Performance Optimisation of ZnO Nanorods Based Energy Harvesters

Nimra Jalali[1], Joe Briscoe[1], Peter Woolliams[2], Mark Stewart[2], Paul M. Weaver[2], Markys Cain[2] and Steve Dunn[1]

[1]Queen Mary University of London, [2]National Physical Laboratory

Importance of P-N Junction

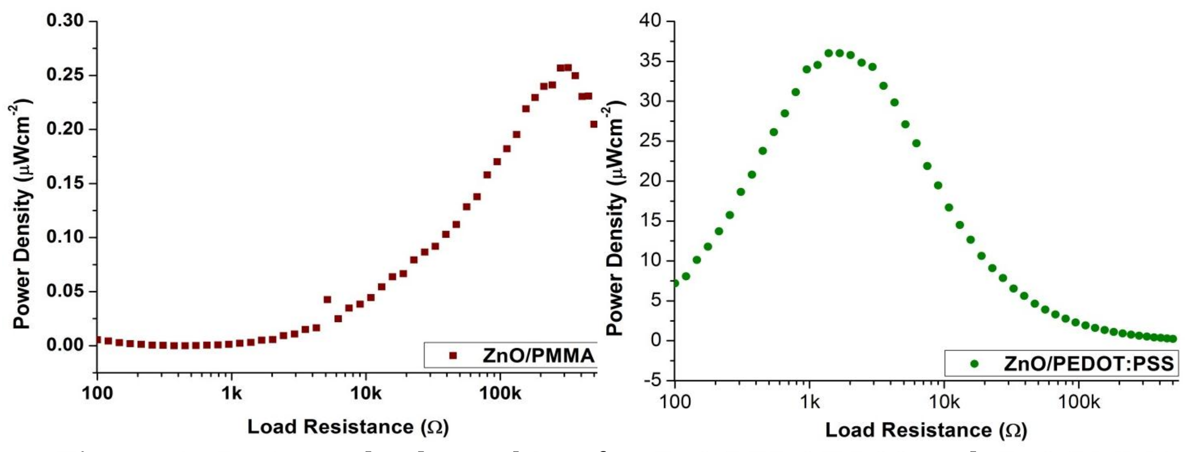


Figure 1. Resistive load matching for ZnO/PEDOT:PSS and ZnO/PMMA energy harvesters [1].

Table 1. Performance parameters of ZnO/PEDOT:PSS device in comparison with ZnO/PMMA device[1].

