triple junction cell structure
Three stacked "P-N" junctions improve spectral response.