European Materials Research Society (E-MRS), University of Technology, Warsaw, Poland

Optical and photoresponse study of ZnO nanorods for optoelectronic applications

Keshav Nagpal [1], Erwan Rauwel [1], Frédérique Ducroquet [2], Isabelle Gélard [3], and Protima Rauwel*[1]

[1]Chair of Energy Applications, Estonia University of Life Sciences, Tartu, Estonia

[2] IMEP-LaHC, Micro and Nanotechnology innovation center, Grenoble, France

[3] LMGP, Micro and Nanotechnology innovation center, Grenoble, France

Introduction

- Four different ZnO nanorods samples were grown on indium tin oxide (ITO) coated glass substrate by using low cost hydrothermal method.
- The novelty of this work lies in varying the seeding solvent (Table 1) and studying the relevance of different solvents on the physical and electrical properties of ZnO nanorods.
- Photoresponse measurements of ZnO nanorods were carried out with a 125 Watt Hg lamp with an output wavelength of 365 nm and irradiance of ~ 15 mW/cm^2.
- A diode device structure ITO/ZnO NR-B/F8BT/PEDOT:PSS/Ag was prepared and the thickness of F8BT was optimized by spin coating.

Sample	Seeding solvent	Nanorod diameter (nm)
ZnO NR-A	Methanol	85
ZnO NR-B	Ethanol	90
ZnO NR-C	70% ethanol	110
ZnO NR-D	Isopropanol	80

Table.1: List of ZnO nanorod samples prepared by varying the seeding solvent. The diameters of ZnO nanorods were estimated form size distribution histograms of SEM images.

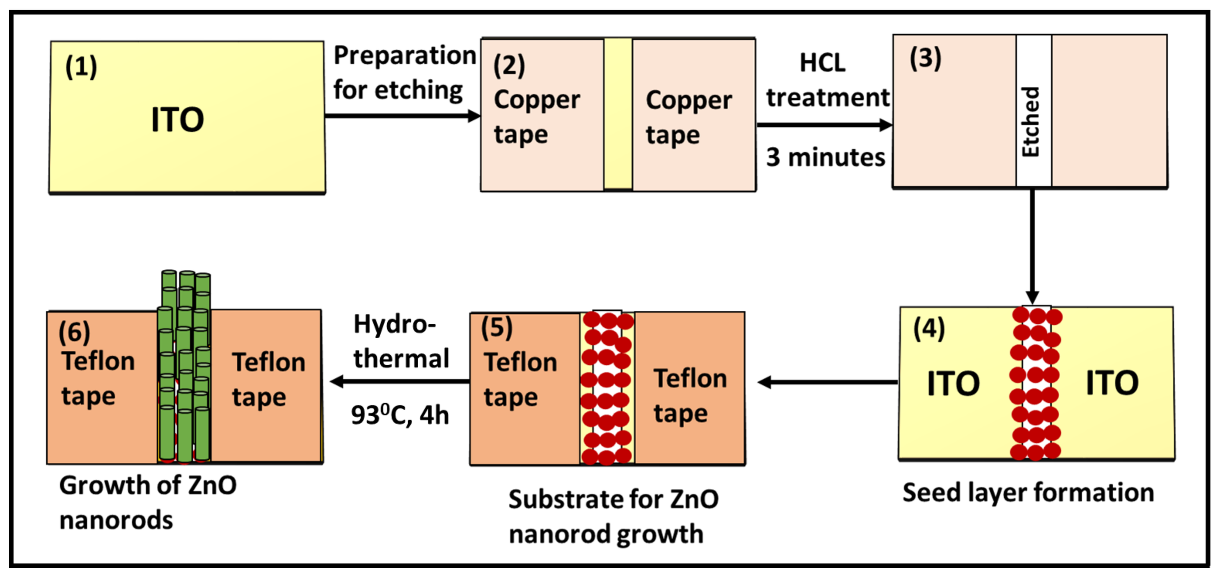

Figure.1: Schematic of the procedure for ZnO nanorod growth through the hydrothermal method.

