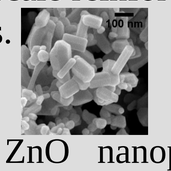
Synthesis and Characterization of SU8/ZnO Nanocomposite Films for Application in Energy-Harvesting Microsystems

Braj Krishna[1], Amritendu Roy[1], and Kaushik Das[1]
[1]School of Minerals, Metallurgical and Materials Engineering
Indian Institute of Technology Bhubaneswar

National Science Day 10th Research Scholars' Day 2020 IIT Bhubaneswar

Motivation

- SU8 (negative photoresist) matrix with nano-scale reinforcements can act as structural components of micro-systems.

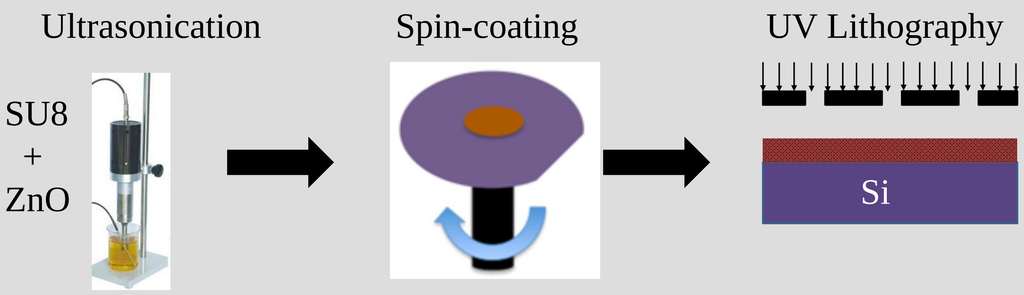


- Zinc Oxide: lead-free piezoelectric ceramic.
- A composite with SU8 as matrix and ZnO nanoparticles as reinforcement can be used as flexible structural components of micro/nanoscale energy-harvesting devices.
- **Applications:** Energy-source for wearable devices, and for autonomous micro/nano-sensors.

Objectives

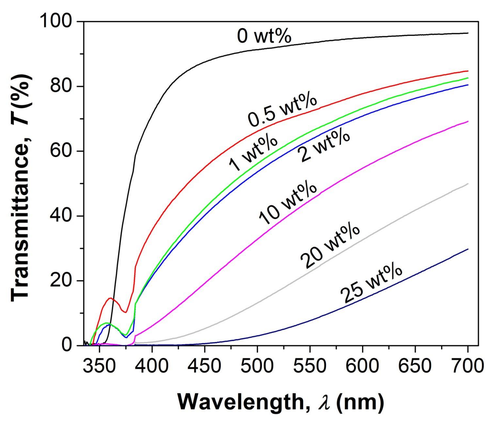
- To study the feasibility of spin-coating and patterning of thin films of the SU8/ZnO nanocomposite.
- To develop process-structure-property relationship through
  i. characterization of the physical properties of the thin film,
     i. mechanical property
     ii. electrical property
  ii. microstructural characterization.

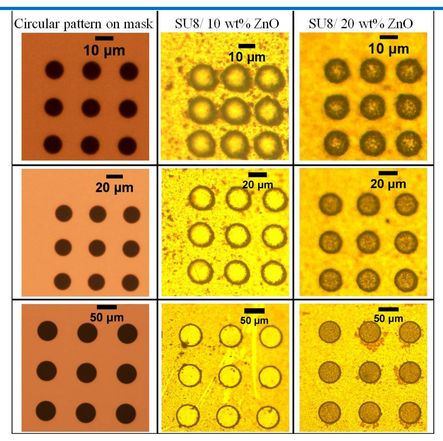
Synthesis of SU8/ZnO Nanocomposite



- The ZnO content varied between 0 - 25 wt%.
- Process parameters were optimized.

