Comparative Analysis of Piezoresistive Sensors Fabricated with 3D Mold and Electrospinning Techniques Using PVDF, PZT, and Graphene on PDMS Substrate

Presenter: Nathnael Minuta, Faculty Mentor: Dr. Puteri Megat Hamari, Dr. Bhushan Dharmadhikari
Minnesota State University, Mankato, Department of Electrical and Computer Engineering and Technology

Abstract

The focus of our study is on the fabrication and performance comparison of piezoresistive sensors, which have numerous applications in wearable electronics, robotics, and medical devices. Two methods were used to fabricate the sensors: 3D printing and electrospinning. To create the 3D-printed mold sensors, we designed the mold using Tinker Cad and printed it. Then, we poured a composite of polyvinylidene fluoride (PVDF) and lead zirconate titanate (PZT) with a graphene dopant in the ratio of 80:20 into the mold and air-dried it for two days to create a 3D cast of the sensor. A substrate was formed by pouring a 40% polydimethylsiloxane (PDMS) solution onto the dried composite. For the electrospinning method, we mixed PVDF and PZT with graphene in the same ratio as before and loaded the solution into a syringe fitted with a spinneret needle. We electro spin the solution onto the PDMS substrate, adjusting spinning parameters such as voltage, distance, and flow rate to achieve uniform and continuous nanofibers. We characterized the sensors using SEM and tested their performance under various mechanical and electrical stimuli, such as pressure or strain. The sensitivity of the sensors was determined by recording the ratio of change in resistance to change in stimulus.

Introduction

Biosensors have become an essential tool in various fields such as academia, industries, and research laboratories due to their exceptional ability to recognize biological events and quantify biological or biochemical responses. Biosensors are a devices that detect and measure biological or chemical substances by converting a biological response into an electrical or optical signal. These devices monitor diseases, water contamination, and biomarkers in physiological fluids like blood, urine, saliva, tears, and sweat.

In recent years, the market for biosensor technologies is exploding at breakneck speed. In fact, it is predicted by Global Market Insights Inc. that it will hit USD 58 Billion by 2032.

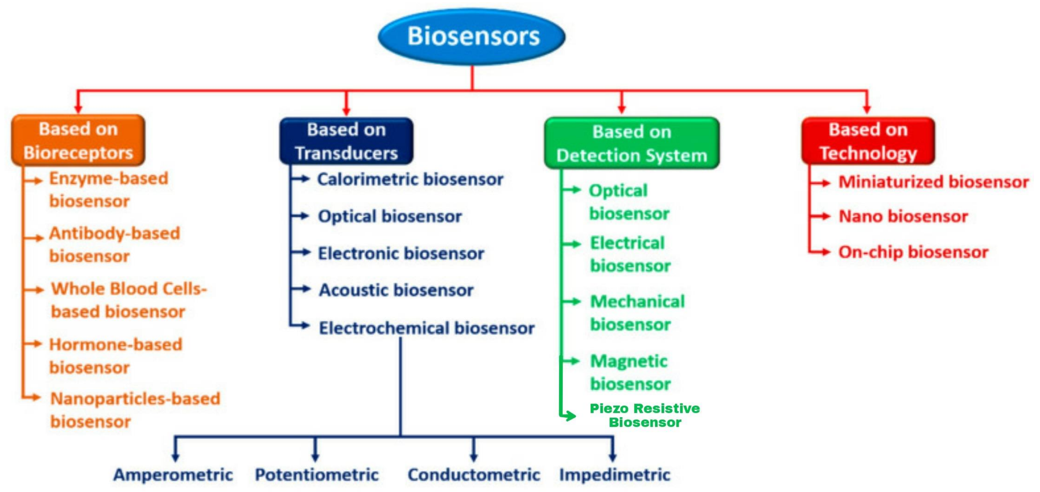
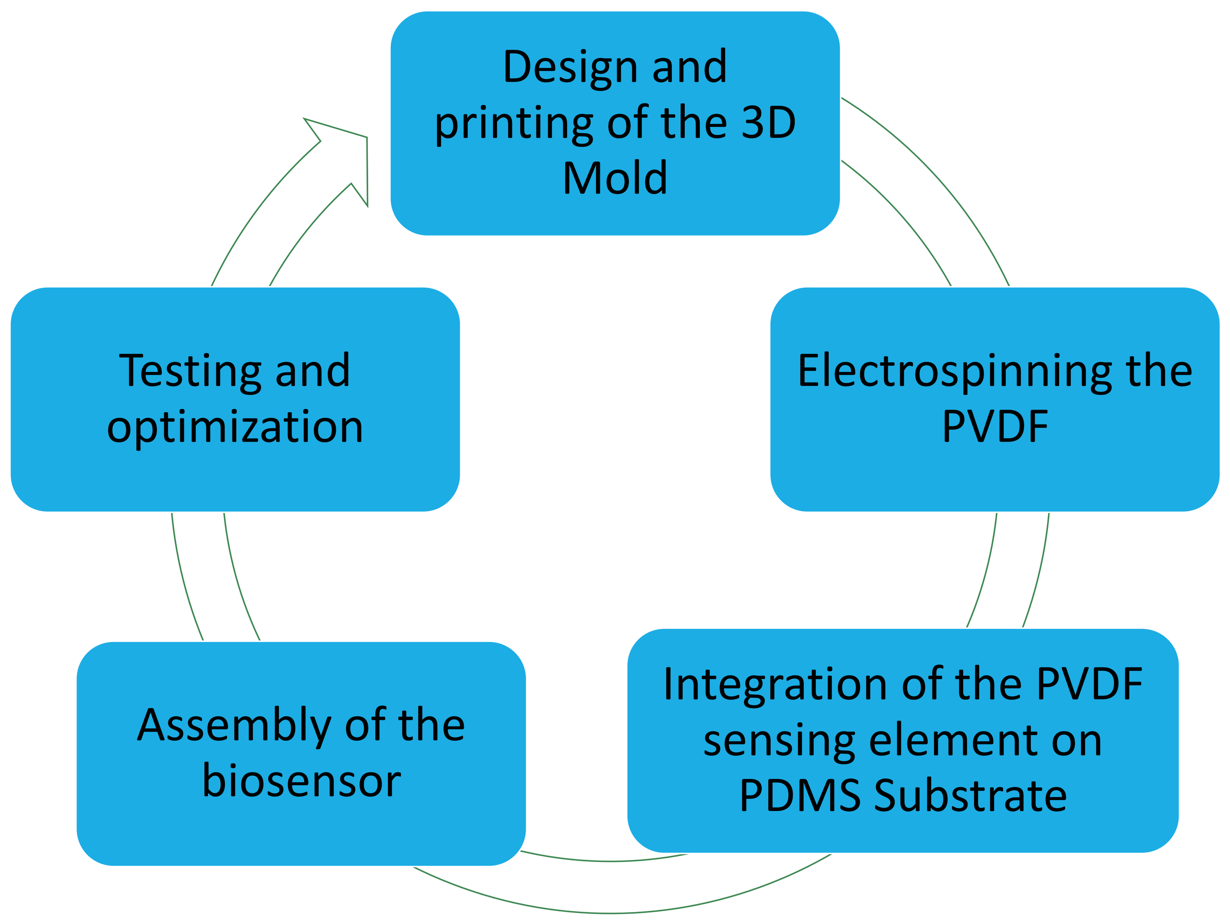


