Effect of Cu-doping on crystallization and photovoltaic performance of Sb_2Se_3 thin films.

Giulia Spaggiari [1,2]*, Danilo Bersani [2], Davide Calestani [1], Edmondo Gilioli[1], Enos Gombia[1], Francesco Mezzadri [1,3], Michele Casappa [1,3], Francesco Pattini [1], Giovanna Trevisi [1] and Stefano Rampino [1]

*lead presenter: giulia.spaggiari1@unipr.it
1 Institute of Materials for Electronics and Magnetism (IMEM), CNR, Parco Area delle Scienze 37/A, 43124 Parma, Italy
2 Department of Mathematical, Physical and Computer Sciences, University of Parma, Parco Area delle Scienze 7/A, 43124 Parma, Italy
3 Department of Chemistry, Life Sciences and Environmental Sustainability, University of Parma, Parco Area delle Scienze 11/A, 43124 Parma, Italy

The search for reliable alternatives to the currently leading absorber materials for thin-film photovoltaic solar cells is still very active. In this field one of the emerging alternative materials for p-type absorbers is Antimony Selenide (hereafter Sb_2Se_3 or "ASe") [1]. ASe gathers important properties (optimal energy gap, high absorption coefficient) but also a very anisotropic (1D-ribbon like) structure and low free carrier density. For this reason, a deep study has been carried out in the last years to optimize its crystallization on the substrates. In particular, the aim of the research was to correlate the crystallographic ribbon orientations with the photovoltaics performances [2,3].
In this work Copper-doped antimony selenide (Cu-doped Sb_2Se_3) thin-films were deposited as absorber layers in photovoltaic solar cells using Low-Temperature Pulsed Electron Deposition (LT-PED) technique.
In order to compare the results with those reported for undoped thin-films, ASe was deposited on different substrates and different deposition parameters were explored.
Despite the possible presence of barriers and/or traps due to a not yet optimized cell structure, the introduction of Cu in the Sb_2Se_3 absorber demonstrated to increase V_{OC} up to remarkable values higher than 510 mV, while charge carrier density raised up to 3.8×10^{16} cm^{-3}.

References

[1] Mavlonov, A.; Razykov, T.; Raziq, F.; Gan, J.T.; Chantana, J.; Nishimura, T.; Wei, H.M.; Zakutayev, A.; Minemoto, T.; Zu, X.T.; Li, S.A.; Qiao, L. A review of Sb2Se3 photovoltaic absorber materials and thin-film solar cells. Sol. Energy 2020, 201, 227-246.
[2] Pattini, F.; Rampino, S.; Mezzadri, F.; Calestani, D.; Spaggiari, G.; Sidoli, M.; Delmonte, D.; Sala, A.; Gilioli, E.; Mazzer, M. Role of the substrates in the ribbon orientation of Sb2Se3 films grown by Low-Temperature Pulsed Electron Deposition. Sol. Energ. Mat Sol. C. 2020, 218, 110724.
[3] Spaggiari, G.; Pattini, F.; Bersani, D.; Calestani, D.; De Iacovo, A.; Gilioli, E.; Mezzadri, F.; Sala, A.; Trevisi, G.; Rampino, S. Growth and structural characterization of Sb2Se3 solar cells with vertical Sb4Se6 ribbon alignment by RF magnetron sputtering. J. Phys. D Appl. Phys. 2021, 54, 385502.