β-In2S3 thin films deposited by Chemical Spray Pyrolysis technique at different substrate temperatures (250 °C300 °C350 °C) showed well crystallized thin films with (0 0 12) as preferred direction perpendicular to the plane containing the surface of glass substrate. SEM images showed dense, uniform, well-covered layers that adhere well to substrates and no crack and void space were noted for all substrate temperatures. Microanalysis X confirms the presence of In and S elements with good stoichiometry after vacuum annealing for 30 minutes. Raman spectroscopy analysis confirms β-In2S3 phase with more prominent modes after vacuum annealing. We also noted a reduction in the gap energies after annealing for films prepared at 250 °C and 350 °C substrate temperatures while for those prepared at 300 °C, the energy of the gap remains stable.

Tin mono-sulfide (SnS) thin films must be deposited onto glass substrate with [S][Sn] ratio equal to one (1) and substrate temperature equal to 350 °C to obtained dense, well-covered, and homogeneous films without pinholes and cracks. Distance between nozzle to substrate is kept to 25cm, sprayed volume 5mL, air pressure 0.7bar and spray rate 1.5 mLmin.

Films doped with Silver (Ag) and Aluminum (Al) were all orthorhombic structure with (111) as main peak. The intensity of main peak increased when the percentage of dopant element increased in the initial solution without any secondary phase for Al-doping films and with Ag**8**SnS**6** and Ag for Ag-doping ones. SEM and AFM analysis showed that Ag-doping element had no effect in the morphology and the topography while Al-doping affected the surface morphology with “fishing net” like morphology with lots of holes for samples doped from 3% to 7%. EDS highlighted an increase of Ag in films when its amount increased in the solution with SSn0.98 near to 1 at 5% of Ag-doping percentage where as for Al-doping EDS highlighted improvement of stoichiometry with an increase of Al percentage atomic in films when Al concentration increased in the initial solution with SSn0.99 at 10%. Electrical and energy band gap measurement showed a decrease of resistivity when Ag and Al percentages increased in the solution to reach relatively low resistivity of 108Ω.cm and 170Ω.cm at 10% for both, and an increased of energy band gap when the Ag and Al-doping elements increased in the solution with 1.66eV and 1.70eV for SnS doped with Ag and SnS doped with Al, respectively.

Spray pyrolyzed SnS thin films doped with indium were studied using various optical and electrical techniques. Structural analysis shows that all films crystallize in orthorhombic structure with (111) as a preferential direction without secondary phases. Doping of SnS layers with indium results in better morphology with increased grain size. Absorption measurements indicate dominant direct transition with energy decreasing from around 1.7 eV to 1.5 eV with increased indium supply. Apart from direct transition, an indirect one, of energy of around 1.05 eV, independent on indium doping was identified. The photoluminescence study revealed two donors to acceptor transitions between two deep defect levels and one shallower with energy of around 90 meV. The observed transitions did not depend significantly on In concentration. The conductivity measurements reveal thermal activation of conductivity with energy decreasing from around 165 meV to 145 meV with increased In content.

Finally, we were investigated the J-V characteristics of FTOCdSSnS,FTOZnOCdSSnS, FTOZnO:AlCdSSnS, FTOZnO:AlSnS and FTOIn2S3SnS solar cells and we found that efficiencies are very low due probably to the recombination at the junction, grain boundaries, etc.