Structural, optical and morphological characterization

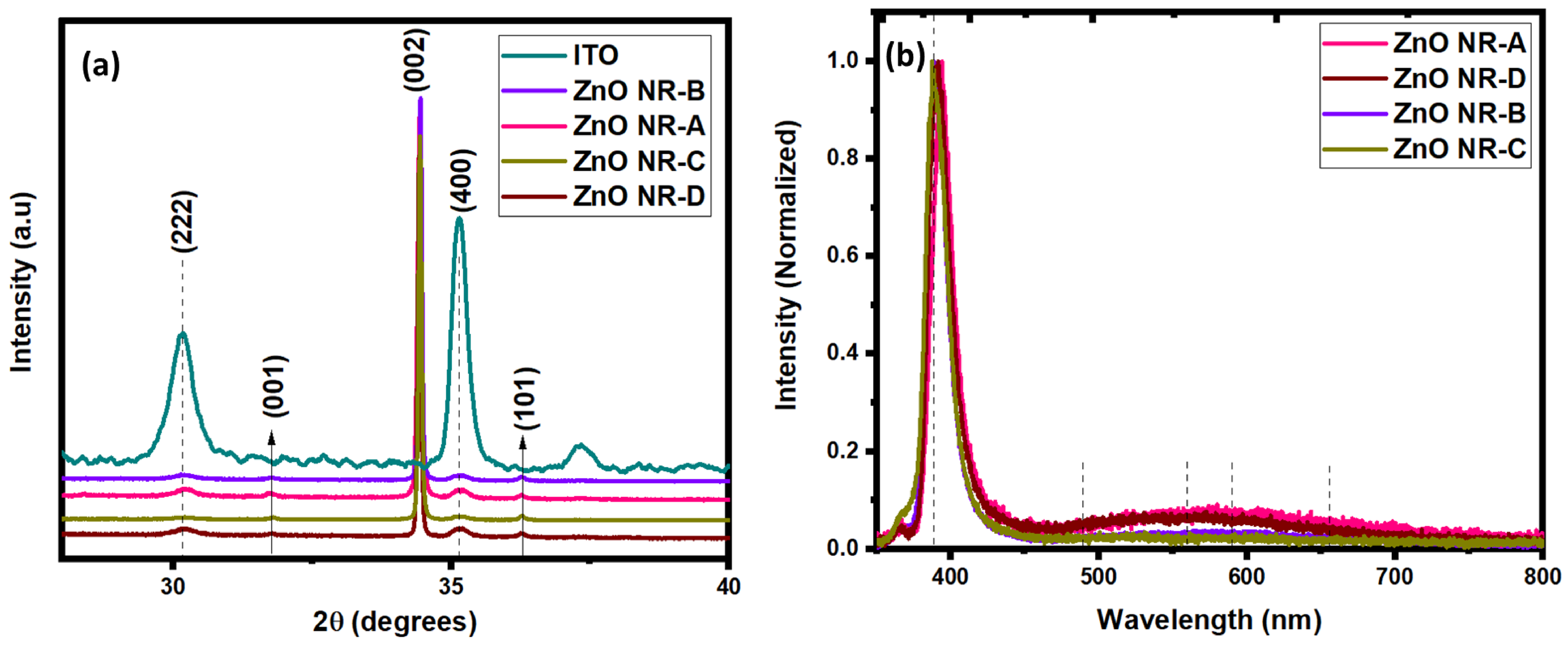

Figure.2: (a) XRD and (b) PL of ZnO nanorods samples, showing growth along c-axis (002) reflection and higher UV emission compared to defect level emission, respectively.