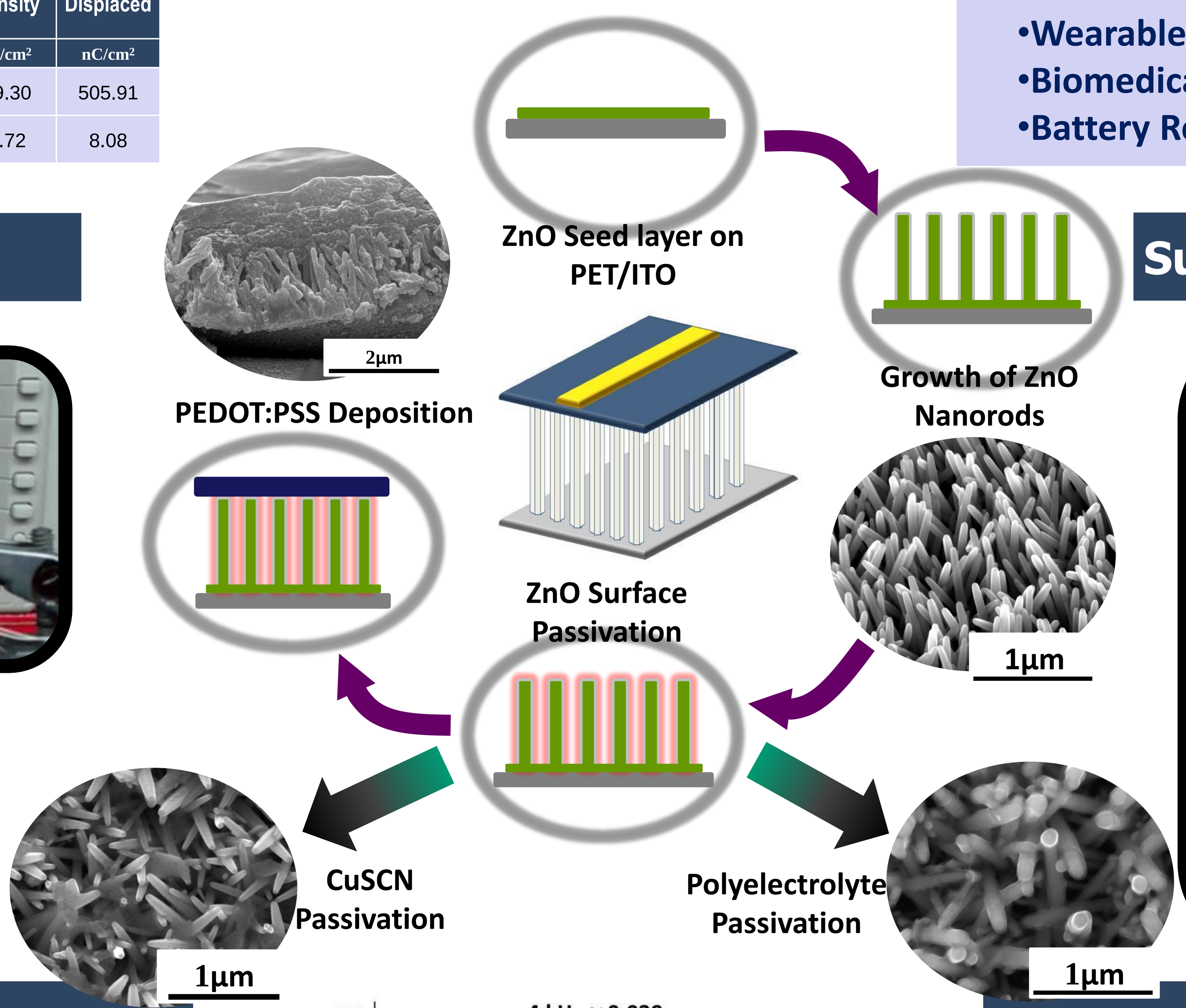
Device	Open Circuit Voltage	Load Resistance	Power Density	Power/ cm^3	Energy Density	Charge Displaced
	mV	kΩ	µW/cm ²	mW/cm³	nJ/cm²	nC/cm²
ZnO/ PEDOT:PSS	130	1.63	28.88	115.52	19.30	505.91
ZnO/ PMMA	200	245	0.26	1.28	0.72	8.08

