# New measurements on the diamond/CdTe solar cell

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A p-diamond/n-CdTe PV cell has been designed and fabricated to demonstrate the concept of an inverted p-n heterojunction solar cell. Measurements to characterize and understand the cell are presented.

A boron doped diamond thin film substrate with p-type conductivity was treated with ozone to modify the electron affinity and facilitate growth of the CdTe layer. Thin film CdTe was grown onto the diamond with a close space sublimation (CSS) method. The film was moderately doped with indium to render the material n-type conductivity. The diode structure was completed with front and back contacts and evaluated with current-voltage (I-V) measurements, spectral response, x-ray photo-electron spectrometry (XPS), and surface photovoltage spectrometry (SPVS).

The proposed device geometry cross section of the diamond/CdTe solar cell and the proposed electronic energy band diagram of the diamond/CdTe heterojunction device are presented in Fig s. 1a and 1b. The band diagram suggests that the resulting band bending when forming the p-n junction should be around 0.7 to 1.0 eV and should not include any band mismatch at the junction. The diamond/CdTe cell I-V measurement in Fig. 2 can be summarized by an ideality factor n of 1.23 at a forward bias of 100 mV. The reverse bias saturation current $J_0$, the series and shunt resistances, $R_S$ and $R_{SH}$ are 0.12 A/cm $_2$, 606 Ω and 200 kΩ, respectively. AM1 illumination generates a low open circuit voltage ($V_{OC}$) of 230 mV and a low short circuit current ($J_{SC}$) of 1.5 mA/cm$^2$. A low fill factor (FF) of 0.32 shows that the series resistance is too high. The visible crossover of the dark curve across the light curve indicates that the dark conductivity in the CdTe is poor. The light curve does not suffer from high bias roll over, which means that the $V_{OC}$ is not reduced by a high back contact Schottky barrier. XPS valence band measurements with depth profiling on the diamond/CdTe device confirms that the band bending at the heterojunction is 0.7 eV and reveals that the Fermi level of the n-CdTe film is quite low, 0.4 eV under the conduction band. This explains the poor conductivity of the CdTe film and could be the result of inefficient doping. Spectral response measurements of the cell and transmittance measurements of the diamond film are shown in Fig. 3. The overall low transmittance of the diamond film explains the low $J_{SC}$ of the solar cell. The high band gap diamond is quite dark when highly doped. The relatively high spectral response at 500 nm shows that the cell is fairly efficient at separating photogenerated holes and electrons near the diamond/CdTe interface, whilst the poor infrared response near 800 nm indicates that the deep CdTe bulk is a region with a high recombination rate, most likely a consequence of compensated or inactive donors in the CdTe film. An SPVS measurement (Fig. 4) on the p-diamond/n-CdTe junction confirms the n-type conductivity and the band gap of the CdTe film. The sharp drop in SPV at 844 nm indicates a p-n junction free of interface states, which suggests that the bulk of the CdTe film as the likely region of high recombination rates.

More efficient doping of the CdTe film and thinner diamond films should improve conductivity and spectral response of the diamond/CdTe solar cell.

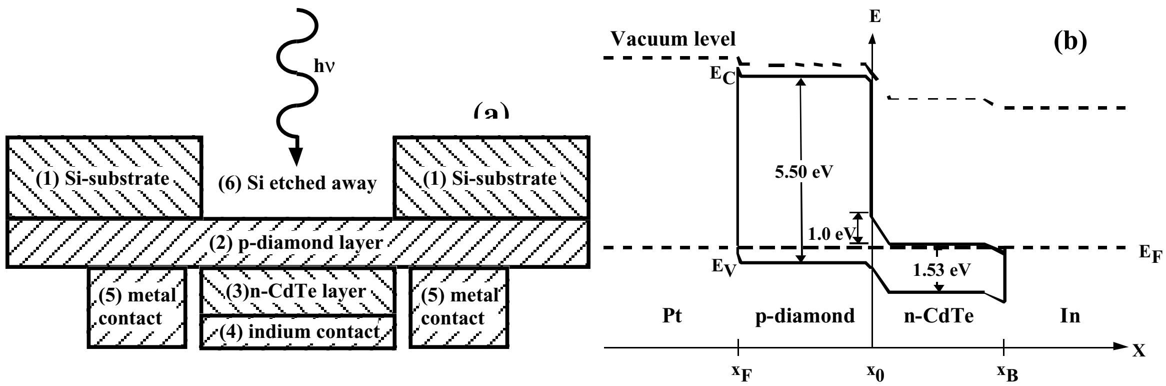


**Fig 1a and 1b.** The proposed device geometry cross section of the diamond/CdTe solar cell and the proposed electronic energy band diagram of the heterojunction device.

