ZnO nanowire-based radial structures for photovoltaic applications

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ZnO NANOWIRE-BASED RADIAL STRUCTURES FOR PHOTOVOLTAIC APPLICATIONS

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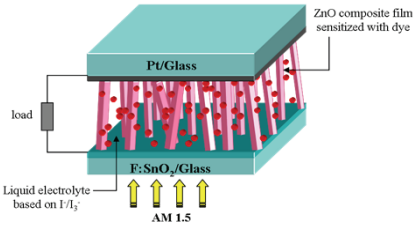
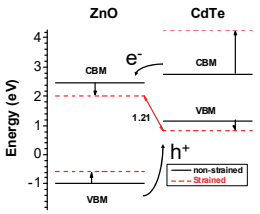


principles of dye-sensitized solar cells (DSSC)

ZnO nanowire-based radial structures have been grown in order to combine a large specific surface area with efficient electron transport properties as well as with type II heterostructures.

Nanowires (NW) were grown by chemical bath deposition (CBD) on fluorine-doped tin oxide (FTO). NWs were then covered with ZnO nanoparticles (NPs) by CBD or CdTe nanograins (NGs) by close space sublimation (CSS).



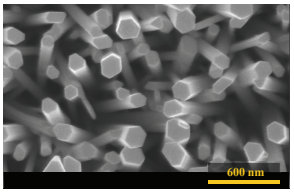
principles of type II heterostructures

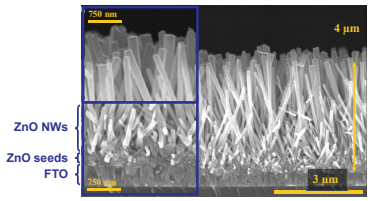
CBD grown ZnO nanowires as core

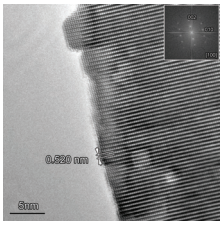
Growth procedure:

- Fluorine-doped tin oxide grown by spray pyrolysis and seeded by dip coating → *zinc acetate 0.375 M and monoethanolamine 0.375 M in ethanol + annealing for 20 min at 400°C*
- ZnO NW growth in aqueous solution → *zinc nitrate 0.025 M and hexamethylenetetramine 0.025 M at 90°C refreshed all 2.5 hours.*

SEM







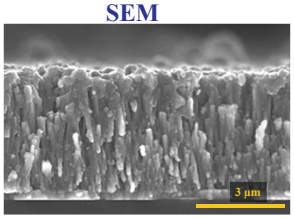
- würtzite
- c-axis oriented growth – vertically aligned
- hexagonal base
- very low extended defect density
- diameter = 70-300 nm
- length = 500 nm to several µm

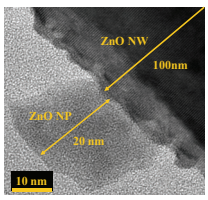
CBD grown ZnO nanoparticles as shell

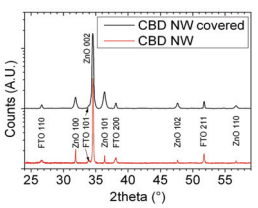
Growth procedure:

- Deposition of layered hydroxide zinc acetate (LHZA) → *zinc acetate dihydrate 0.15 M in methanol at 60°C for 20 h.*
- Decomposition of LHZA into ZnO NPs → *5 min at 200°C followed by 10 min at 450°C.*

SEM **TEM** **XRD**





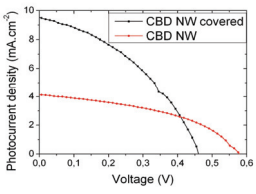


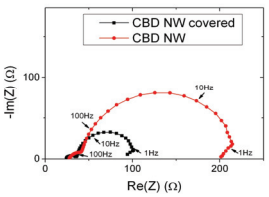
- Conformal deposit of ZnO NPs
- Randomly oriented ZnO NPs with an average size of 20 nm
- No epitaxial relationship between ZnO NPs and NWs
- Very high surface area → high dye loading 3.10^{-8} Dye Mol.cm^{-2}

I(V) + electrochemical impedance spectroscopy

Performing DSSCs:

- Dye: N719 + Electrolyte: Dyesol HSE + Cathode: 100 nm thick platinum on glass





R_{ct} = charge transfer resistance at the ZnO/dye/electrolyte interface

		J_{sc} (mA/cm²)	V_{oc} (V)	FF	Efficiency (%)	$R_{//}$ (Ω.cm²)	R_{serie} (Ω.cm²)	R_{ct} (Ω)
CBD	NWs	4.1	0.58	0.44	1.1	730	17	175
	NWs + NPs	9.5	0.47	0.40	1.8	270	7	68

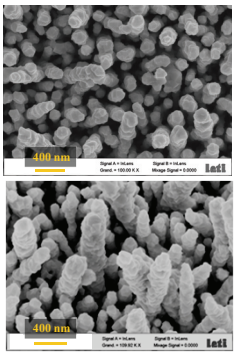
- ↑ J_{sc} and ↓ R_{ct} due to ↑ specific surface area and dye loading
- ↓ V_{oc} owing to ↑ defect density at the ZnO/dye/electrolyte interface

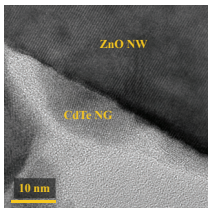
CSS grown CdTe nanograins as shell

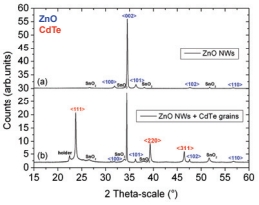
Growth procedure:

- CdTe powder source at a distance of a few mm from the substrate composed of ZnO NWs on FTO thin films
- Source temperature = 480°C and Substrate temperature = room

SEM **TEM** **XRD**



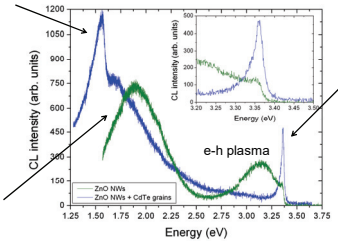




- Conformal deposit of CdTe NGs
- Slightly <111> oriented CdTe NGs with an average size of 45 nm
- No epitaxial relationship between CdTe NGs and ZnO NWs

Cathodoluminescence

Excitonic emission band from CdTe NGs = 1.58 eV



Excitonic emission band from ZnO NWs = 3.36 eV

Red-orange emission band from ZnO NWs around 1.7-1.9 eV

Intense emissions from ZnO NWs and CdTe NGs

Conclusion

ZnO nanowire-based radial structures have successfully been grown by low cost deposition techniques. The prospects regard the investigation into the interfaces of the radial structures.