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TCO and carrier selective materials open circuit voltage and efficiency significance in solar photovoltaic cells

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Si and CdTe hetero-junction (HJ) solar cells are most promising in commercial stage photovoltaic (PV) technologies. Their contacts and interface defects related opto-electrical losses are still vital to limit its further technological benefit. Besides pioneer Si and CdTe PV cell, the rapid development of organic and organic-inorganic Perovskite solar cells are also huge energy potential. Enhancement of conduction and lessening recombination the carrier selectivity (CS) by field effect is most significant for majority carrier selection to improve open circuit voltage. The dark carrier injection due to thermal effects and traps are mostly classified as recombination losses [1-2] and it is related to the barrier effect. Temperature and photonic interaction with PV materials the l$V \propto \frac{K_B T}{q} In\left(\frac{J}{Jo}\right)$g to temperature the current density function, J/Jo and associated built in potential are determining factors of energy losses ΔE= ΔqV.

$$V_{oc} = V_{oc}^{SQ} - V_{oc}^{SC} - V_{oc}^{rd} - V_{oc}^{nrd} \quad (1)$$

The effective charge modulation at the surface is directly proportional to the dielectric constant of the nanostructure back surface passivation layer of high-k dielectrics effects are vital [3-4].

$$Q_{eff} \propto \frac{\epsilon A}{d} \quad (2)$$

Qeff is effective charge density, ϵ is dielectric permittivity, d is thickness, A is area. CS is essential to combat Fermi level pinning (FLP) effects. Careful selection of the material work function with respect to the doping level the contact resistivity is varied with the Schottky barrier height.

$$\rho_c \propto exp\left(\frac{\varphi_B}{\sqrt{N_d}}\right) \quad (3)$$

The contact resistivity, ρ_c, barrier height, φ_B and doped N_d are interrelated. The TCO, emitter and back contact materials proper band edge, permittivity and thermal as well as electrical conductivity has lot of influence on carrier selectivity, contact resistance, Voc and efficiency. The TCO and back barrier passivation thickness and doping effect on both Voc and efficiency variation more specifically can be understand and it is supportive to further progress in diverse materials design and electrical performance of diverse solar cell.