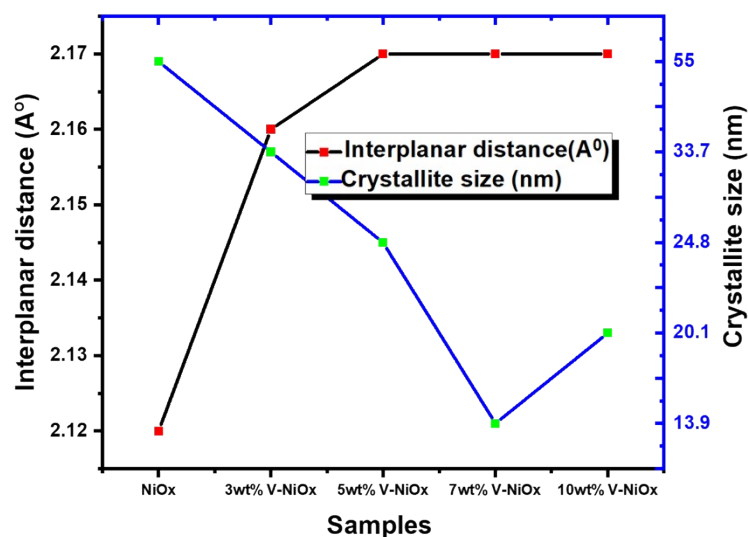
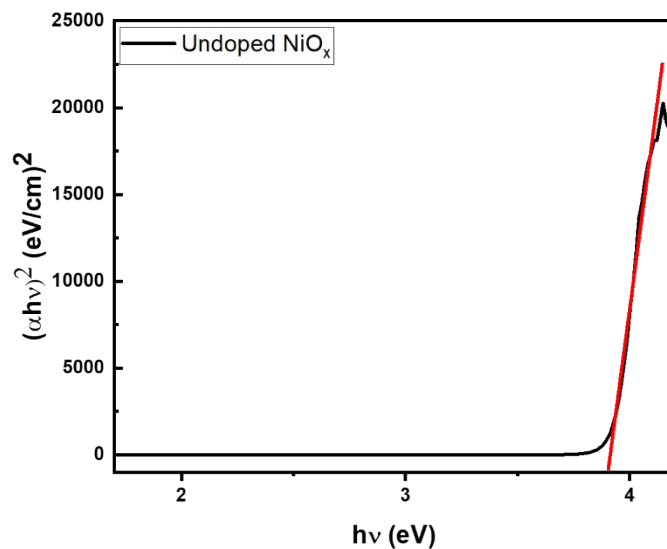


