

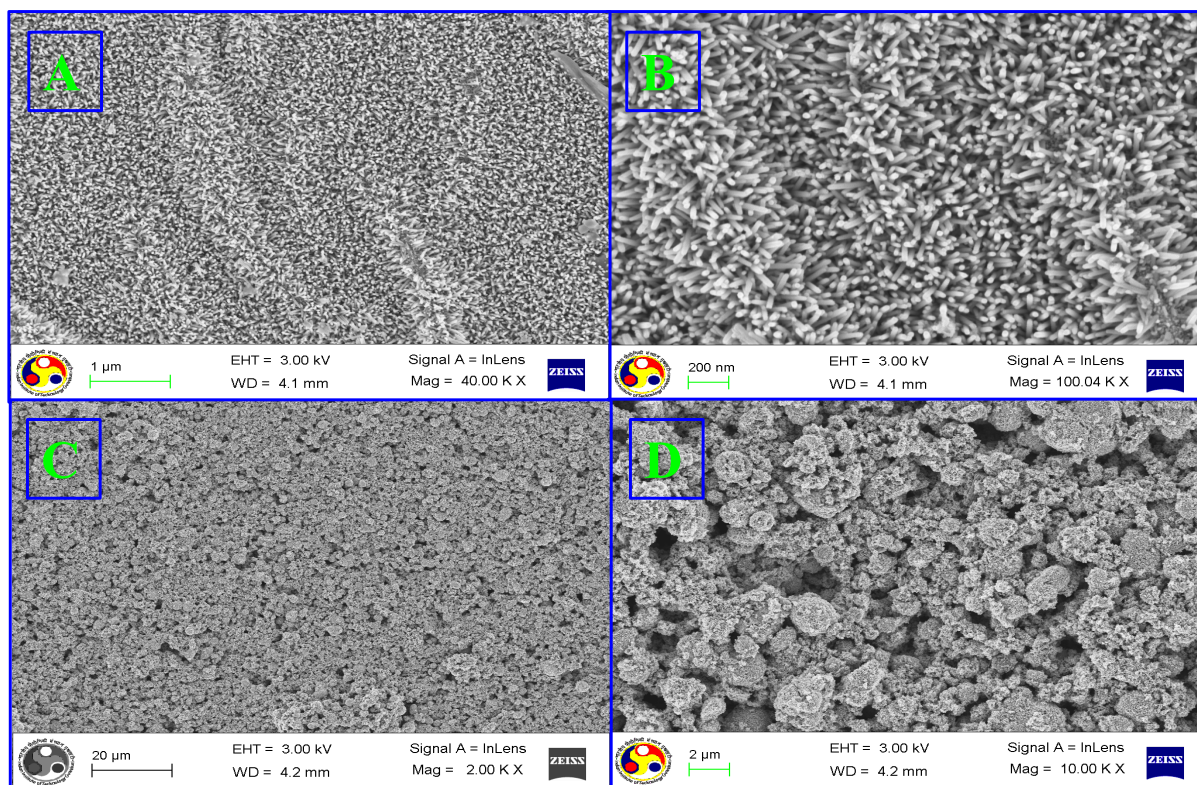
## Electronic Supporting Information

### **Enhanced photovoltaic performance utilizing effective charge transfers and light scattering effects by the combination of mesoporous, hollow 3D-ZnO along with 1D-ZnO in CdS quantum dot sensitized solar cells**

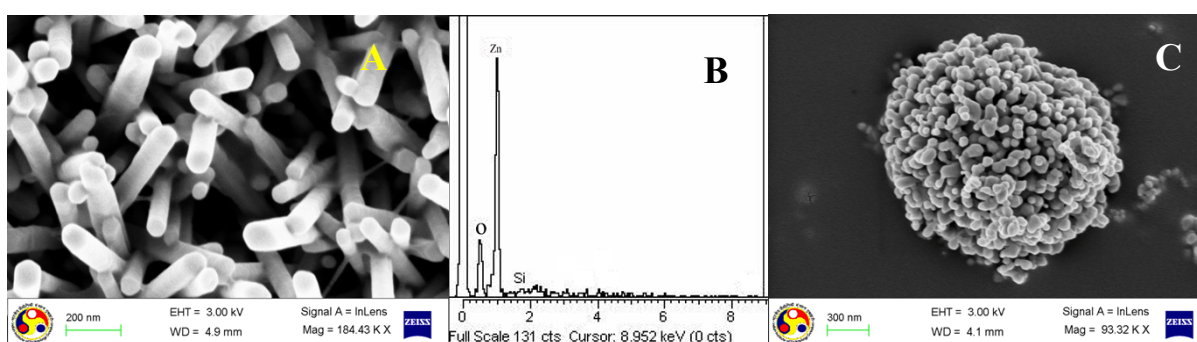
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## 1. Morphology study of the photoanode films:

