Similarities of a hot electron solar cell with thermionic and thermoelectric energy converters.

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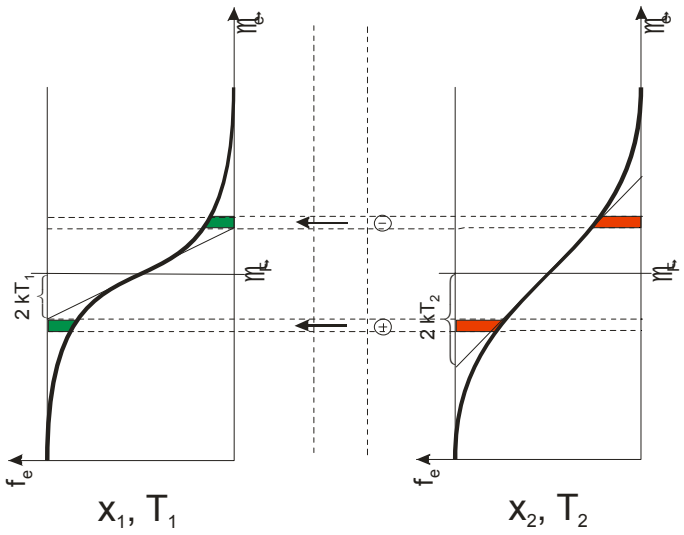
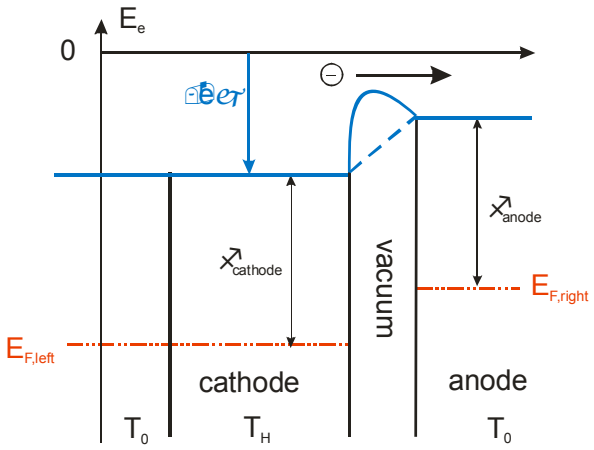
Solar energy conversion in solar cells is based on the transport of electrons and holes. For example, the transport of electrons with energy ε_e into the +x-direction requires that states at ε_e must be more highly occupied at x_0 than at $x > x_0$. This is true for homogeneous and inhomogeneous temperature distributions.
For a homogeneous temperature distribution, an occupation changing with x requires a gradient of the electrical or (and) of the chemical potential of the electrons, giving rise to a gradient of the Fermi-energy, the general driving force for the electrons at constant temperature.
For an inhomogeneous temperature distribution, differences in the occupation are present in hot electron cells and in thermionic and thermoelectric converters due to temperature gradients and gradients of the electrical and chemical potentials. Transport of electrons at energy ε_e may be partly balanced by transport of other electrons at different energies in the opposite direction. This occurs predominantly in metallic thermocouples and is the reason for their very small voltages and low conversion efficiencies as is seen in Fig.1, where the exchange of electrons and holes between 2 points (x_1 and x_2 with temperatures $T_1 < T_2$) occurs at constant Fermi-energy.



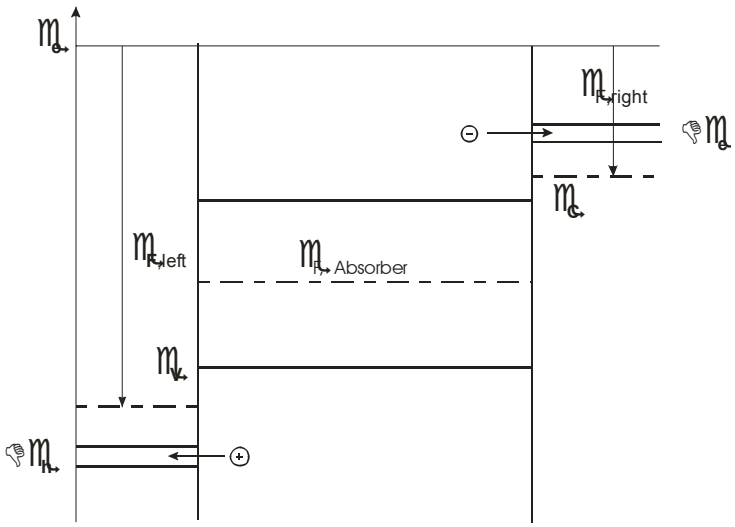
A much larger efficiency is found for thermionic converters. It is due to a barrier for electron emission, the workfunction of the hot emitter, which greatly suppresses transport in the wrong direction at one of the two electrodes of the converter.

The best performance is achieved in the hot electron cell, in which transport in the wrong direction can be totally avoided at both contacts, if both allow only a mono-energetic exchange of electrons.

Thermionic converter



Hot electron cell



The increasing ability to suppress transport in the wrong direction is the main difference in the conversion of heat into electrical energy by thermoelectric converters, thermionic converters and hot electron solar cells, making the hot electron cell the ultimate thermoelectric device.