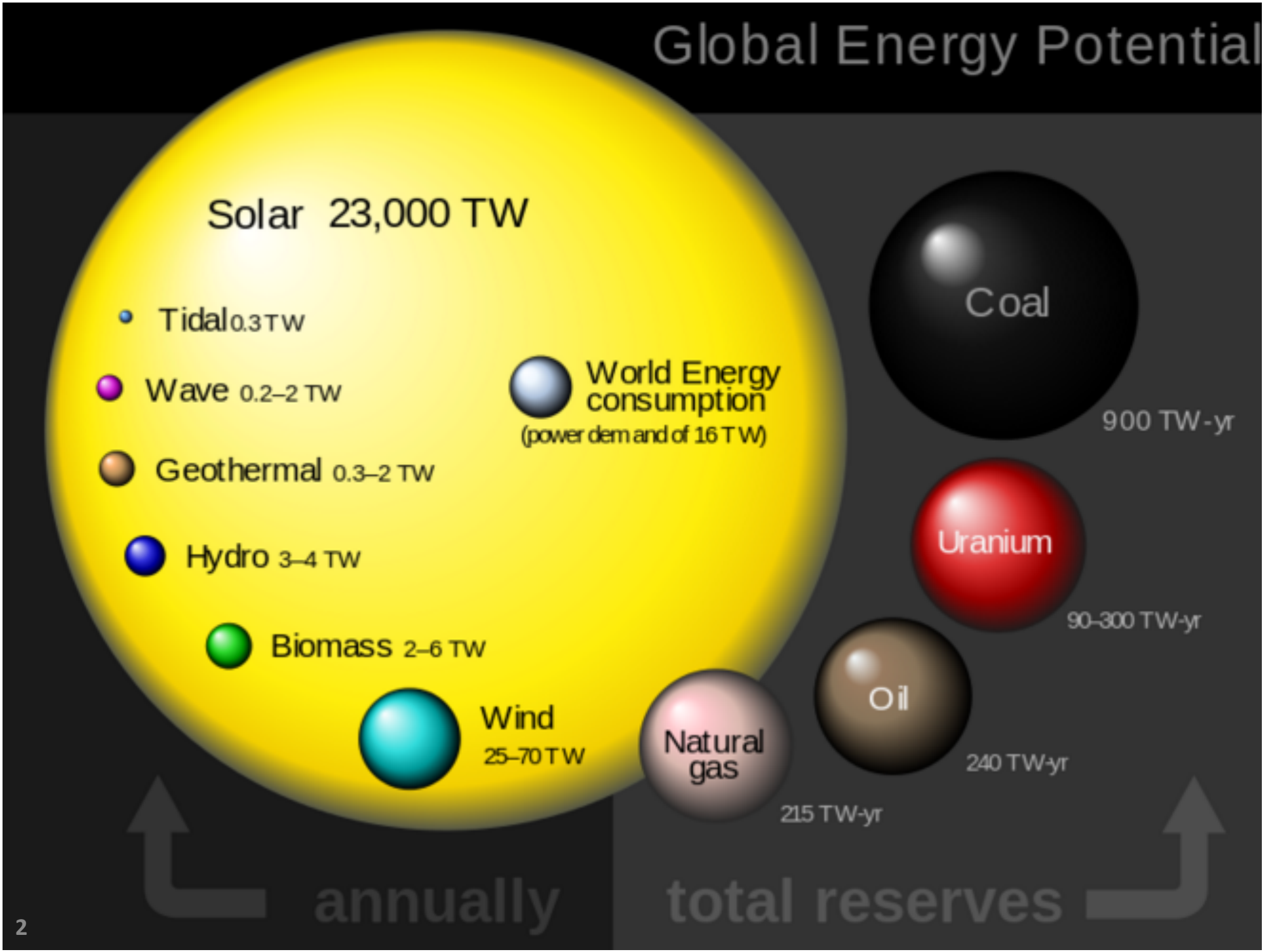
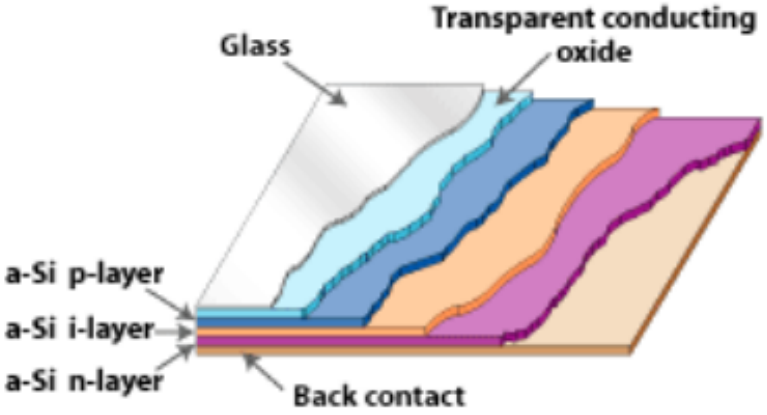
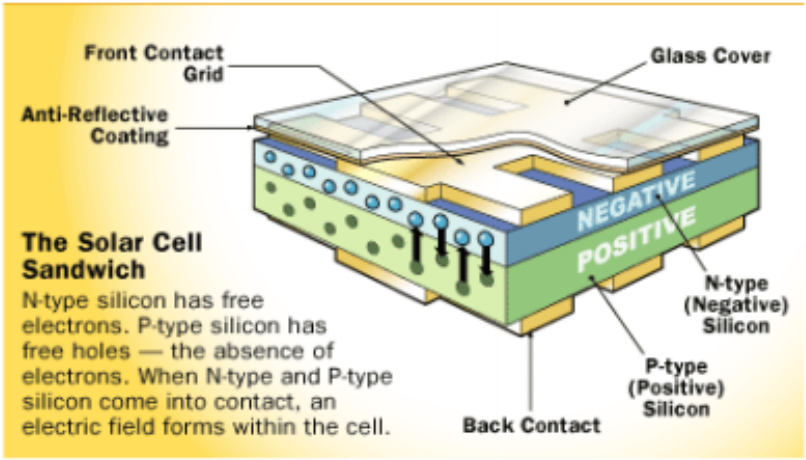
Chalcogenide glass-ceramics for photovoltaic applications : developpment of the new compositions