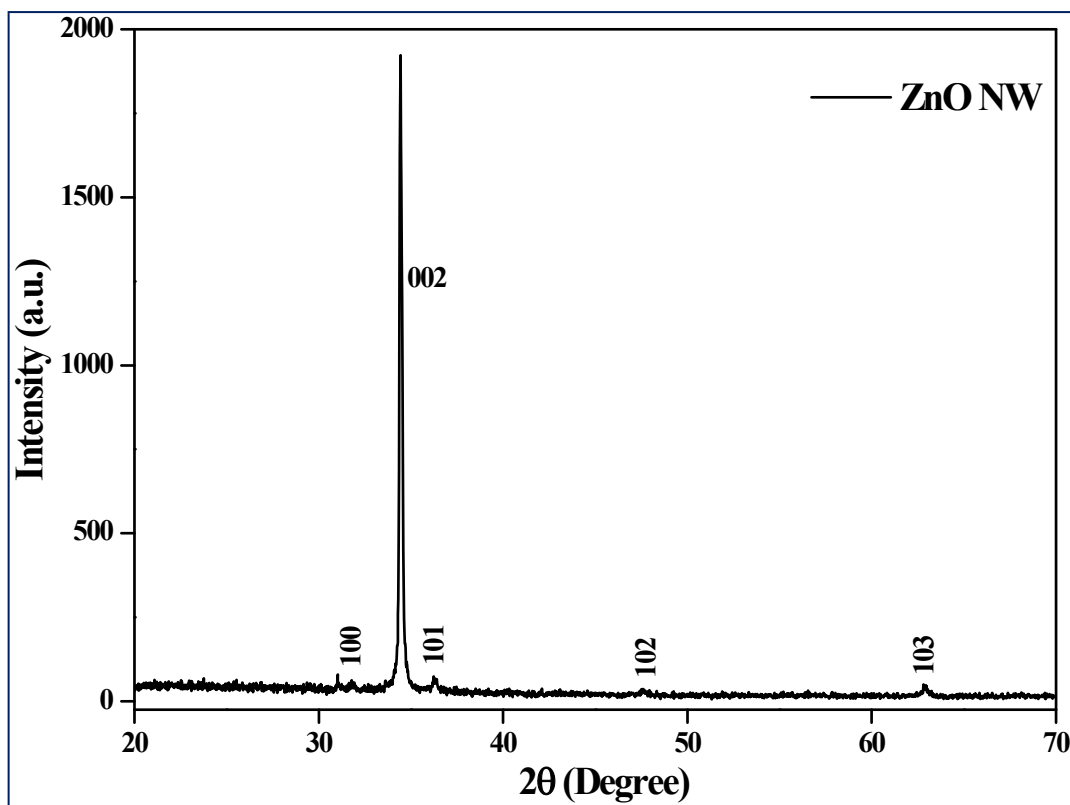


**Figure S1.** Field emission scanning electron microscopy (FESEM) images of **A. & B.** One dimensionally ZnO NWs grown on FTO substrates hydrothermally **C. & D.** Top view of ZnO HMSP layer deposited over it by doctor blade technique.