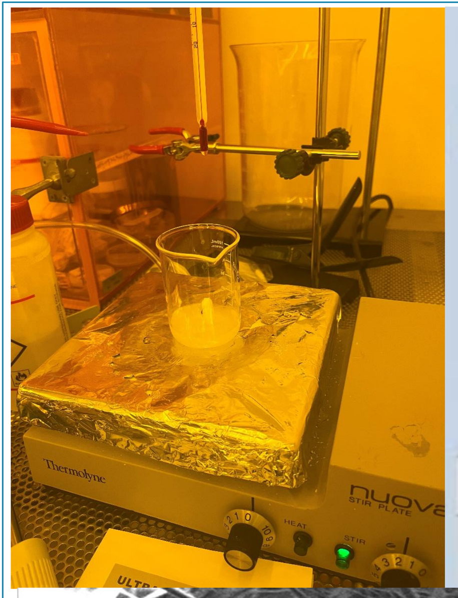
Figure 1. Classification of Biosensors

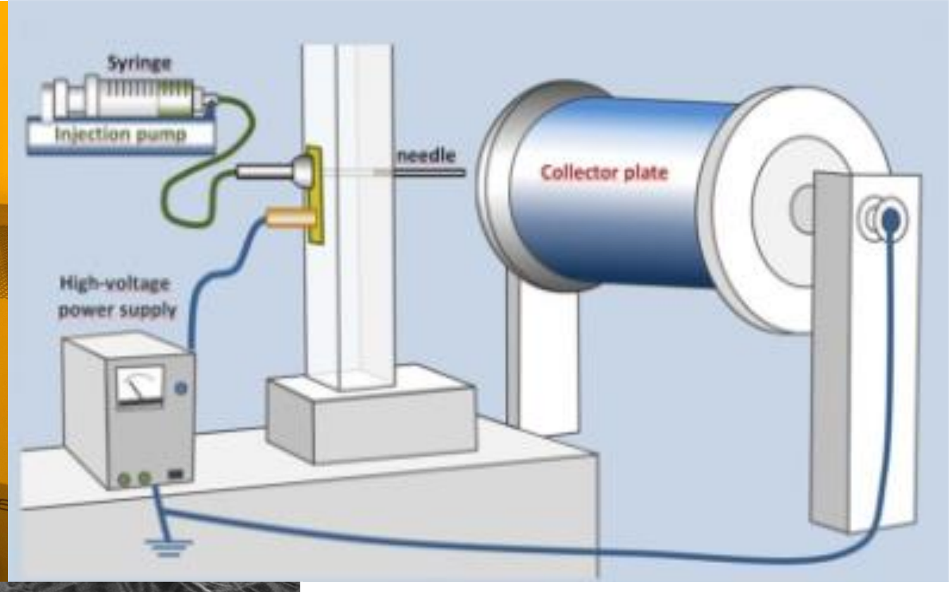
Our device uses Piezo resistive mechanism for sensing. The mechanic stress from the channel wall gives electric signal that we can measure and analyze. This helps us to detect specific biomolecules in the sample.