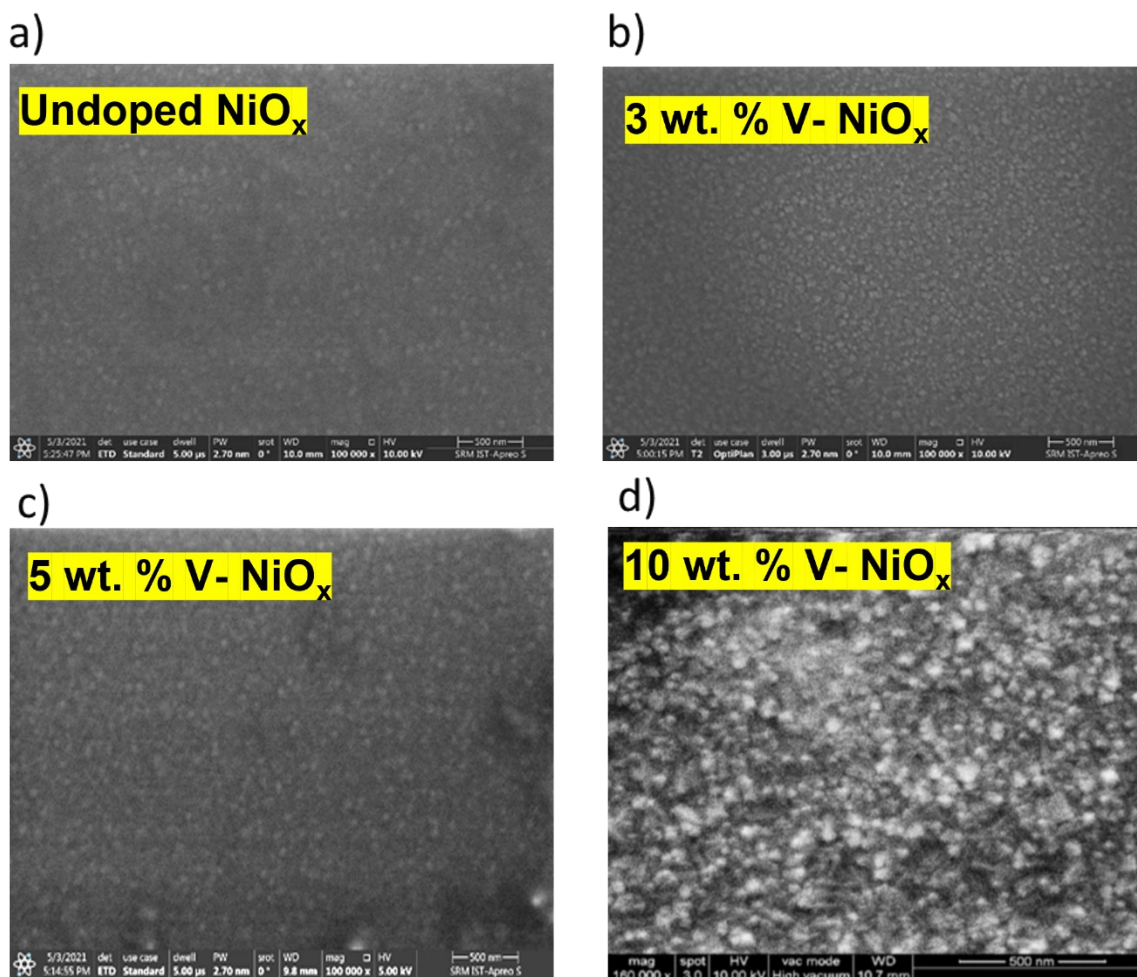
**Fig. S1.** Enlarged XRD plot of undoped and doped NiO<sub>x</sub> thin films showing shift to lower 2θ value with increased dopant concentration



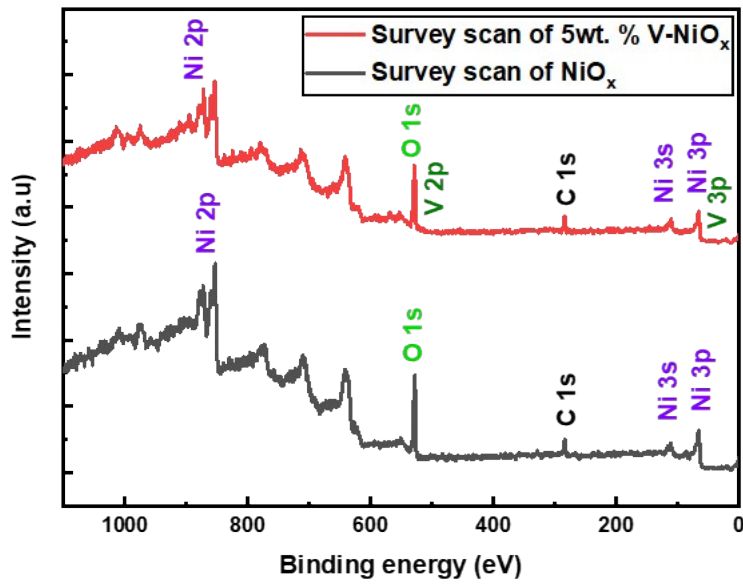
**Fig. S2.** Comparison plot of interplanar spacing and crystallite size in undoped and different wt. % V doped NiO<sub>x</sub>