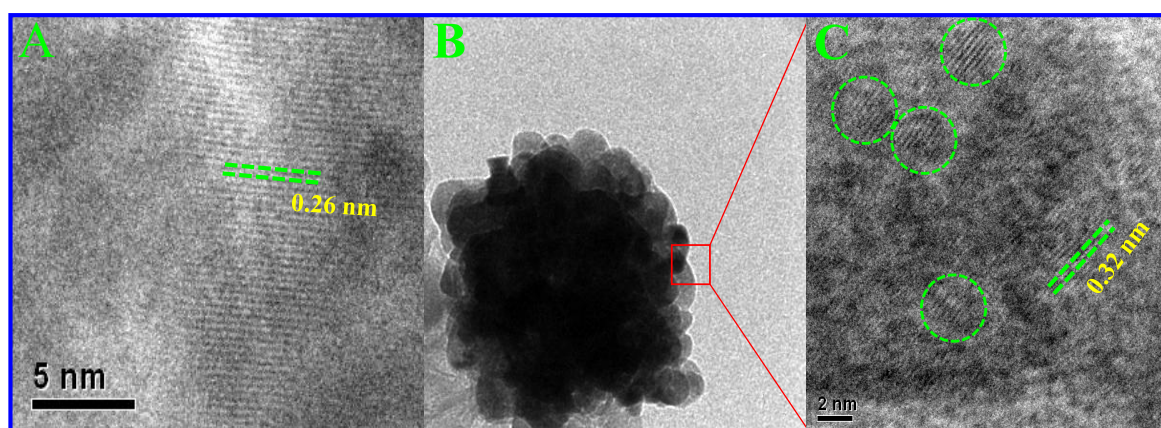
**Figure S2.** High magnification FESEM image and energy dispersive X-ray (EDX) analysis (**A & B**) of one dimensional ZnO NWs grown on FTO substrates hydrothermally. (**C**) High magnification FESEM image of a single ZnO HMSP.

## 2. XRD analysis of ZnO nanowires grown on glass substrates:



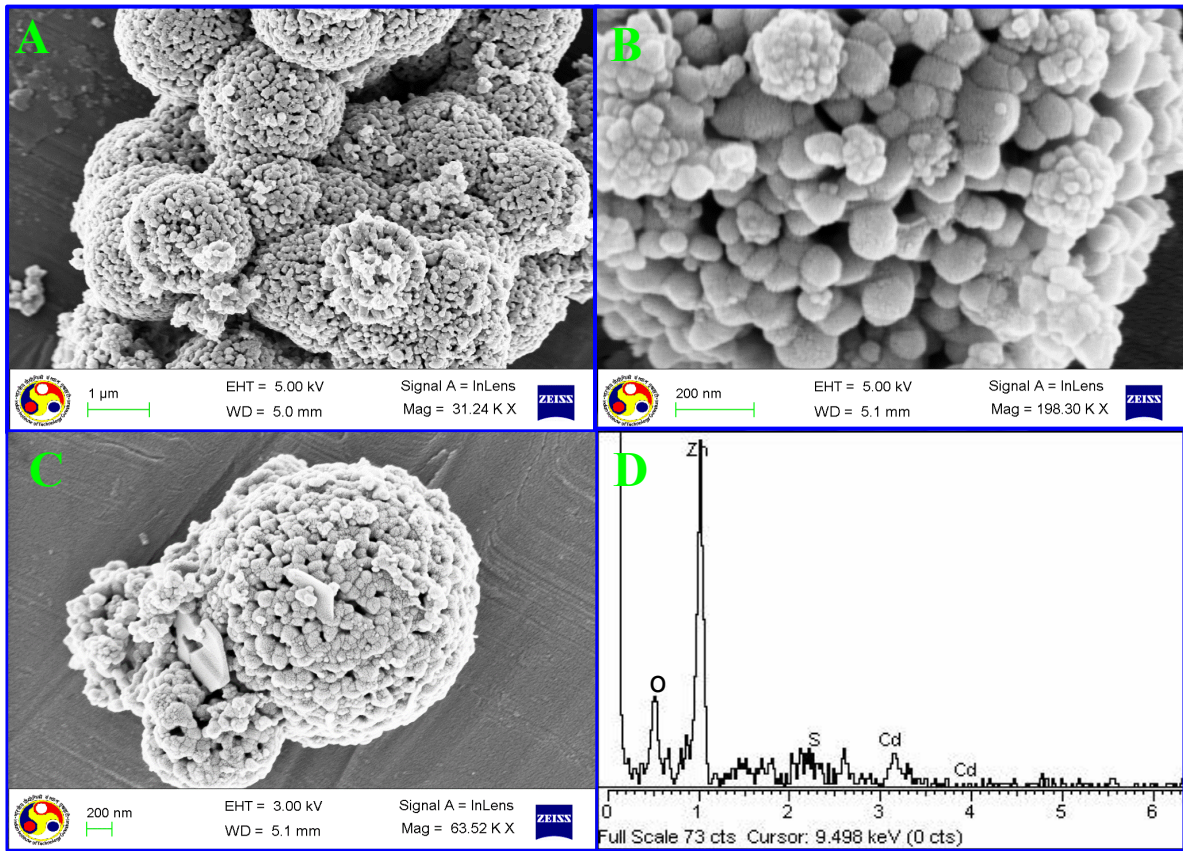
**Figure S3.** The XRD displays diffraction peaks of (100), (002), (101), (102), and (103) planes that correspond to the ZnO hexagonal wurtzite structure according to JCPDS Card No. 036-1451 and proving 1D growth of ZnO NW along the c-axis normal to the substrate.

