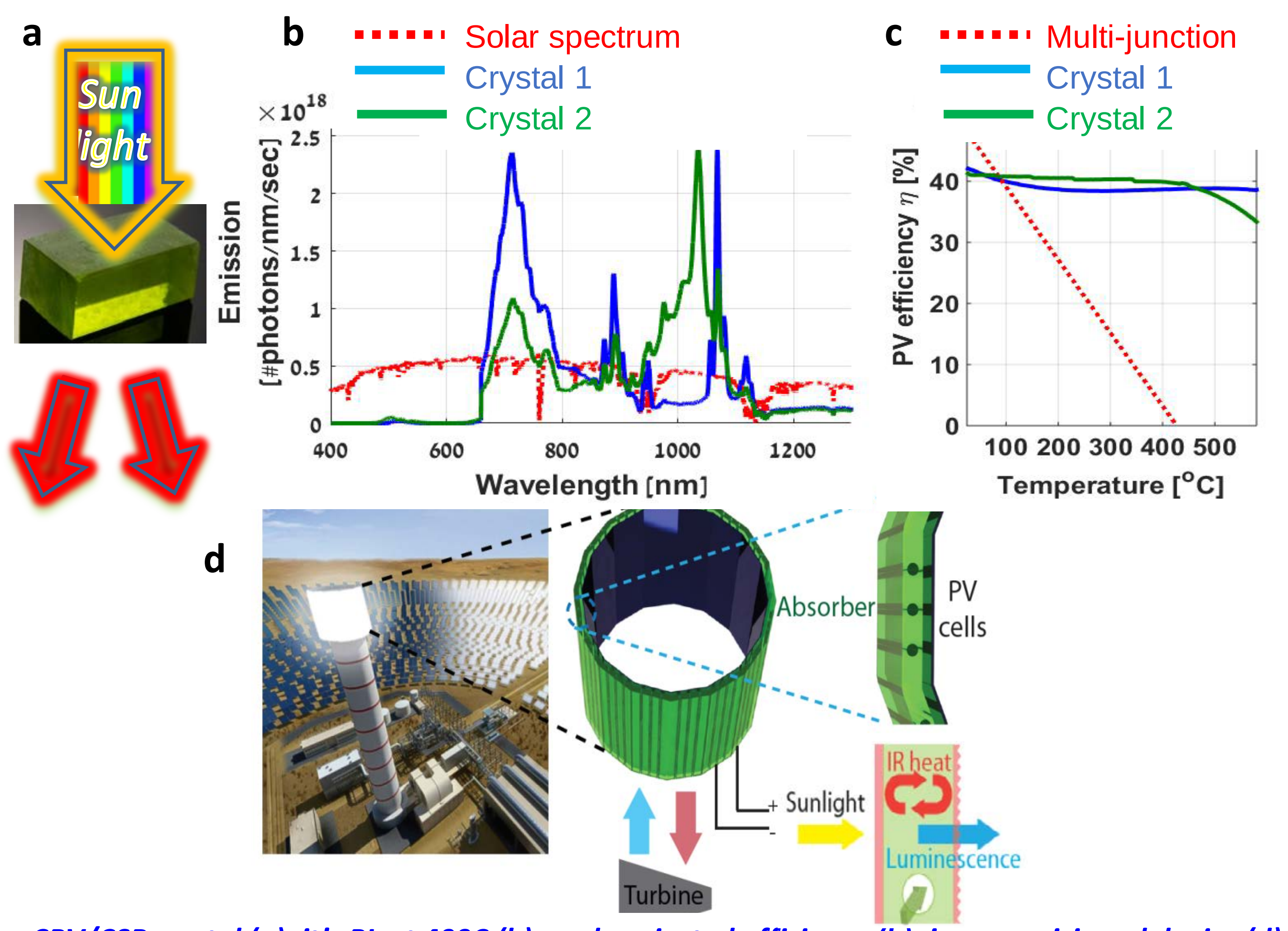
CSP-CPV on a single Thermally-Enhanced-Photoluminescent crystal

Prof. Carmel Rotschild Mechanical Engineering, Technion-Israel Institute of Technology

The biggest challenge in solar energy today is not the electricity generation price, which is already under fossil fuel price for photovoltaics (PVs) (<0.04 $/kWh), but rather the ability to store utility-scale electricity at competitive prices. To date, the only method to efficiently and reliably store such energy is Thermal Energy Storage (TES) which is combined with Concentrated Solar Power (CSP). Despite its past decline, demands for CSP are increasing in that require alternative dispatchable energy generation**.** However, the combined production and storage price for this technology is still much higher than PVs (0.06 $/kWh - 0.12 $/kWh).

Thermodynamically PVs and CSP relay on two different energy transport mechanisms. PVs relay on the free energy captured in an electron-hole pair generated by the quantum process of photon absorption, while CSP relay on the generation of many phonons in the process of thermalization, where free energy is lost. Even though these processes may be considered as independent, the generation of electron-hole pairs cannot occur spontaneously without the loss of free energy in a thermalization process. If PVs efficiency would tolerate high temperatures, for example, 600C, it would be beneficiary to concentrate solar radiation onto PVs, harvesting the available free energy, while in parallel harvesting the high-quality thermal energy through CSP. **Doubling the conversion efficiency this way cannot be done with PVs as their efficiency decreases sharply with temperature, but can be done optically**. In our method, we focus solar radiation onto a photoluminescence (PL) absorber and demonstrate 90% quantum efficiency while operating at 600C. The PL has a narrow line shape that matches the band-edge absorption of Si (or equivalent PV) and GaAs PVs, which offers CPV at 35% efficiency with minimal heating of the PV. The high quality heat at the PL-absorber is collected by heat transfer fluid (HTF) and converted to electricity at 35% turbine efficiency. A detailed analysis based on experimental validation of the concept shows 50% enhancement in the efficiency of CSP, with minimal additional costs thereby reducing expected electricity price own below 0.04 $/kWh.



CPV/CSP crystal (a), it's PL at 400C (b), and projected efficiency (b), in an envisioned device (d)