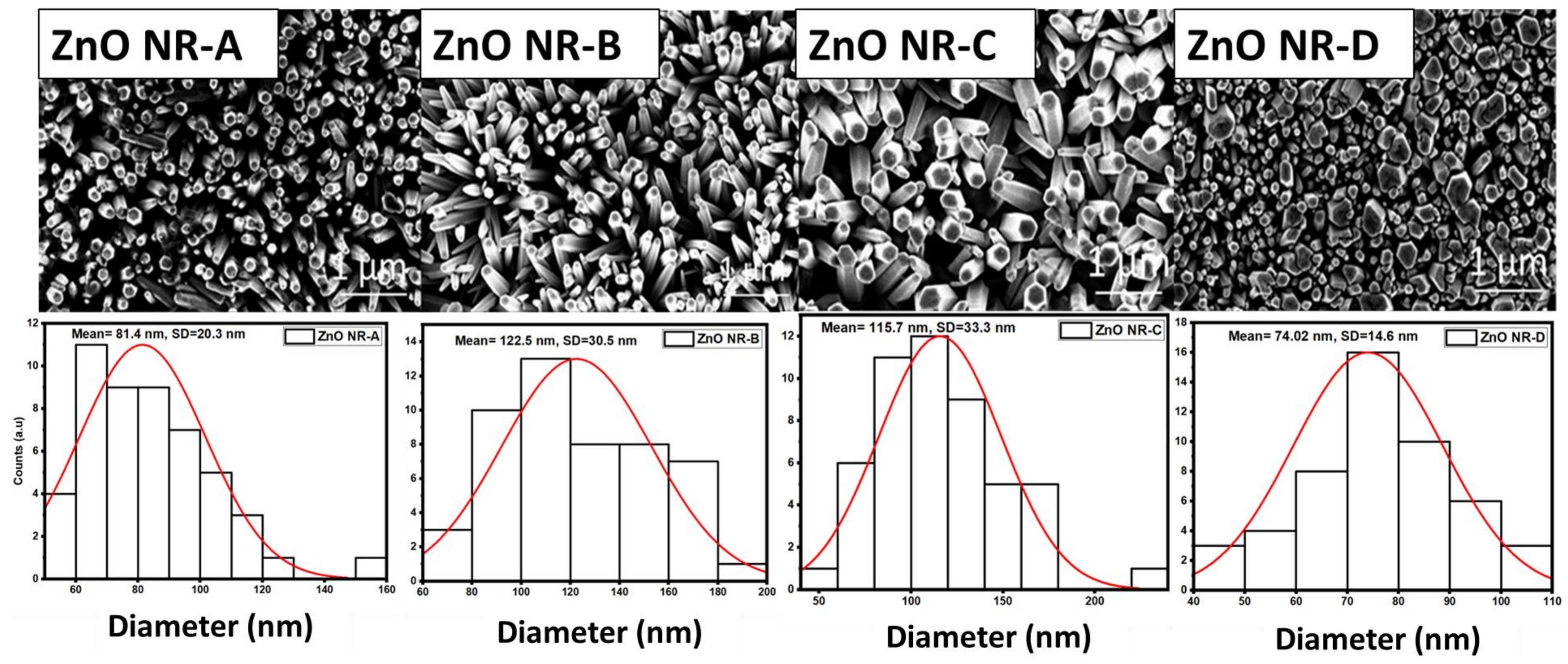

Figure.3: SEM images and size distribution histogram of ZnO nanorod samples. The average diameter size between 80-110 nm was estimated for ZnO nanorods samples from size distribution histograms.