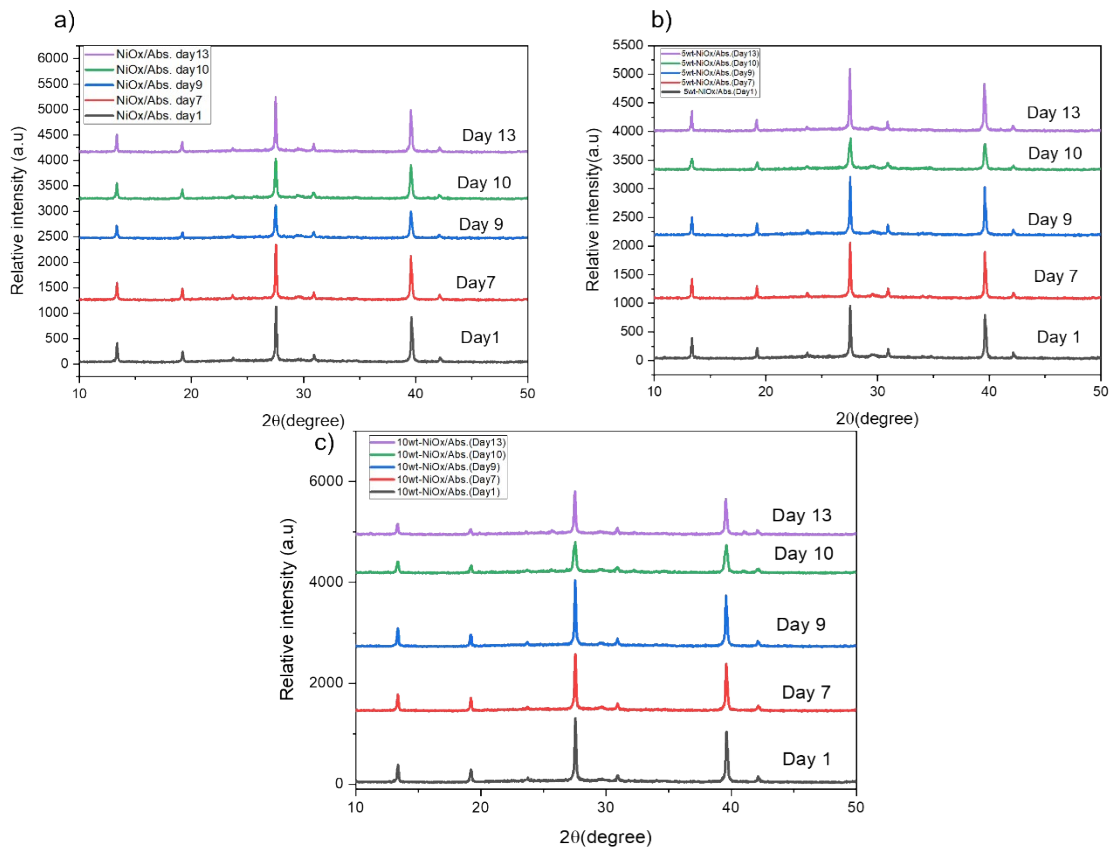
**Fig. S3.** Tauc plot of undoped NiO<sub>x</sub> thin film.