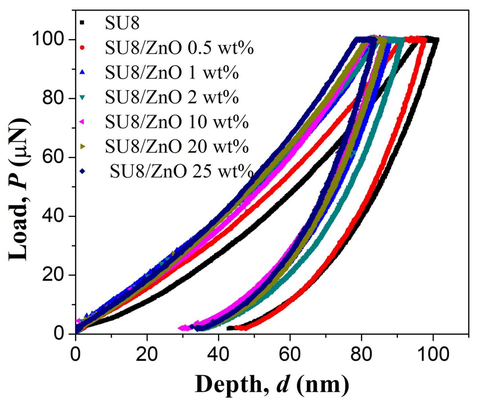
Feasibility of Patterning of SU8/ZnO Nanocomposites

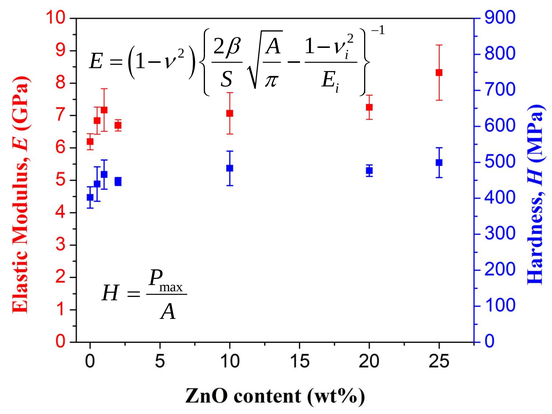




- Optical transparency of nanocomposite is lost at 25 wt% ZnO content, and hence could not be patterned.

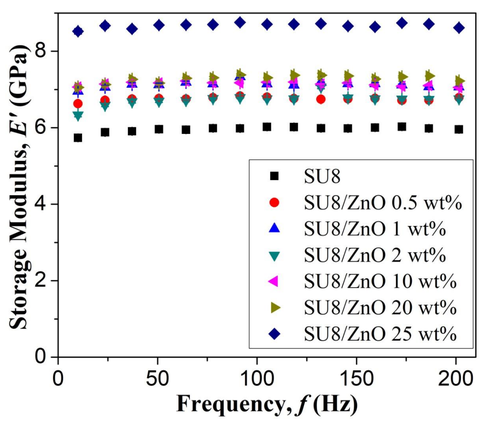
Quasi-static Nanoindentation

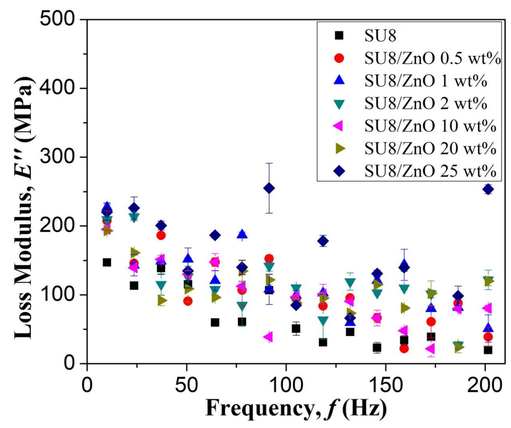




- Elastic modulus obtained via quasi-static nanoindenation varies from 6.2 GPa for pristine SU8 to 8.8 GPa for SU8/25 wt% ZnO nanocomposite.
- Hardness varies from 402 MPa to 520 MPa for SU8/ZnO nanocomposites in the same range of ZnO wt%.