### 3. TEM analysis of ZnO HMSP and CdS-sensitised ZnO HMSP:



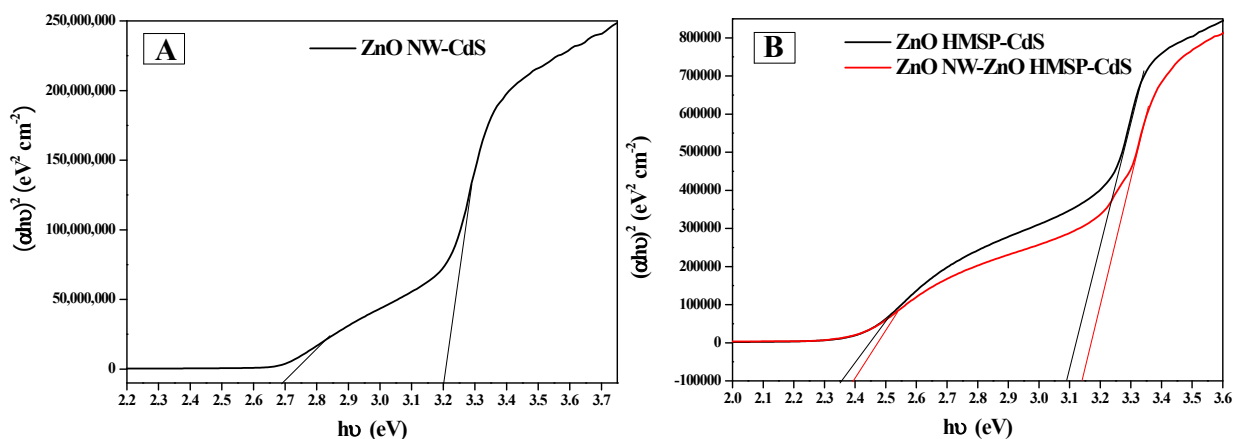
**Figure S4.** **A.** High resolution transmission electron microscopy (HRTEM) image of ZnO HMSP showing lattice pattern of single crystalline ZnO nanoparticles. **B.** TEM image of a CdS deposited ZnO HMSP. **C.** HRTEM image of the indicated portion of the microsphere showing lattice pattern of CdS QDs deposited over it.

#### 4. FESEM images of CdS sensitised ZnO HMSP:



**Figure S5.** High- and low-magnification FESEM images of CdS sensitised ZnO microspheres scratched from the photoanodes. **A, B, C.** Magnified images of ZnO microspheres showing the available pores even after CdS sensitisation. **D.** Energy dispersive X-ray (EDX) analysis of CdS sensitised ZnO hollow microspheres.