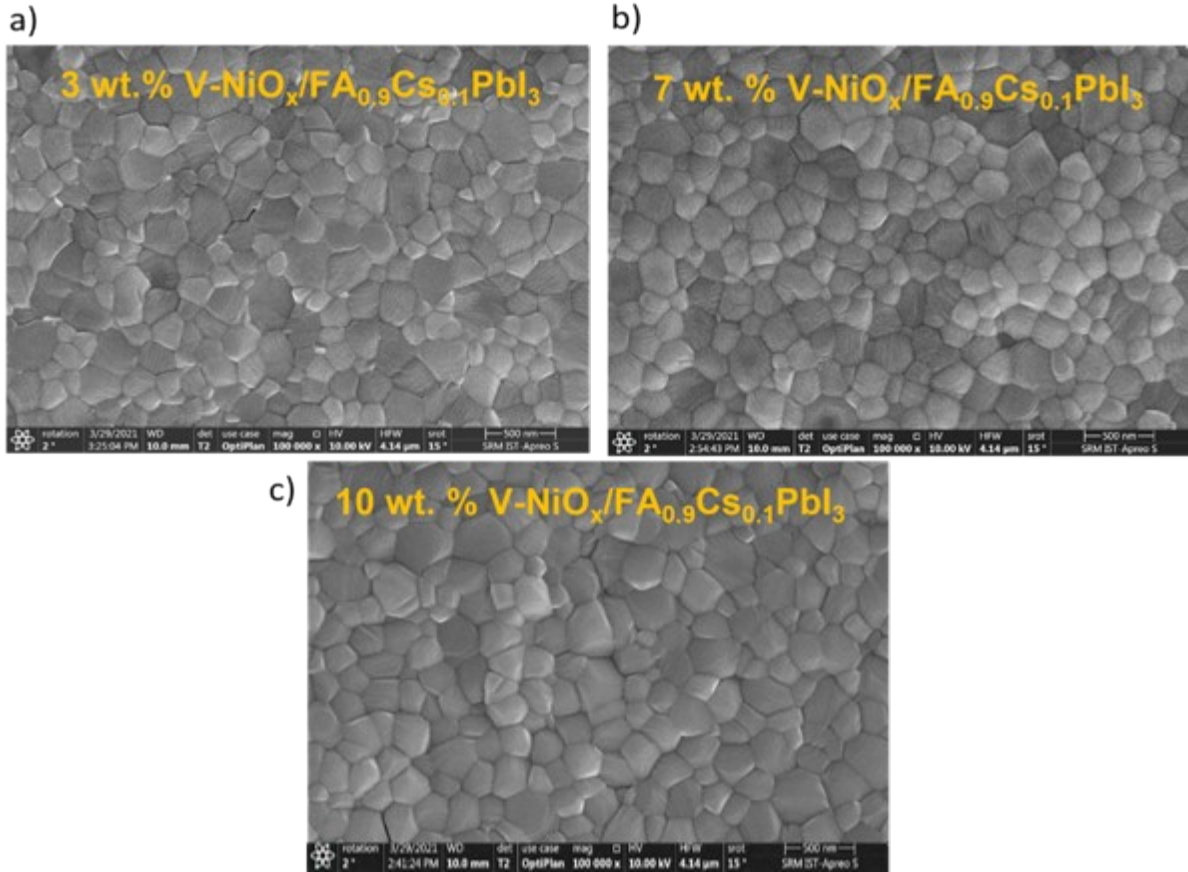
**Fig. S4.** SEM images of a) undoped NiO<sub>x</sub> b) 3wt.% V-NiO<sub>x</sub> c) 5wt.% V-NiO<sub>x</sub> d) 10wt.% V-NiO<sub>x</sub> thin film.



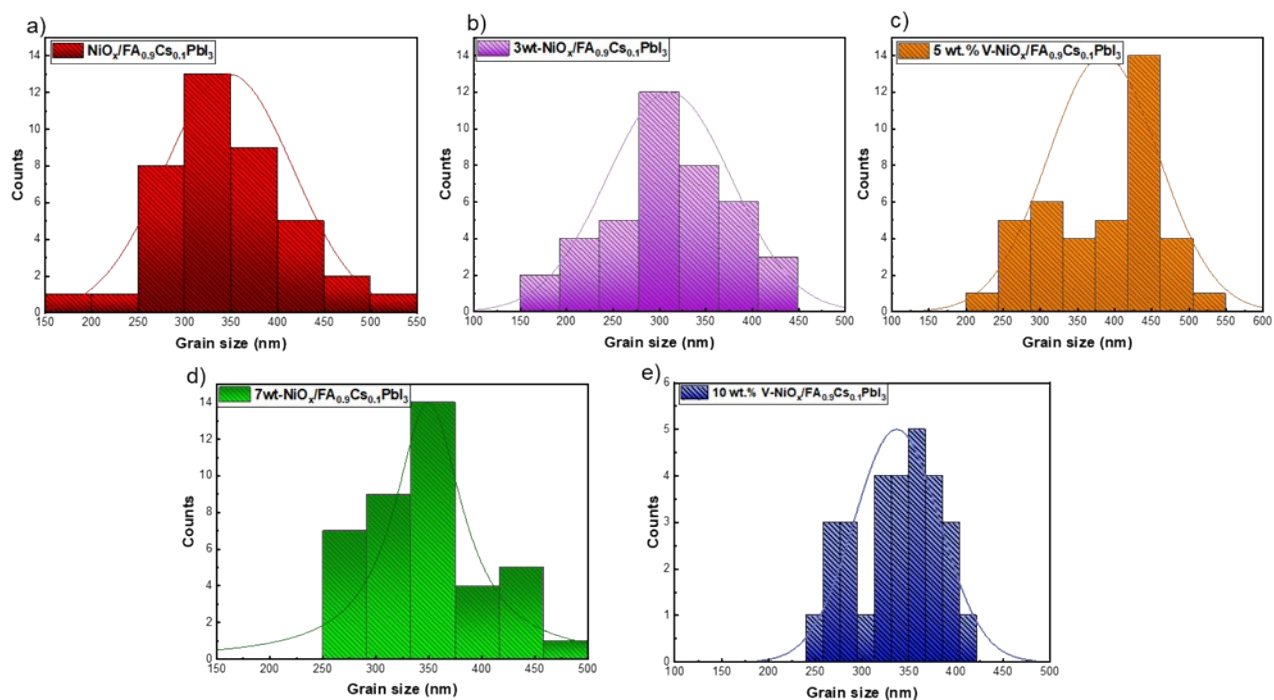
**Fig. S5.** XPS survey scan for undoped NiO<sub>x</sub> and 5 wt. % V doped NiO<sub>x</sub>