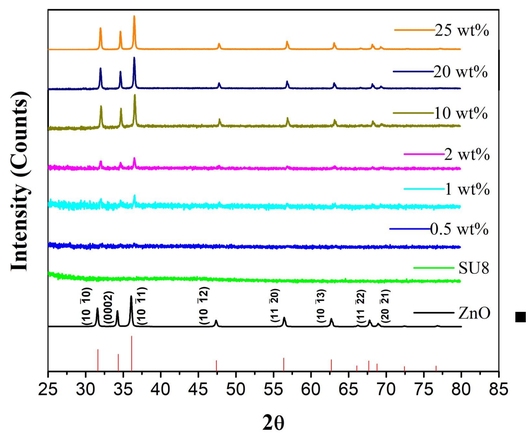
Dynamic Nanoindentation

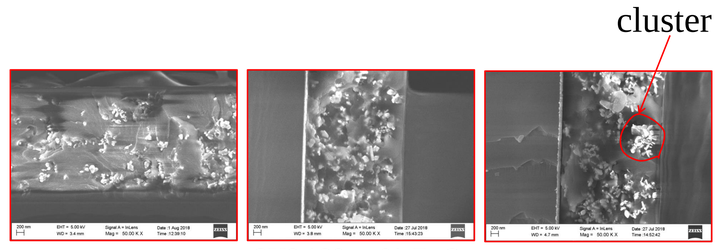




- Dynamic nanoindentation (nano-DMA) results show that the SU8/ZnO nanocomposites exhibit viscoelasticity at room temperature in the frequency range of 10Hz to 201.5 Hz.

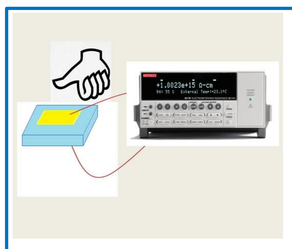
Microstructural Characterization

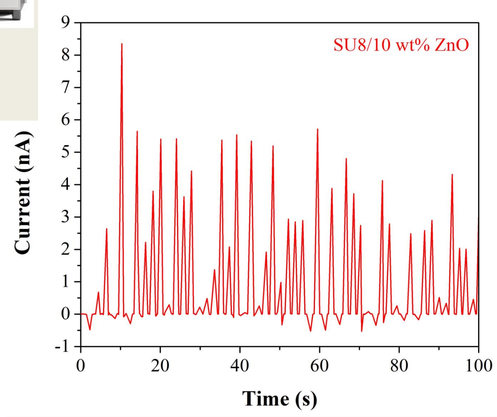




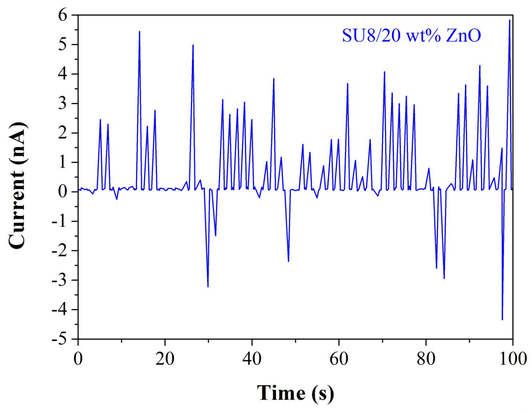
- Scanning electron micrographs confirm clustering of nanoparticles as ZnO content increases.
- The integration of ZnO nanoparticles into SU8 produces neither new diffraction peak nor a peak shift, showing that ZnO nanoparticles filled SU8 composite consists of phase separated structures, i.e., polymer SU8 and ZnO nanoparticle.

Current Generation under Mechanical Tapping Mode





Maximum output current = 8.5 nA



Maximum output current = 5.8 nA

Summary

- Nanocomposites thin films were microfabricated using photolithography.
- The nanocomposites were patternable up to 20 wt% ZnO content.
- Considering the optical transparency, distribution of ZnO, mechanical and electrical property the 10 wt% ZnO content nanocomposite will be useful for the device fabrication.

Acknowledgments

Financial support from the Department of Science and Technology-Science and Engineering Research Board (DST-SERB), Government of India, under Young Scientist Scheme (Grant no. YSS/2014/000830) is gratefully acknowledged. The authors would like to thank Indian Nanoelectronics User Program, CeNSE, Indian Institute of Science Bangalore for use of clean room facilities under project code CPU1026.

References

- B. Krishna, A. Chaturvedi, N. Mishra, and K. Das, "Nanomechanical characterization of SU8 / ZnO nanocomposite films for applications in energy-harvesting microsystems," *J. Micromech. Microeng.*, vol.28, no. 11, , pp. 1-10, Nov. 2018.