Device Features

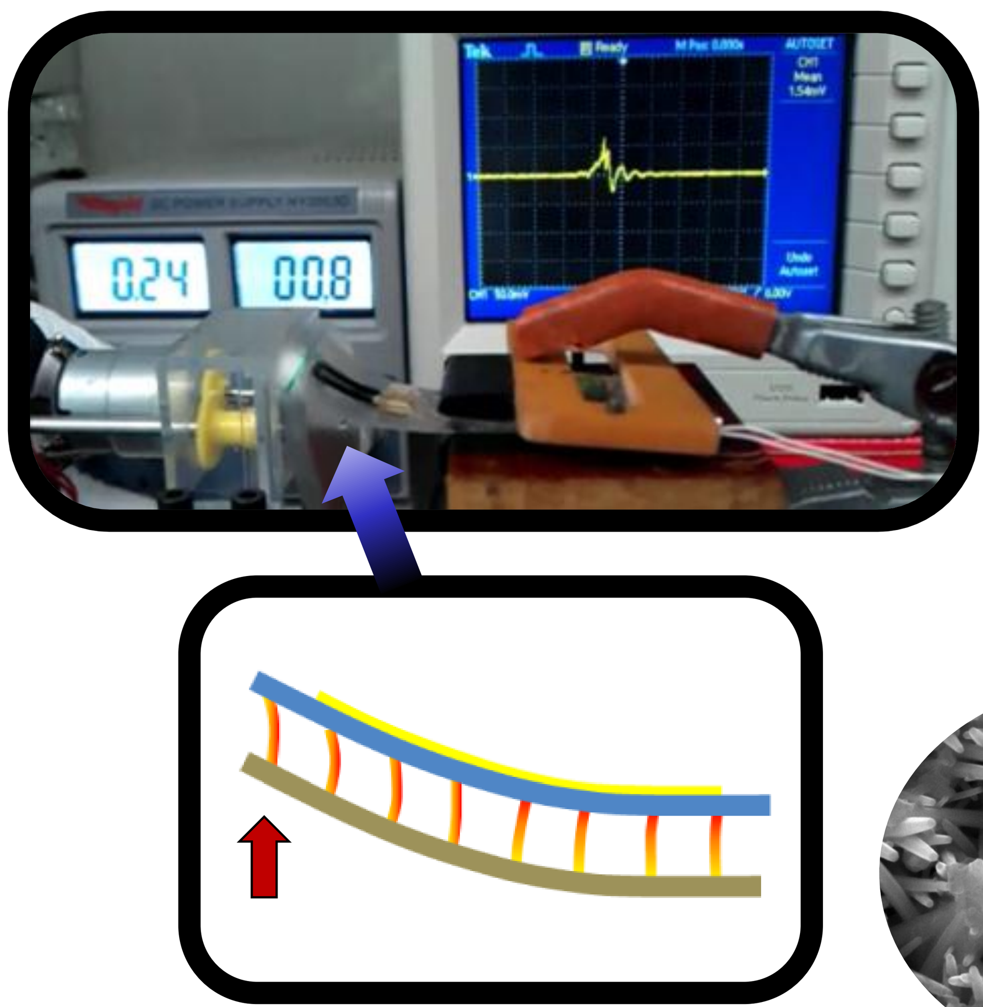
Low temperature processes (<100°C) used to fabricate stand-alone and self-powered energy harvesters

Power density of p-n junction type device 2 orders of magnitude higher than insulator-type device