#### 5. Tauc plots for ZnO NW–CdS, ZnO HMSP- CdS, ZnO NW-ZnO HMSP- CdS:

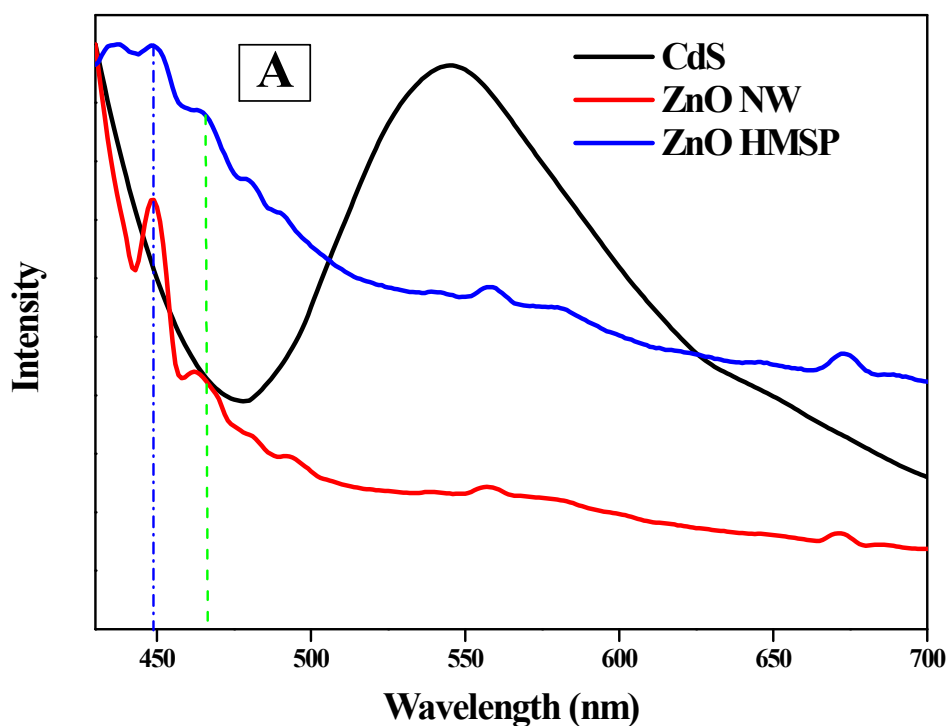


**Figure S6.** (A) Tauc plot for ZnO NW-CdS and (B) Tauc plots for ZnO HMSP-CdS and ZnO NW-ZnO HMSP-CdS.

Photoanode	Thickness ( $\mu\text{m}$ )	Band Gap ZnO (eV)	Band Gap CdS (eV)
ZnO NW-CdS	$\sim 1$	3.2	2.69
ZnO HMSP-CdS	$\sim 14$	3.09	2.35
ZnO NW-ZnO HMSP-CdS	$\sim 1+14$	3.14	2.39

**Table S1.** Optical band gap energy of ZnO and CdS estimated from the tauc plots of all the photoanodes.

## 6. Steady-state fluorescence spectra of pure CdS, ZnO NW and ZnO HMSP



**Figure S7.** Steady-state fluorescence spectra of pure CdS, ZnO NW and ZnO HMSP excited at an wavelength of 410 nm.

**Table S2. Present scenario of ZnO based solar cells and their relevant performance parameters along with our result**

Ref No.	ZnO Nanostructure	Sensitizer QDs	Counter electrode	Cell Area (cm <sup>2</sup> )	$J_{sc}$ (mA/cm <sup>2</sup> )	$V_{oc}$ (mV)	$FF$ (%)	$\eta$ (%)
9	ZnO NW	CdSe	Pt/FTO	No data	2.1	600	30	0.4
37	Hierarchical tetrapod-like ZnO nanoparticles	CdS, CdSe	Pt/FTO	0.25	13.85	722	42.4	4.24
38	ZnO NP	CdS, CdSe	Cu <sub>2</sub> S/Brass	0.15	10.48	683	62.3	4.5
40	ZnO NP-CdS-GO Composite	CdS	Pt/FTO	1.2	7.3	703	54.6	2.8
SI 1.	ZnO NWs	CdS, CdSe	Au/FTO	0.25	17.3	627	38.3	4.2
SI 2.	ZnO NWs	CdS,	(MSU-F-	0.25	12.6	690	42	3.6

		CdSe	C)/FTO					
SI 3.	ZnO NWs	CdS	Pt/FTO	No data	5.42	580	34	1.1
SI 4.	ZnO NW(Core)/ Zn <sub>2</sub> SnO <sub>4</sub> (Shell)	CdS	Pt/FTO	0.25	3.68	760	44	1.3
SI 5.	ZnO NP (Surface passivated with TiO <sub>2</sub> shell)	CdS, CdSe	Cu <sub>2</sub> S/Brass	0.25	15.4	620	49	4.7
SI 6	ZnO NW	CdS, CdSe	Pt/ITO	No data	5.19	661	41.5	1.4
SI 7	ZnO NT	CdSe	Pt/FTO	0.2	2.09	440	41	0.4
<b>Present work</b>	<b>ZnO NW/ZnO HMSP</b>	<b>CdS</b>	<b>Pt/FTO</b>	<b>1</b>	<b>9.01</b>	<b>511</b>	<b>51</b>	<b>2.4</b>

\*Mesocellular carbon foam

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