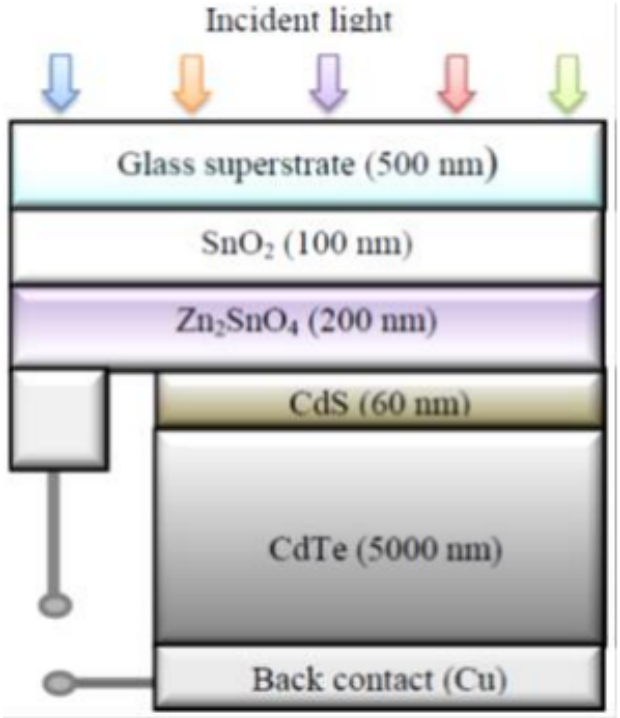
Ilia Korolkov, Xiang-Hua Zhang, Jean-Luc Adam

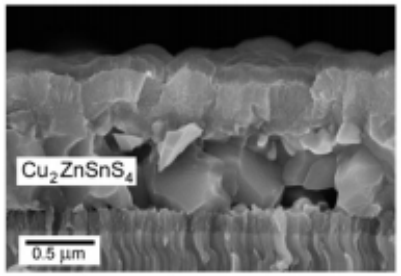

Global Energy Potential
Solar 23,000 TW
Tidal 0.3 TW
Wave 0.2–2 TW
Geothermal 0.3–2 TW
Hydro 3–4 TW
Biomass 2–6 TW
Wind 25–70 TW
World Energy consumption
(power demand of 16 TW)
annually
Coal
900 TW-yr
Uranium
90–300 TW-yr
Oil
240 TW-yr
Natural gas
215 TW-yr
total reserves