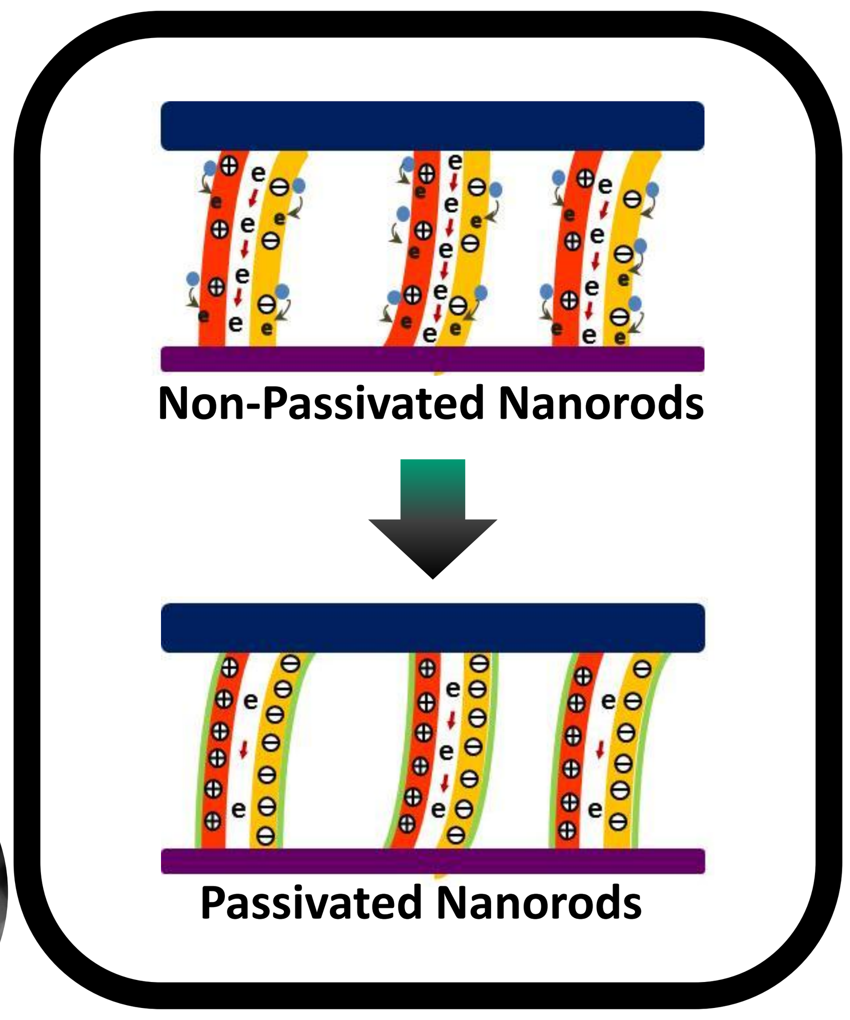
Wide Ranged Applications:
- Wireless Sensing
- Wearable Electronics
- Biomedical Implants
- Battery Replacement



Bend & Release Test



Surface Passivation



CuSCN Passivation

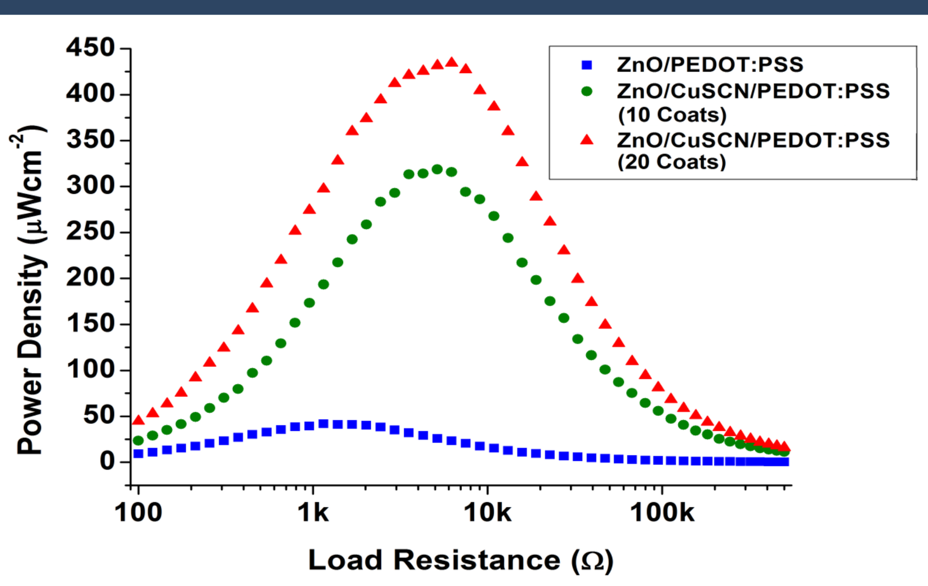


Figure 2. Resistive load matching of ZnO (As grown) and CuSCN-passivated ZnO based energy harvesters.

Table 2. Performance parameters of CuSCN-passivated ZnO devices.