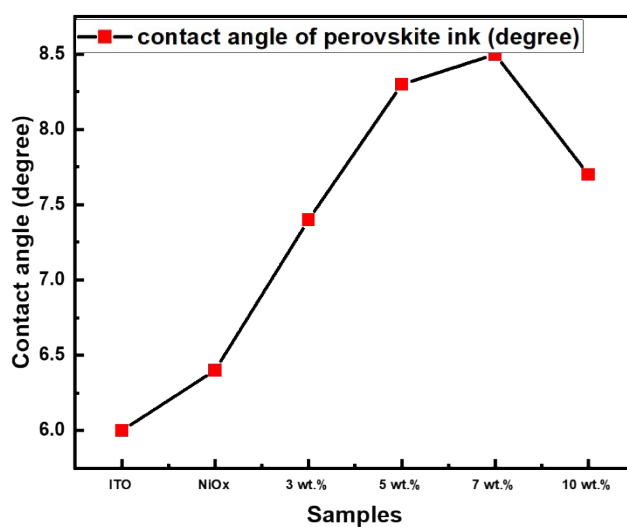
**Fig. S6.** Degradation analysis of CsFAPbI<sub>3</sub> thin films samples stored in dark, N<sub>2</sub> atmosphere for 13 days. a) CsFAPbI<sub>3</sub> absorber on undoped NiO<sub>x</sub> b) CsFAPbI<sub>3</sub> absorber on 5 wt. % V-NiO<sub>x</sub> c) CsFAPbI<sub>3</sub> on 10 wt. % V-NiO<sub>x</sub>



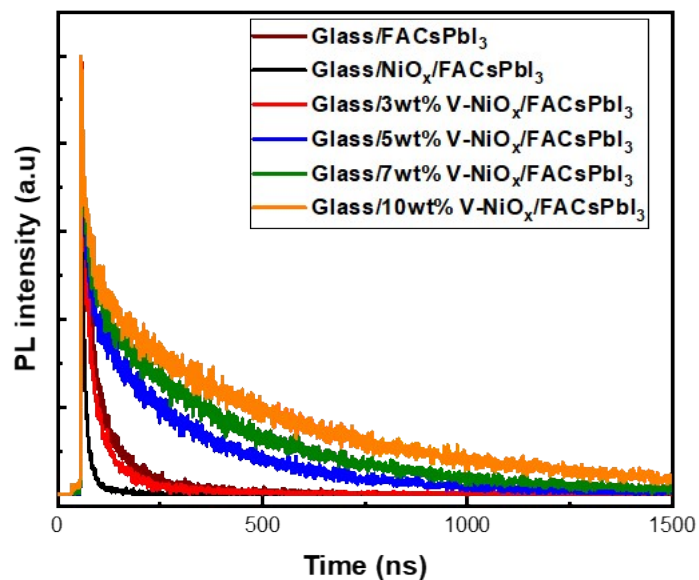
**Fig. S7.** SEM image of absorber coated on a) 3 wt. % V-NiO<sub>x</sub> b) 7 wt. % V-NiO<sub>x</sub> and c) 10 wt. % V-NiO<sub>x</sub> with inset showing corresponding grain size distribution.