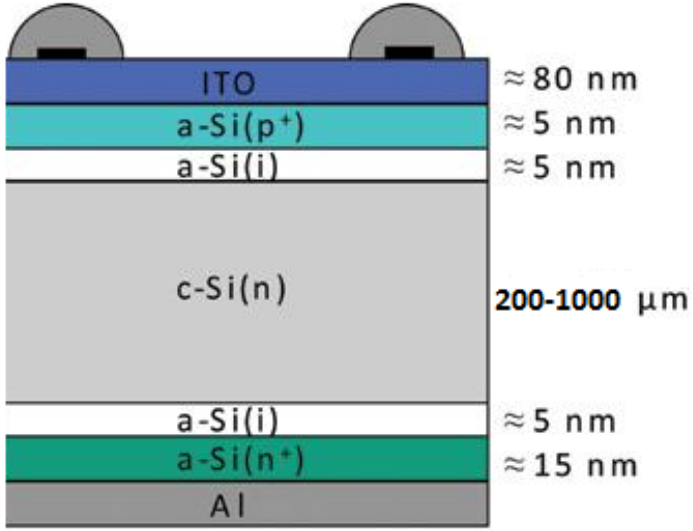
Modern solar cells : State-of-the art



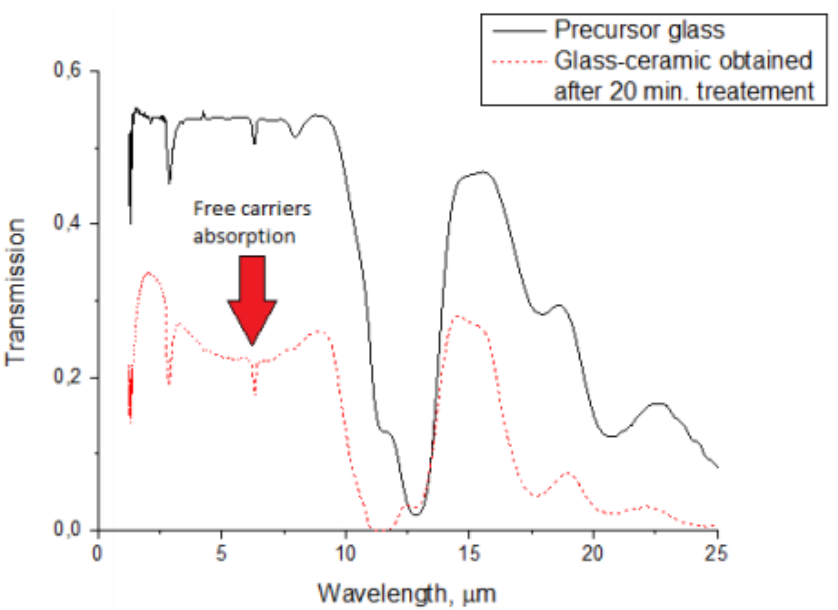


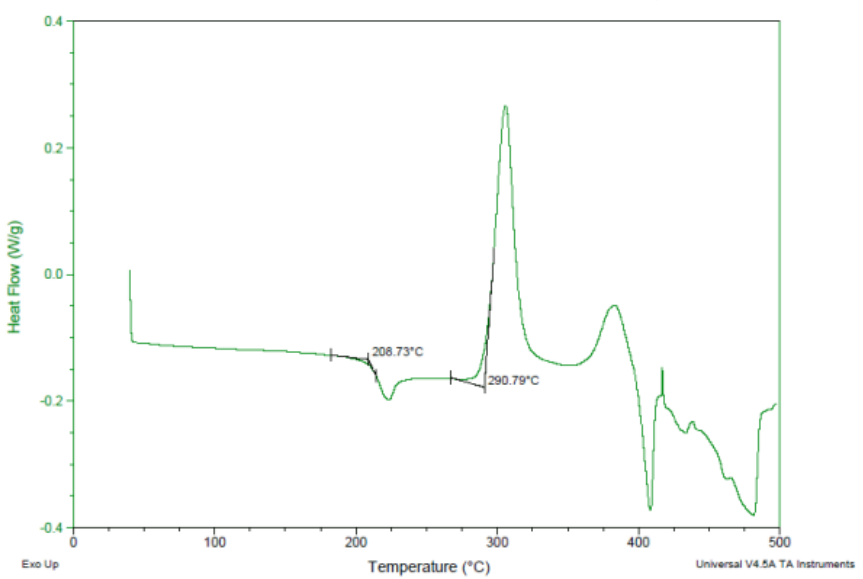






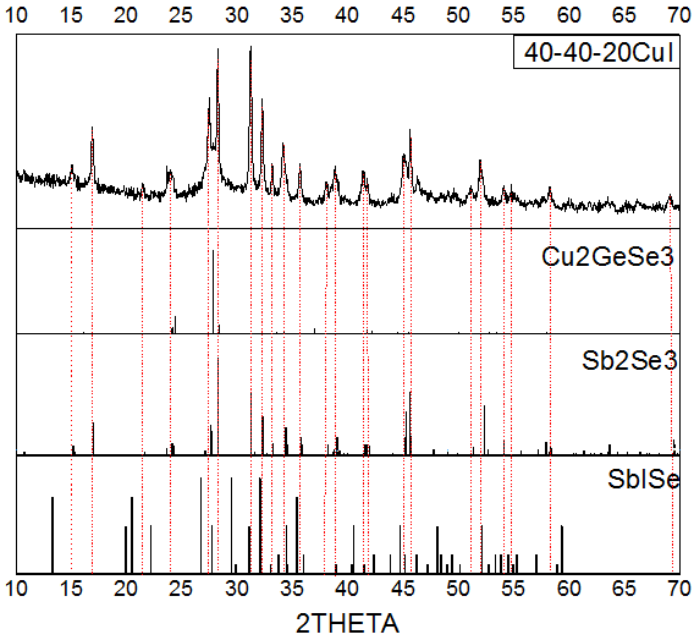
$40GeSe_2 – 40Sb_2Se_3$ - 20CuI



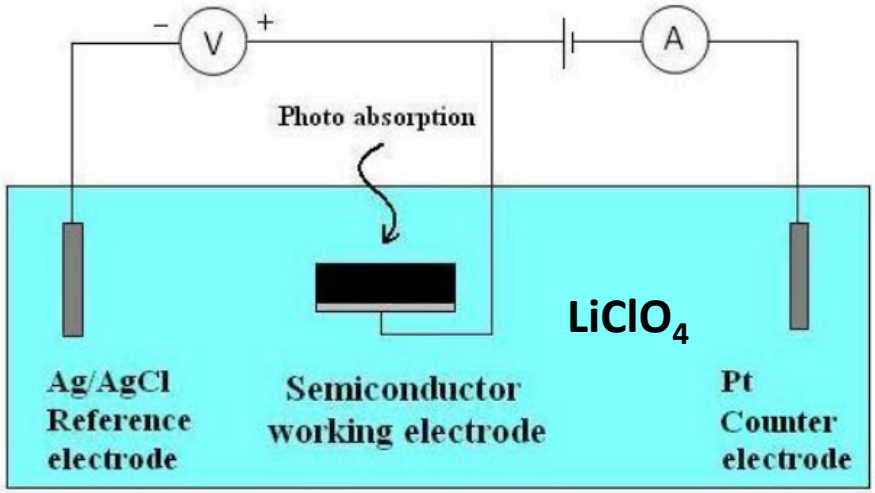


Favorable ceramization parameters:
T = Tg+50

Initial phase separation :
Co-existance of stable and unstable phases