Device	Open Circuit Voltage	Short Circuit Current	Load Resistance	Power Density	Power/ cm^3	Energy Density	Charge Displaced
	mV	mA/cm ²	kΩ	µW/cm ²	W/cm³	nJ/cm²	nC/cm²
ZnO (As Grown)	219	0.71	1.39	41.07	0.16	22.20	236.27
CuSCN (10 coats)	897	1.30	5.15	318.71	1.28	175.53	647.38
CuSCN (20 coats)	1000	1.88	6.21	434.33	1.73	255.68	848.11

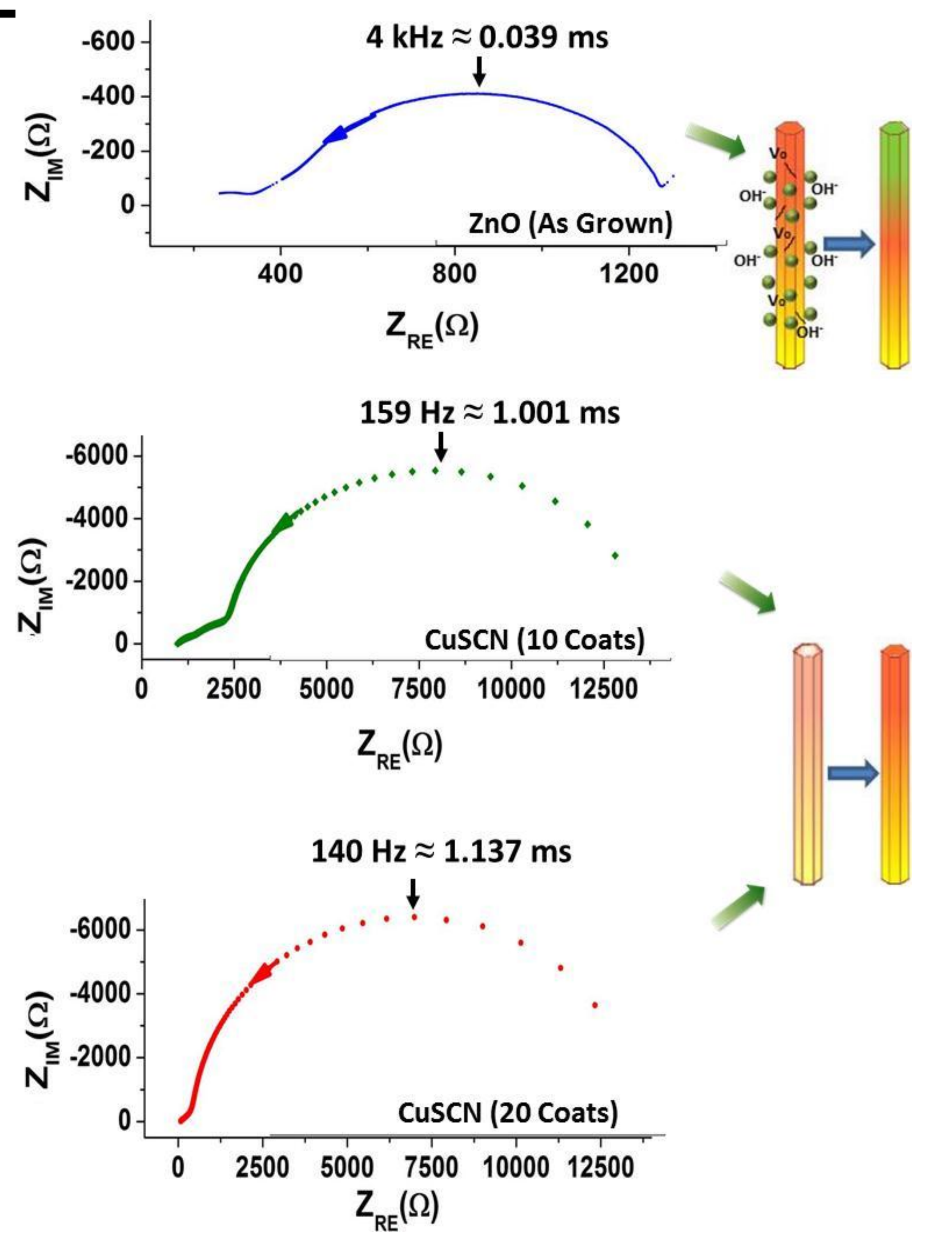


Figure 3. Impedance Analysis of CuSCN-passivated ZnO energy harvesters indicating the circuit RC time constants.