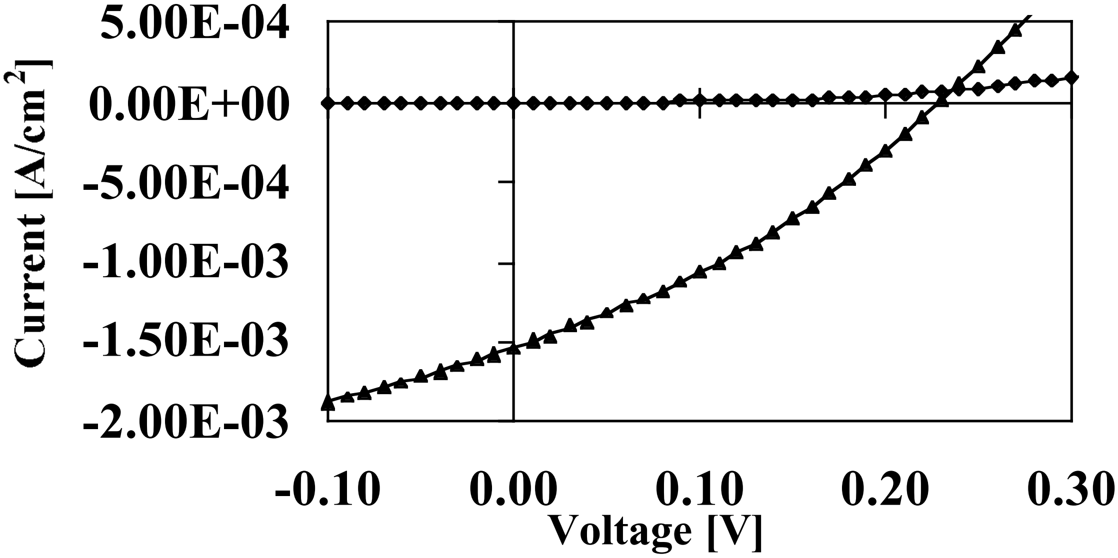


**Fig. 2.** An I-V measurement on a diamond/CdTe solar cell.

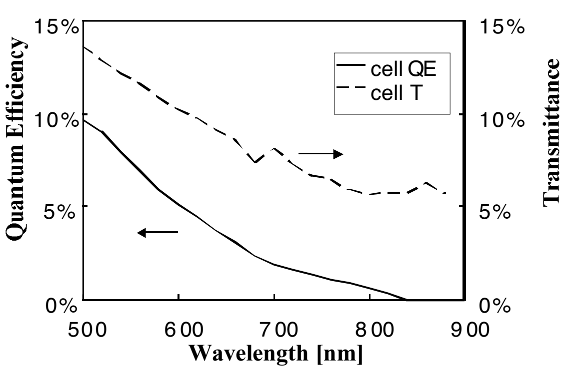


**Fig. 3.** Spectral response of the diamond-CdTe solar cell and transmittance of the diamond film window layer.

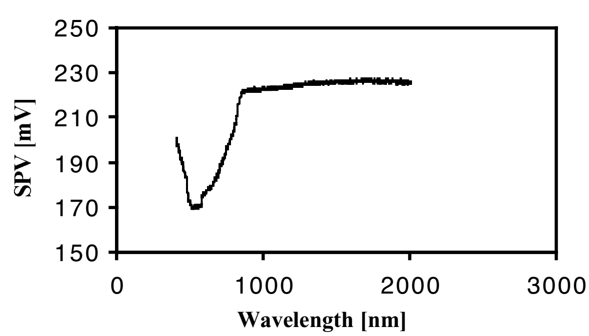


**Fig. 4.** SPVS measurement on the diamond/CdTe junction.