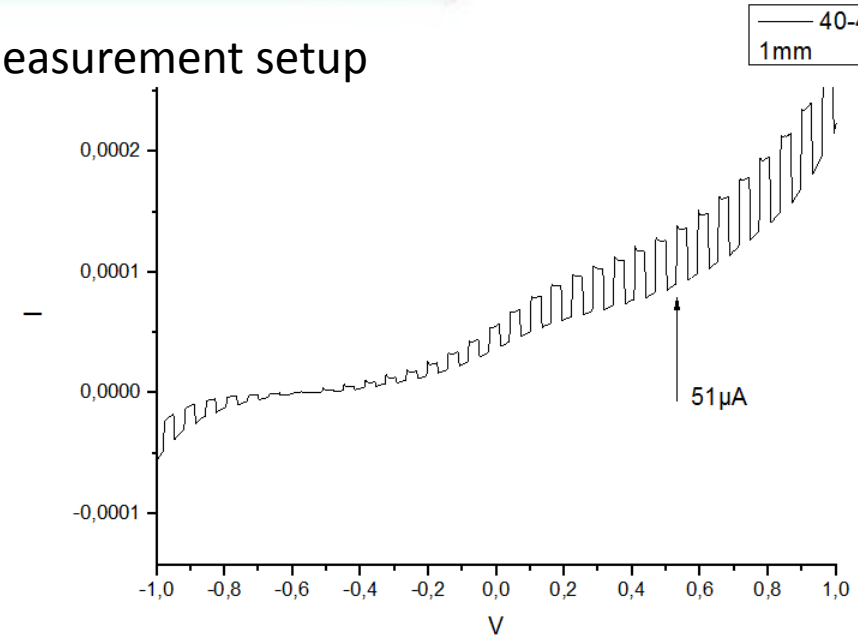
Photochemical mesurement



3-electrode PC measurement setup

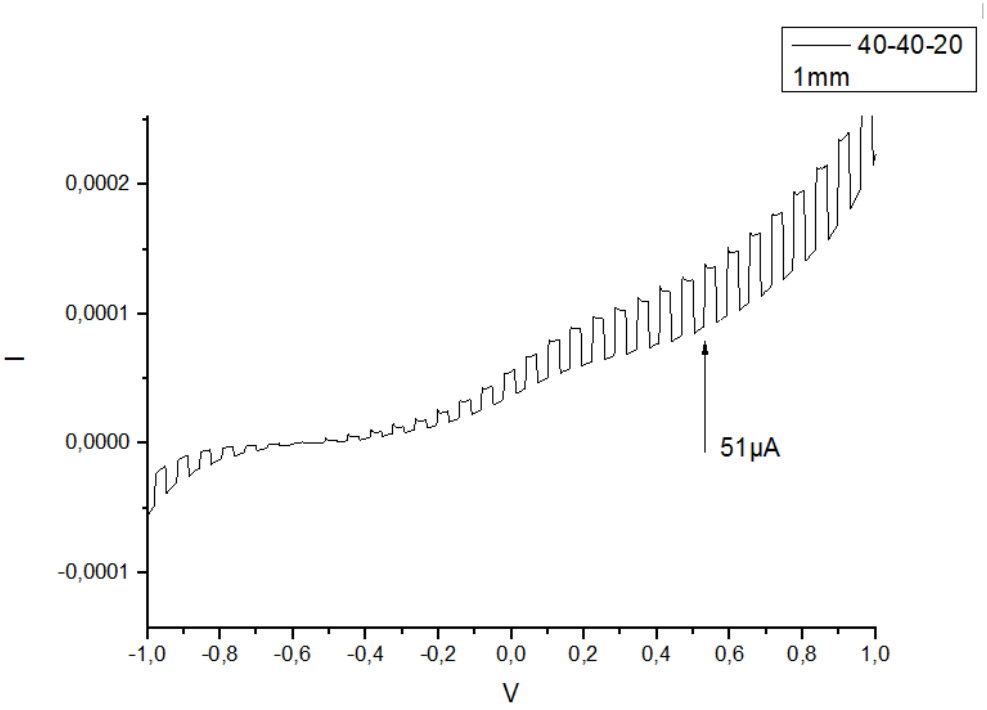
Typical sample External surface well polished, internal covered with silver paste

8 mm

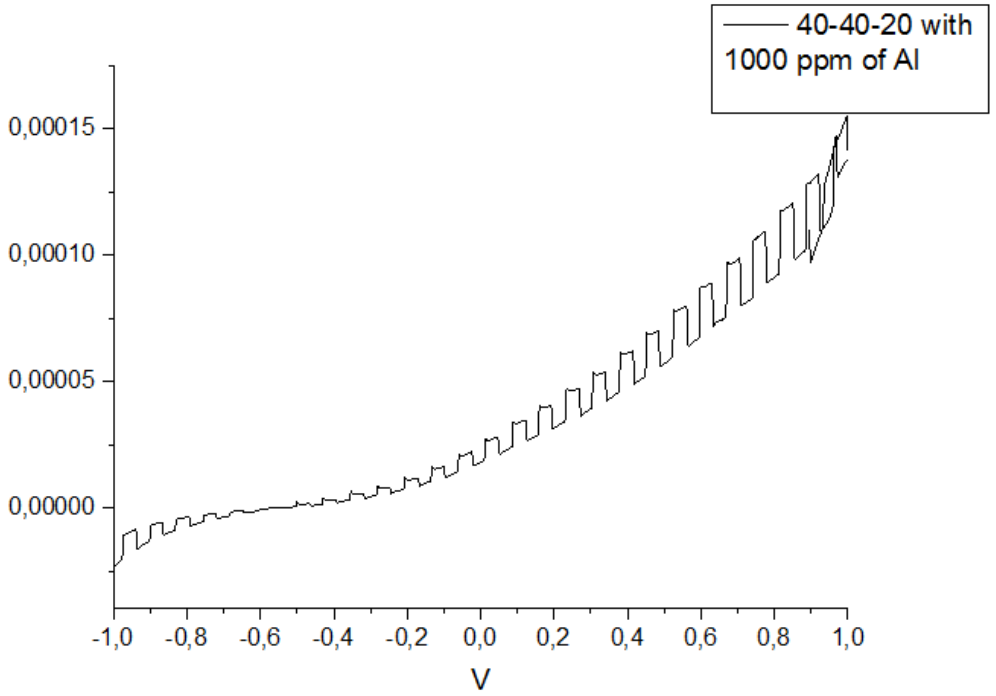


$J_{v=0.6} = 0.102\ mA*cm^{-2}$

IR spectra measurement and SEM image of 40-40-20 glass-ceramic without metal doping

