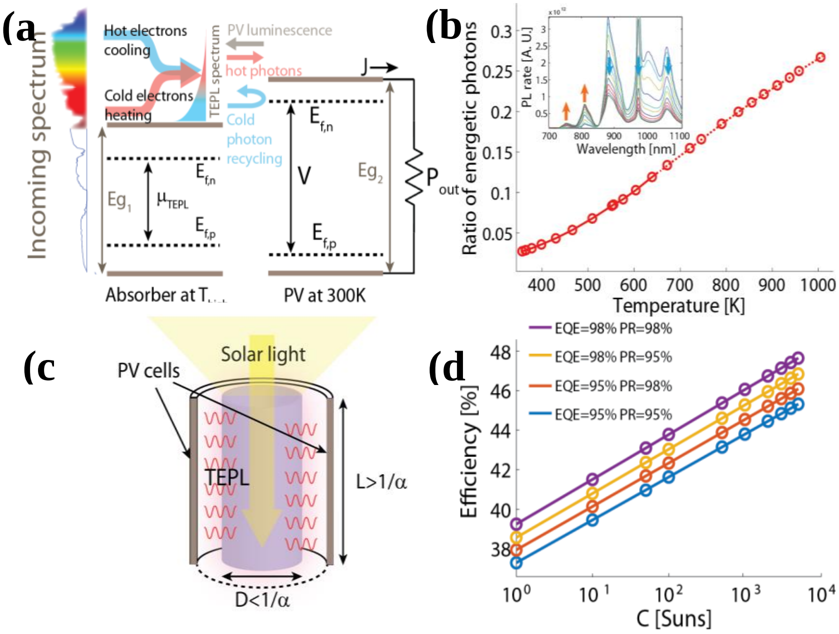
Thermally Enhanced Photo-Luminescence: Device

Carmel Rotschild

Department of Mechanical Engineering, Technion – Israel Institute of Technology, Haifa 32000, Israel

The 32% Shockley-Queisser (SQ) limit on the conversion efficiency of single-junction photovoltaic (PV) cells is mainly due to heat dissipation accompanying absorption of energetic photons. Concepts that aim to harness this heat loss, such as solar thermo-photovoltaics (STPV), are constrained due to the required high temperature. *Thermally Enhanced Photoluminescence* (TEPL)[i] can potentially overcome the SQ limit. I will present first TEPL device where a thermally insulated Cr-Nd-Yb-SiO_2 based photo-luminescent (PL) absorber, acting as a mediator between a GaAs photovoltaic cell and the sun (Fig. 1a). Experimentally, we find that the Cr-Nd-Yb doped glass absorbs 70% of the solar spectrum and its emission is efficiently blue-shifted as temperature rises (Fig 1b). Based on internal quantum efficiency (QE) measurements, 47% of the energy is coupled to the cell while the absorber is operating at temperatures 1000K. Learning from laser technology, in order to maintain high emission QE the dopants are diluted in the matrix and absorption length is few millimeters long. In light of this understanding, a more practical model may be conceived as cylindrical absorber surrounded by PV cells and illuminated by concentrated sunlight at the cylinder top facet (Fig 1c). We use the measured emission spectrum of the Cr-Nd-Yb absorber and set the external QE as a parameter for optimization, together with parameters such as photon-recycling efficiency, absorber temperature (determined by thermal insulation) and solar concentration. Here we find that for solar concentration of 1000 suns and achievable QE and photon-recycling values of 95% the conversion efficiencies are expected to exceed 45% (Fig 1d).

Figure 1: TEPL converter concept and model results. (a) TEPL conversion conceptual energy diagram. (b) Ratio of photon emitted above 870nm from Cr-Nd-Yb glass sample as a function of temperature and (inset) its emission spectrum evolution with temperature. (c) Conceptual converter implementation. (d) Modeled device efficiency for different QE, Photon-recycling (PR) and solar concentration at 1500K.



[i] A. Manor, N. Kruger, T. Sabaphati and **C. Rotschild**, Thermally-Enhanced Photoluminescence for Heat Harvesting in Photovoltaics, Accepted to ***Nat. Comm***. 2016