Electrical measurements and photoresponse

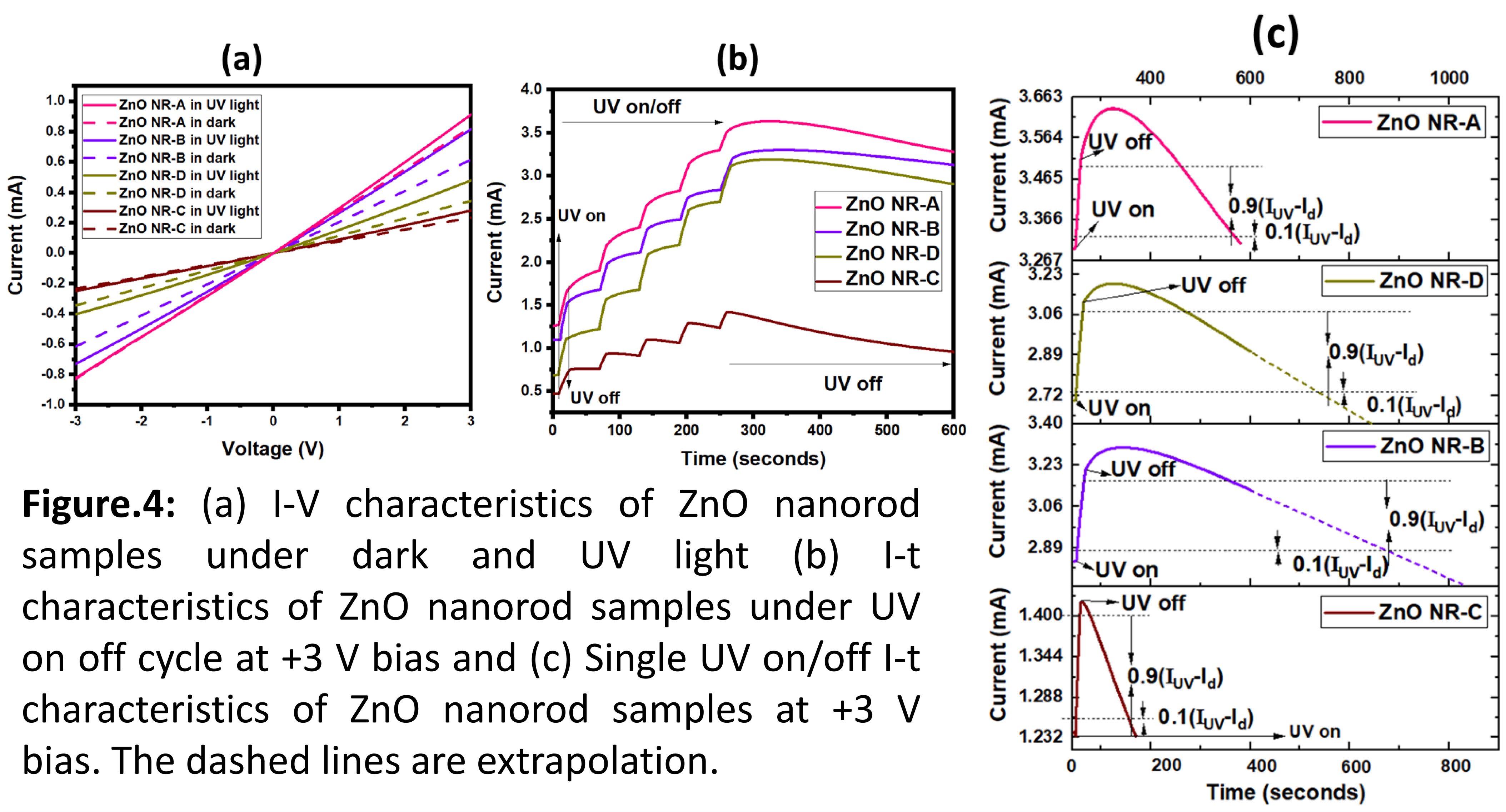

Figure.4: (a) I-V characteristics of ZnO nanorod samples under dark and UV light (b) I-t characteristics of ZnO nanorod samples under UV on off cycle at +3 V bias and (c) Single UV on/off I-t characteristics of ZnO nanorod samples at +3 V bias. The dashed lines are extrapolation.

Sample	Sensitivity	Responsivity (mA/W)	τ_{rise} (s)	I_{rise} rate (μA/s)	τ_{decay} (s)	I_{decay} rate (μA/s)	$\tau_{uv\text{-}light}$ (s)
ZnO NR-A	1.067	116.8	8.4	20.5	107.5	1.6	10.9
ZnO NR-B	1.129	193.7	14.2	20.2	318.1	0.92	17.3
ZnO NR-C	1.145	95.5	7.9	18	77.8	1.84	11.6
ZnO NR-D	1.153	220.2	13.3	25.3	264.4	1.29	14.8

Table2: Photoresponse parameters of ZnO nanorod samples under UV light calculated from Figure.4c.