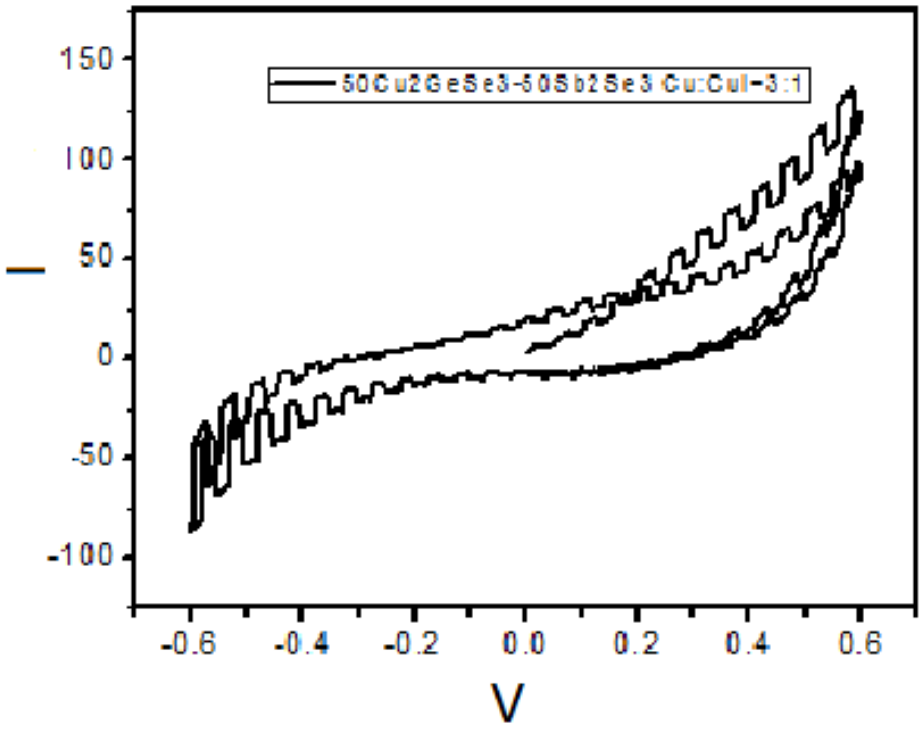


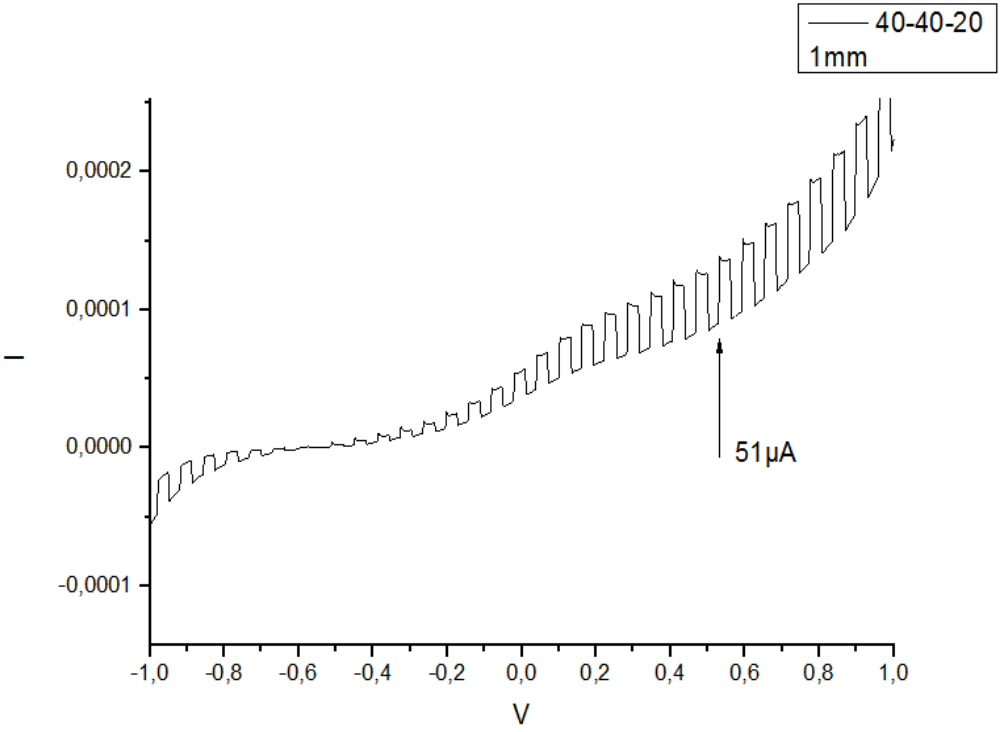
IR spectra measurement and SEM image of 40-40-20 glass-ceramic doped with 1000 ppm of Al



Compositon is tolerante to the oxide impurities ---
No demande of high purity expensive element

