Photovoltaic solar cell technologies for the future

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The solar cell market is booming (over 30% per annum compound growth over the last 5 years). Most solar cells sold on this market to date have been "first generation" devices based on crystalline or "multicrystalline" silicon wafers. "Second generation" thin-film solar cells based on amorphous silicon or polycrystalline films of compound semiconductors are starting to appear on the market in increasing volume and, due to inherently lower material costs, are expected to challenge "first generation" product increasingly over the next decade.

Energy conversion efficiency is a key parameter for both technologies, since this determines the area and hence cost for a given power rating. However, this efficiency for first and second generation technology is quite modest (less than 15%), due to the quantum nature of the conversion process (1 photon/electron) combined with other constraints. The Carnot limit on the conversion of sunlight to electricity is much higher at 95%. This leads to the possibility of a "third generation" of photovoltaic technology based on different conversion principles that allow the Carnot value to be more closely approached.

After a brief introduction to the current status of "first" and "second" generation technologies, candidates for "third generation" technologies will be outlined including hot carrier cells and a variety of schemes based on including multiple excitation processes with different energy thresholds in the one device. Low dimensional semiconductor devices feature prominently in many of these schemes, for a variety of reasons to be discussed.