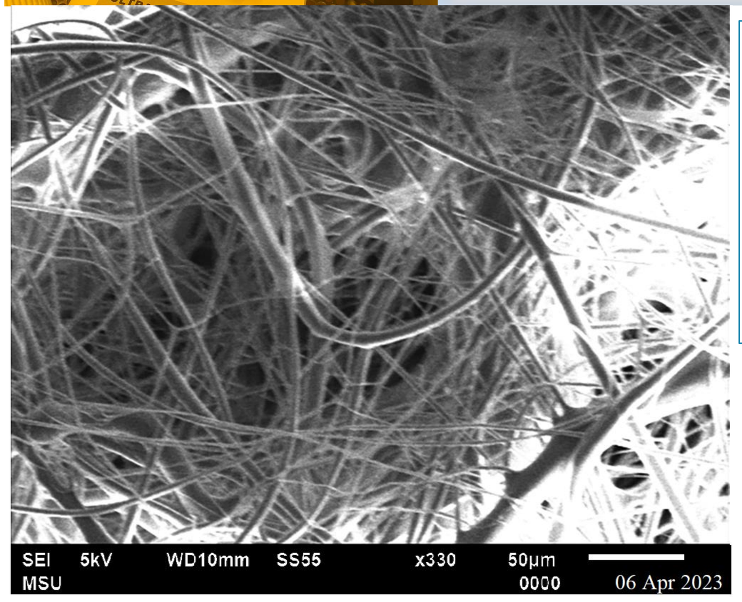
Methods



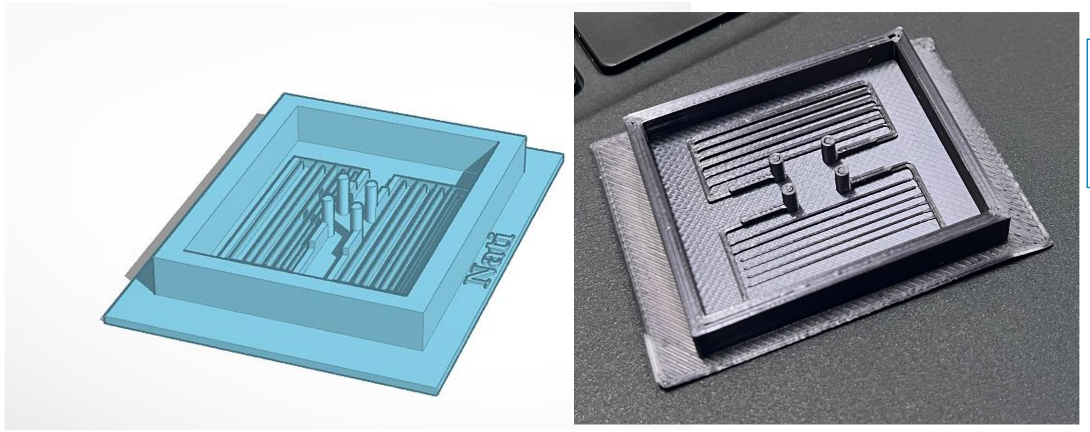
Results







Preparing 20% PVDF solution
Electrospinning and syringe pump setup
SEM image of PVDF & Graphene composite



Comb finger 3D printed mold

Discussion

- In this research, we successfully prepared the PVDF solution by combining 20% PVDF with 50 ml of acetone and a 1:3 ratio of DMF with acetone. The combination of PVDF, acetone, and DMF facilitated the formation of a suitable solution for the electrospinning process. Next, we combined the solution with PZT and Graphene to increase its piezoresistive characteristics.
- Then we did the electrospinning process and we successfully obtained nanofibers on our collector. However due to lack of time we couldn't integrate the PVDF nano fiber with the 3D mold and substrate i.e., PDMS. Also, we couldn't do measurements and analysis.

Conclusions

- In conclusion, this research project achieved significant milestones in the fabrication of a piezoresistive sensing device. We successfully designed and printed the 3D mold.
- In addition, we were able to prepare the PVDF solution and carryout the elctrospining process.
- Although we were unable to complete the integration of the sensing element to the 3D mold and PDMS substrate, and testing part of the research due to unforeseen circumstances, we believe that further development of our device has the potential to contribute to the fields of biomedicine and environmental monitoring.

Future Directions

- In our future work, our primary focus will be on completing the integration of the 3D mold with the PVDF sensing element and perform measurements and analysis on the generated electric signals to check its sensitivity.
- Then we will do performance comparison of our biosensor with the commercially available ones.

Acknowledgments

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Contact

242 Trafton Science Center N242,
Mankato, MN 56001
nathnael.minuta@mnsu.edu
puteri.megat-hamari@mnsu.edu
bhushan.Dharmadhikari@mnsu.edu

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