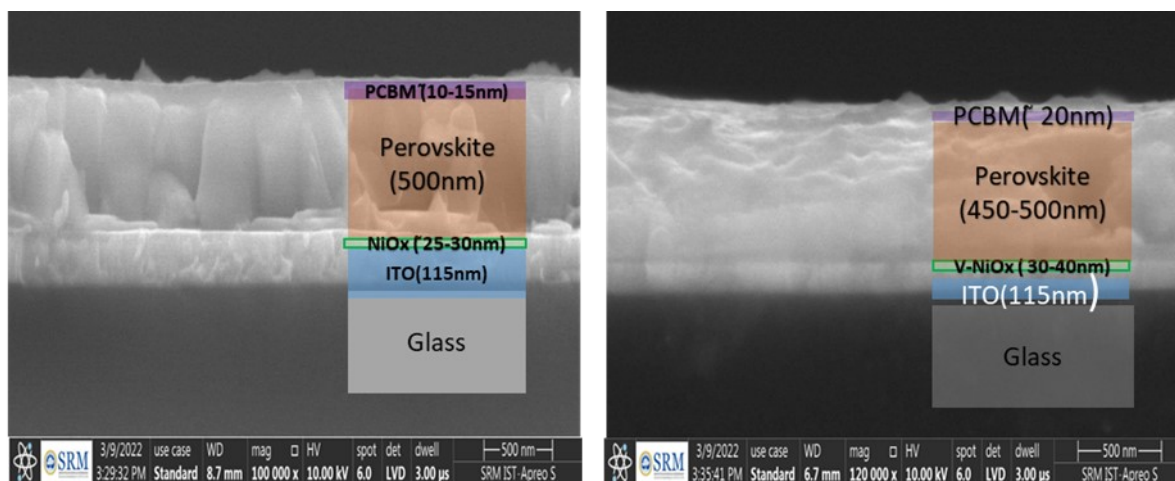
**Fig. S8.** Grain size histograms of absorber coated on top of a) undoped  $\text{NiO}_x$  b) 3 wt.% V- $\text{NiO}_x$  c) 5 wt.% V- $\text{NiO}_x$  d) 7 wt.% V- $\text{NiO}_x$  and e) 10 wt.% V- $\text{NiO}_x$ .



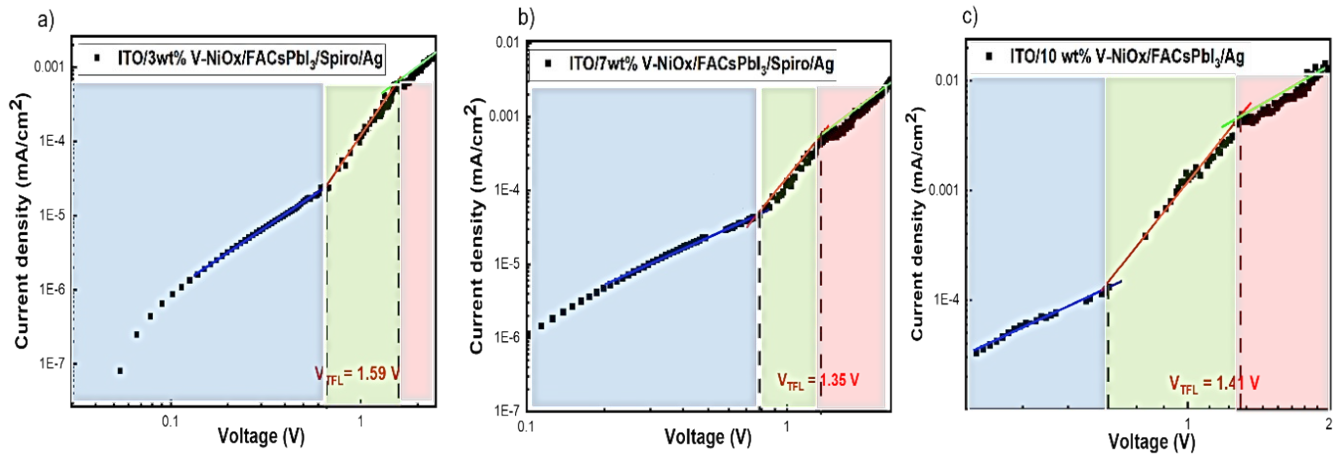
**Fig. S9.** Contact angle measurement on undoped and different wt. % V doped  $\text{NiO}_x$  thin films with DMF:DMSO solvent.