Advantages of glass-ceramics and it unique microstructure

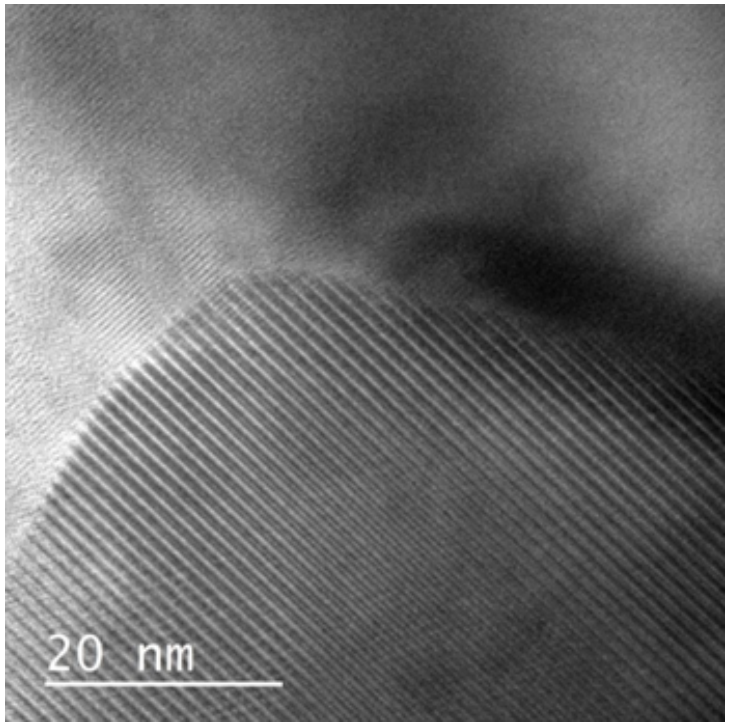




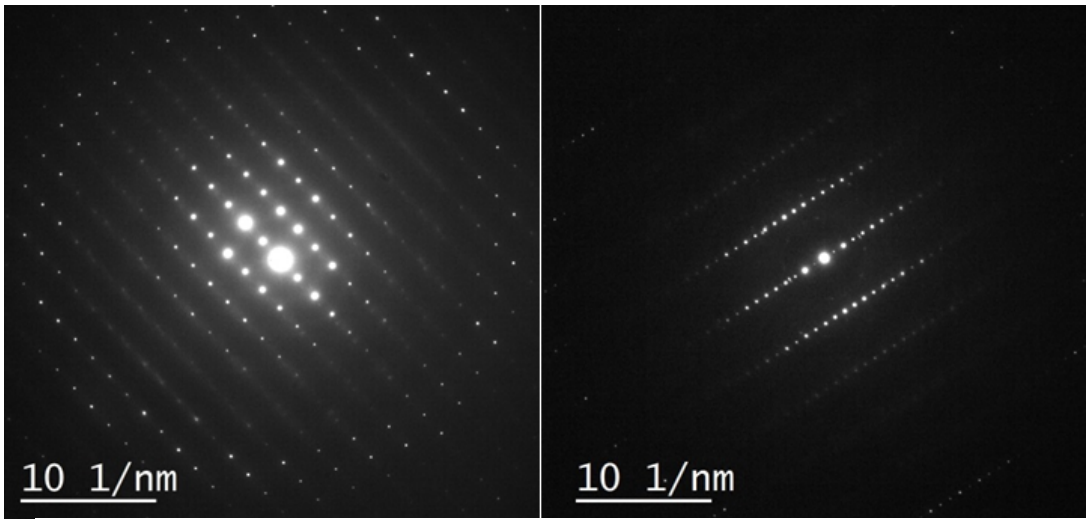
$J_{v=0.6} = 0{,}04\ mA*cm^2$

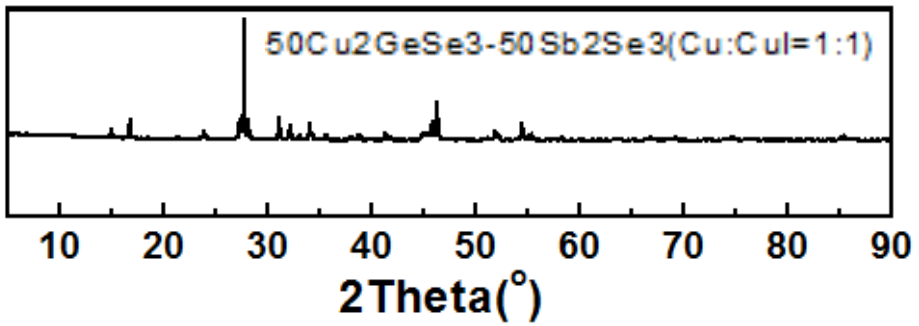
$J_{v=0.6} = 0{,}102\ mA*cm^2$

Advantages of crystall for structural investigations



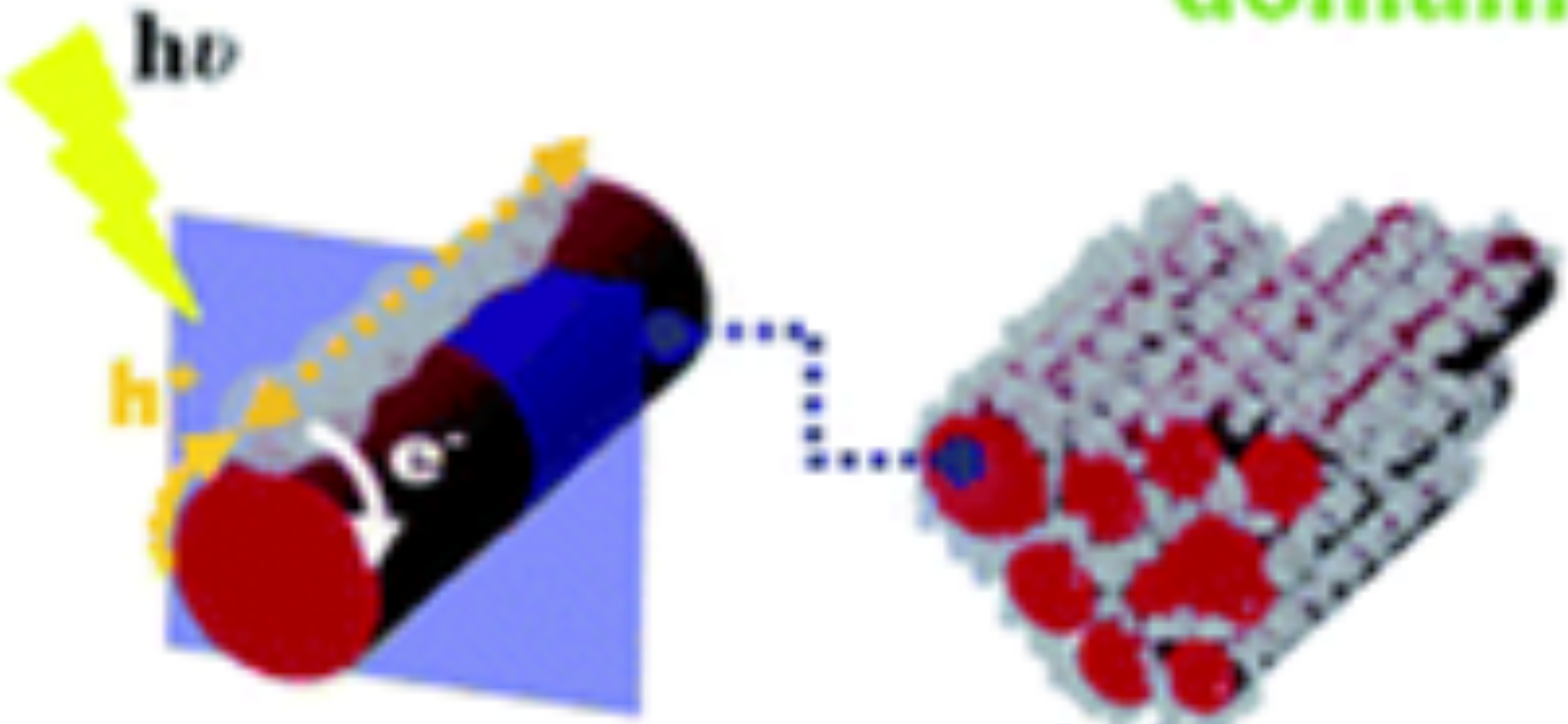
TEM image of P-N junction for crystalized sample. We can see two types of crystals with a large interface





