Hot Carrier Solar Cells with Nano/Bulk Junctions
Igor Konovalov, Oleksandr Slovak, Vitali Emelianov

Concept

Hot carrier solar cell with nano/bulk junctions
E - Selective contact (nano - PbS)
Absorber (bulk PbS)
E - Selective contact (nano - PbS)

- Carrier selectivity by band offset nontransitivity

Application and properties of Nano/Bulk contact
Possible other origins of selectivity:
Different effective mass m:
\[ E_n - E_C = \frac{\pi^2 \hbar^2}{2mL^2} n^2 \]
AND!
\[ n = N_C e^{-\frac{E - E_C}{kT}} \]
\[ N_C = \left( \frac{2\pi m kT}{\hbar^2} \right)^{3/2} \]
Different density of states: \( \Rightarrow \) semiconductor-specific!
Probability of tunneling ? Grows at smaller m?

Band structure of PbS:
Cubic, band edges at L-point)
Electron and hole masses are about the same and small...
\[ E_n - E_C = \hbar^2 k^2 / 2m \]
(I. Kang and F. W. Wise, 1997)

PbS: Large DOS near point \( \Sigma \), BUT!
Different splitting of the valleys from band edges!!!
\( \Rightarrow \) Large difference between the density of states of electrons and holes.

Experiments

Attempt to nanoetch porous sulfide semiconductors electrolytically like porous silicon, here porous CuInS:

Electrolyte: 1M \( \text{H}_2\text{SO}_4 \); substrate: CuInS\(_2\) crystal

CBD of nanocrystalline PbS on glass:
\[ \text{Na}_2[\text{Pb(OH)}_4] + (\text{NaOH} + \text{SC(NH})_2) \]

Light transmission in nanocrystalline PbS:
Lock-In spectrometer

Conclusion: PbS is perspective material for hot carrier solar cells with nano/bulk junctions

We would like to thank Mrs. M Friedrich for REM study and Carl-Zeiss-Stiftung for financial support.