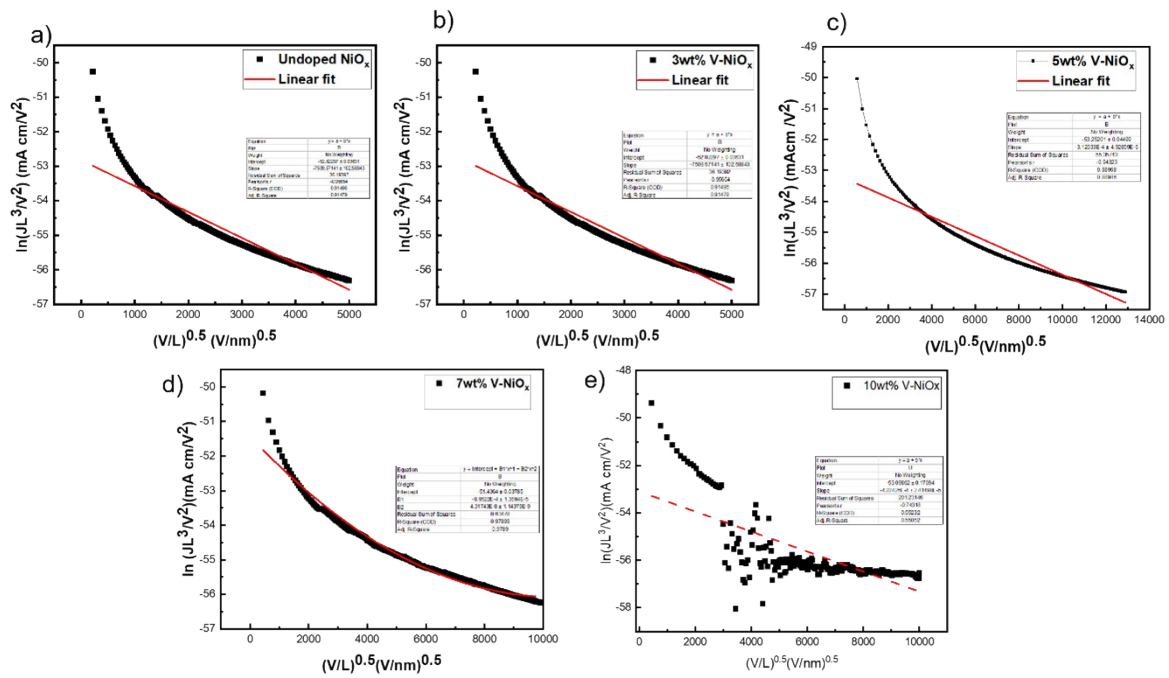
**Fig. S10.** Time resolved PL spectra of absorber on top of undoped and different wt. % V-doped  $\text{NiO}_x$  HTL.



**Fig. S11.** a) Cross-section SEM images of  $\text{FA}_{0.9}\text{Cs}_{0.1}\text{PbI}_3$  absorber on undoped  $\text{NiO}_x$  HTL b) 5 wt. % V- $\text{NiO}_x$  HTL.



**Fig. S12.** SCLC plots of a) 3wt. % V-NiO<sub>x</sub> b) 7wt. % V-NiO<sub>x</sub> and c) 10wt. % V-NiO<sub>x</sub> hole only devices.



**Fig. S13.** Mobility plots of a) undoped NiO<sub>x</sub> b) 3 wt.% V-NiO<sub>x</sub> c) 5 wt.% V-NiO<sub>x</sub> d) 7 wt.% V-NiO<sub>x</sub> and e) 10 wt.% V-NiO<sub>x</sub>.