PDDA & PSS Passivation

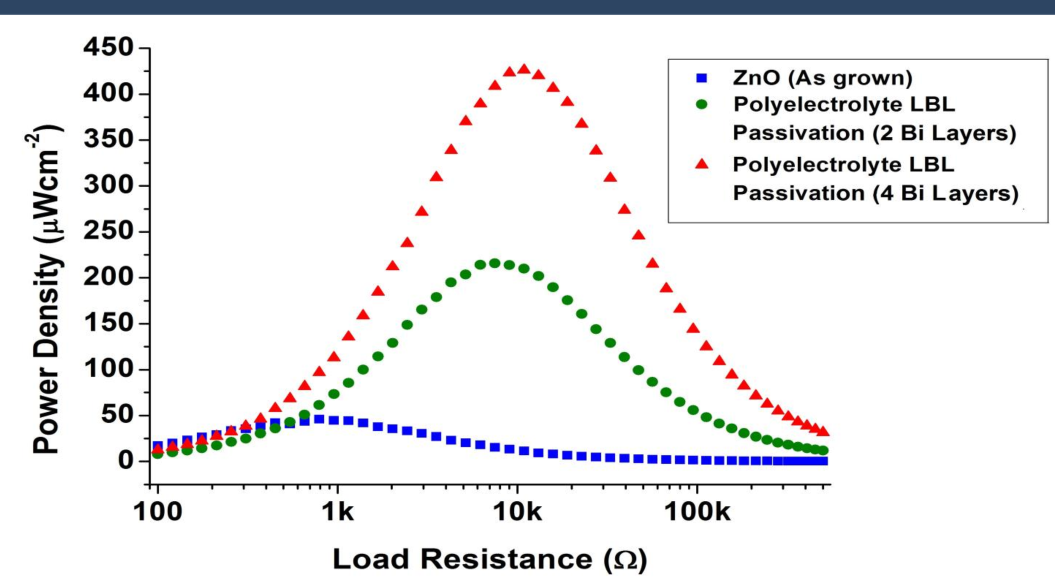


Figure 4. Resistive load matching of ZnO (As grown) and Polyelectrolytes-passivated ZnO based energy harvesters.

Table 3. Performance parameters of Polyelectrolyte-passivated ZnO devices.

Device	Open Circuit Voltage	Short Circuit Current	Load Resistance	Power Density	Power/ cm^3	Energy Density	Charge Displaced
	mV	mA/cm ²	kΩ	µW/cm ²	W/cm³	nJ/cm²	nC/cm²
ZnO (As Grown)	121	1. 25	0. 95	44. 74	0. 17	9. 89	288. 97
PDDA and PSS (2 Bi layers)	480	0. 66	7. 48	216	0. 86	65. 41	438. 98
PDDA and PSS (4 Bi Layers)	1000	1. 47	10. 86	426	1. 70	178. 02	587. 13

Conclusion

- Surface passivation techniques are applied to enhance ZnO energy harvester performance.
- The impedance anaylsis is used as a tool to obtain relationship between device RC time constant and screening effect.

Future Works

- Reduce the n-type conductivity of ZnO
- Reduce the device series resistance by replacing ITO with metal electrode.

References

[1] Briscoe J, Jalali N, Woolliams P, Stewart M, Weaver P M, Cain M and Dunn S 2013 Measurement techniques for piezoelectric nanogenerators *Energy Environ. Sci.* **6** 3035

School of Engineering and Materials Science