Heterojunction

Functional domain



Cu_2GeSe_3

Sb_2Se_3

Facile thin-film preparation

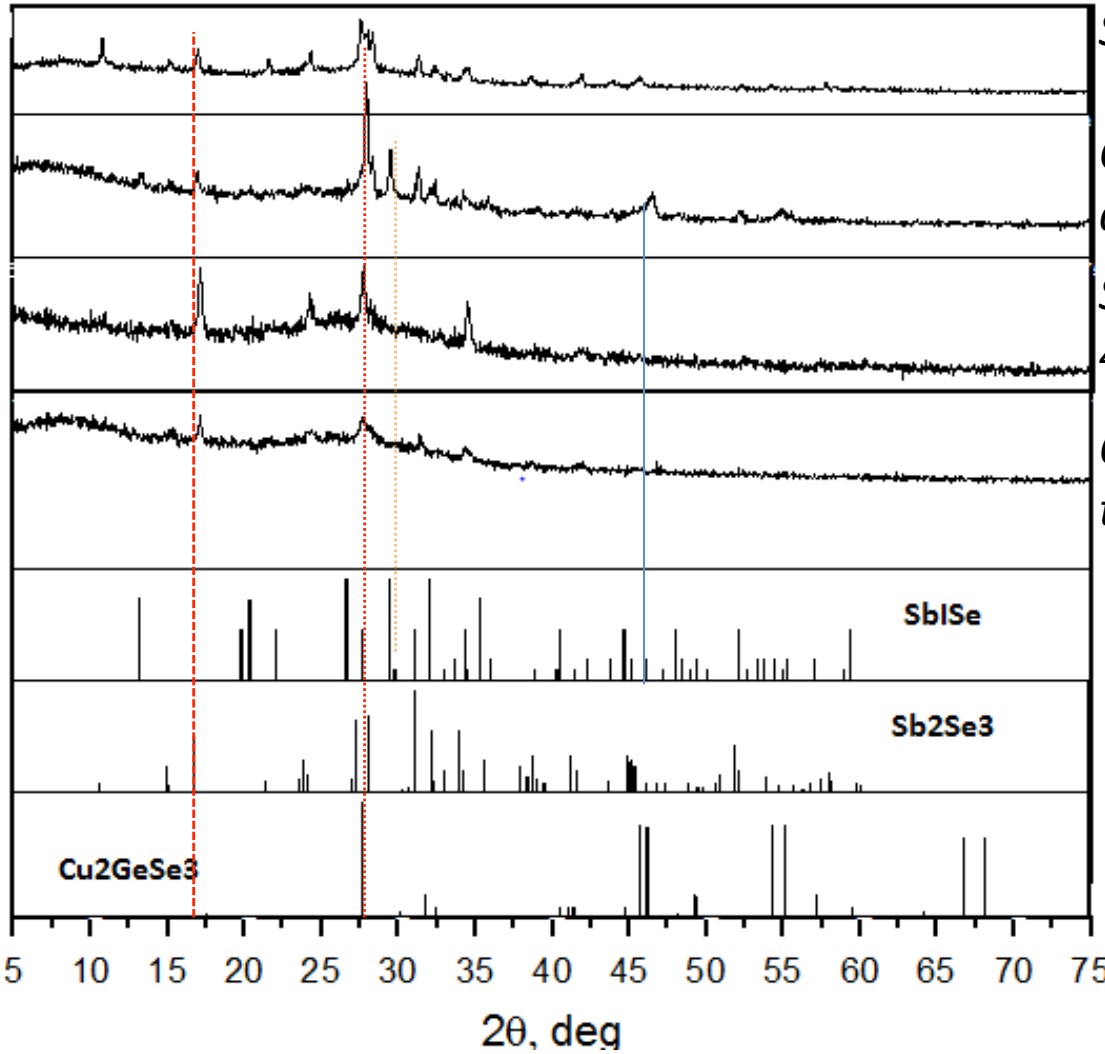
Pomp

Trap+ liquid nitrogen

Raw elements Se, Ge, Sb, CuI

100 mm

Crytstaline phase are tunable due to the possibilty of co-deposition and heating treatment



Sous-couche of CuI 5nm – 200 nm of 40-40-20, annealed for 4 minutes

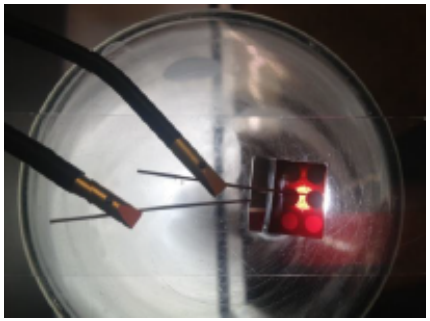
Co-deposition of CuI and 40-40-20 target, annealed for 4 min

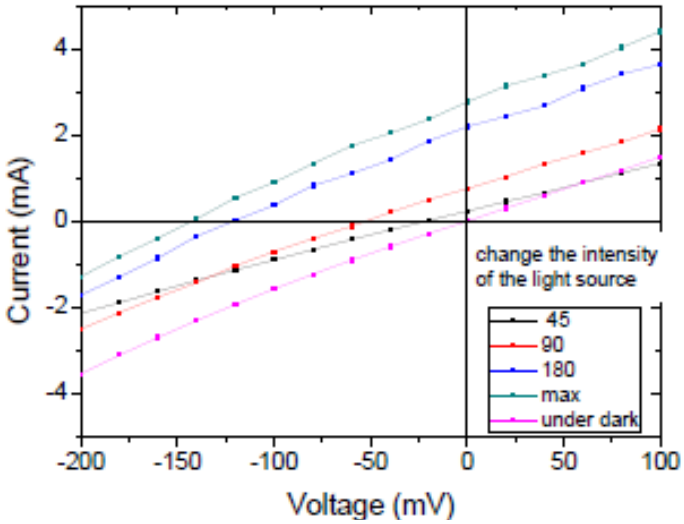
Sous-couche of CuI 5nm – 620 nm of 40-40-20, annealed for 4 minutes

Only 40-40-20 target,annealed

These results obtained by M. Bo Fan
Lab. Verres et ceramique
Mars 2014

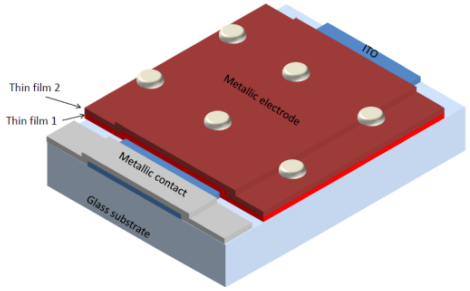
Bulk heterojunction solar-cell