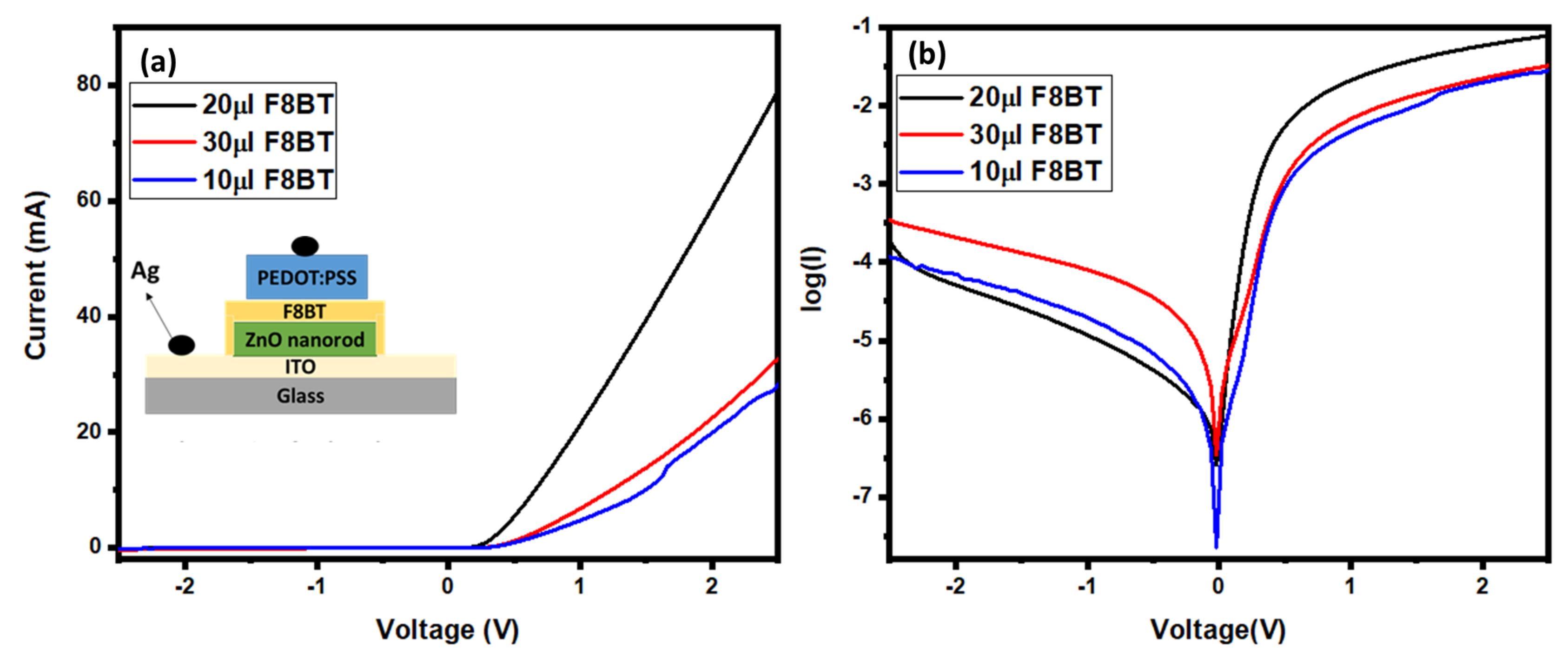

Figure.5: (a) I-V and (b) Semi-log (I)-V characteristics device ITO/ZnO NR-B/F8BT/PEDOT:PSS/Ag. Amount of 20 μl was fixed for PEDOT:PSS spin coating. A spin coating speed of 2000 rpm and 3000 rpm was used for F8BT and PEDOT:PSS for 30 s and 50 s, respectively.

Conclusion

- Differences in the physical, optical and electrical properties of ZnO nanorods were obtained by changing the seeding solvent.
- The sharp (002) reflection in the XRD pattern of all ZnO nanorod samples indicate c-axis growth direction.
- ZnO nanorod samples prepared using aqueous ethanol as seeding solvent show lower persistent photoconductivity and fast τ_{decay} response compared to other samples.
- The F8BT layer thickness was optimized and an ideality factor of ~3.8 was calculated for the diode device with 20μl F8BT spin coating.

Acknowledgement

This research has been supported by the European Regional Development Fund project grant number TK134 “EQUiTANT”, Bridge funding(EMÜ)(P200030VLVB) and international research booster (IRB), ‘NanoComp’ (UGA), with IMEP-LaHC(Minatec, Grenoble, France).

Publications

1. Nagpal et al. *Nanomaterials and Nanotechnology* **(2022)**, 12, 1-10
2. Nagpal et al. *Nanomaterials* **(2022)**, 12**(19)**, 3546
3. Nagpal et al. *Nanotechnology* **(2023)**, 34, 485602

Corresponding author: **Keshav Nagpal** Keshav.Nagpal@student.emu.ee