500 nm GeSe2 – Sb2Se3 – CuI
Annealed for 3 h at 260 C

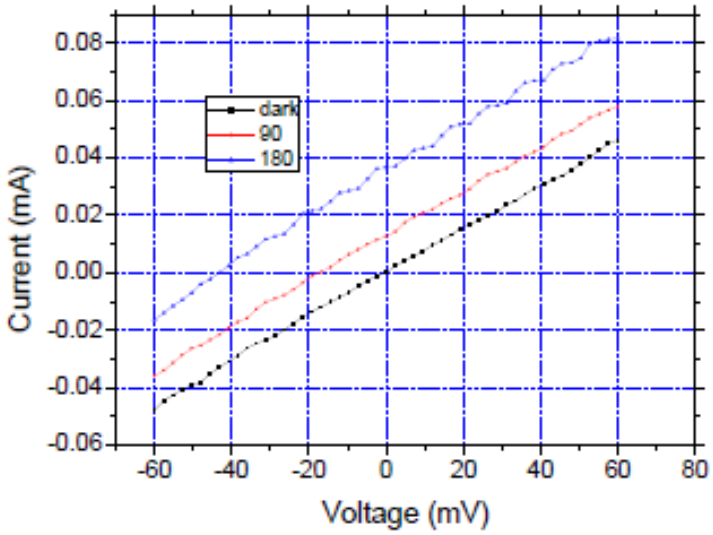




At maximum power, I_{SC}=2.73 mA, V_{OC}=141mV
Assuming the photocurrent is only contributed by the thin film under the top contact, the current density is 55.6 mA/cm^2

Planar p-n junction sollar cell
400 nm Sb2Se3 + 50 nm 4-4-2 VC





Current density is 0.79 mA

Conclusion

- Concentration of Ge does not exceed 10% - it is the only expensive element in this composition
- Glass-cermaic is not sensetive to the presense of Oxygen-impurities.
- Preparation of thin films is flexible due to the ceramization nature
- Stability of the composition can be controlled by varying of Ge concentration

Thank you for your attention