Figure 1. NMP and H20 substance

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The Application of Graphene as a Body Monitoring Sensor

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Background

Wearable sensors are helpful devices that can contribute to the overall quality of physical exercise. Monitoring the body can give feedback on the quality of the exercise and help create a personalized exercise plan to greatly improve the results of exercising. Current wearable sensor technology offers limited accuracy and restricts mobility. Our research proposes to apply graphene nanosheets to kinesthesiology tape (K-Tape) in order to create both accurate and flexible sensors.

Objective

The objective of our research is to create wearable sensors that are accurate and flexible by applying graphene nanosheets to k-tape.

Fabrication

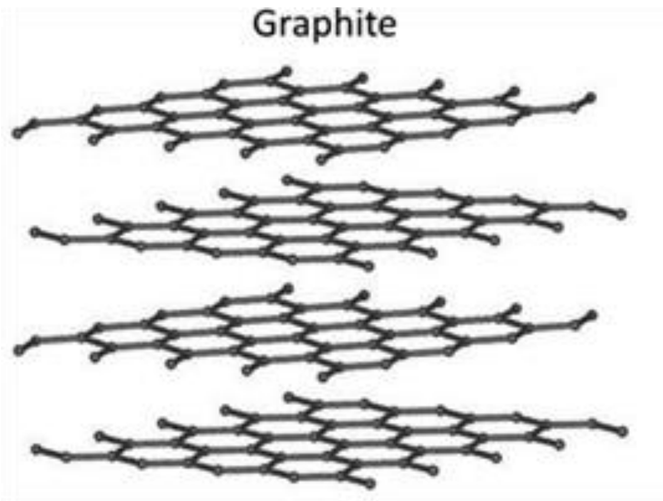

Figure 1. Graphite Diagram

Graphite is made of layers of carbon atoms arranged in a hexagonal honeycomb lattice. Each individual layer is referred to as graphene. In order to separate these sheets, we used the water assisted liquid phase exfoliation process (WALPE).

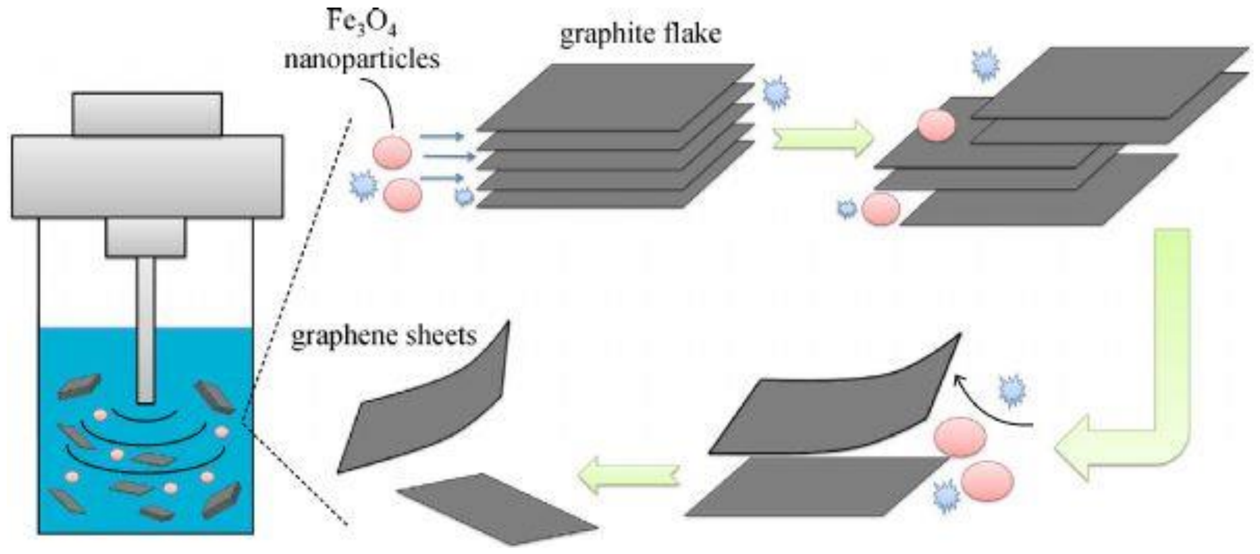

Figure 2. fabrication process

Process:

- Graphite mixed into a solution of N-Methylpyrrolidone (NMP) and water (H2O) with a 4:1 NMP-H2O ratio
- 5 g of graphite for every mL of solution
- Bath sonicator for 6 hours and left to rest overnight
- Centrifuge at 3000 rpm for 30 minutes.
- Top 75% of the mixture is separated and left to rest overnight
- The top 67% is separated and put into the vacuum oven at 70ºC until liquid has completely evaporated

Fabrication Process

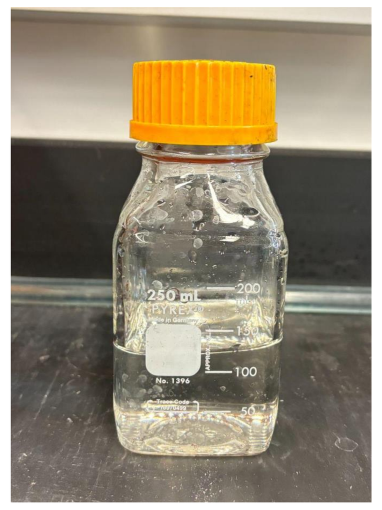

Figure 3. NMP and H20 solution

Figure 4. NMP, H20, graphite solution

Figure 5. Solution placed into bath sonicator

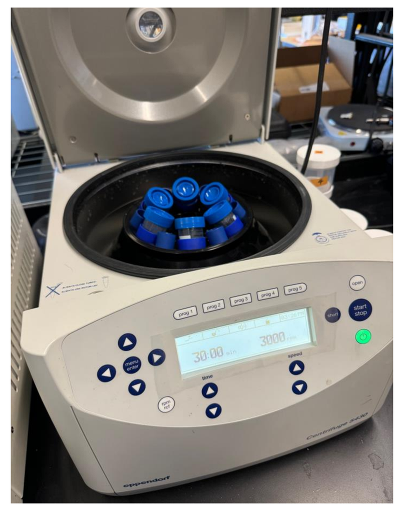

Figure 6. Solution placed into centrifuge

Figure 7. Extracting 75% of substance top layer

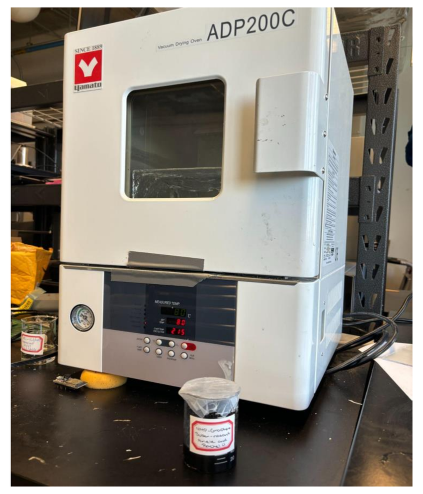

Figure 8. Substance being placed into vacuum oven

Resistance Testing

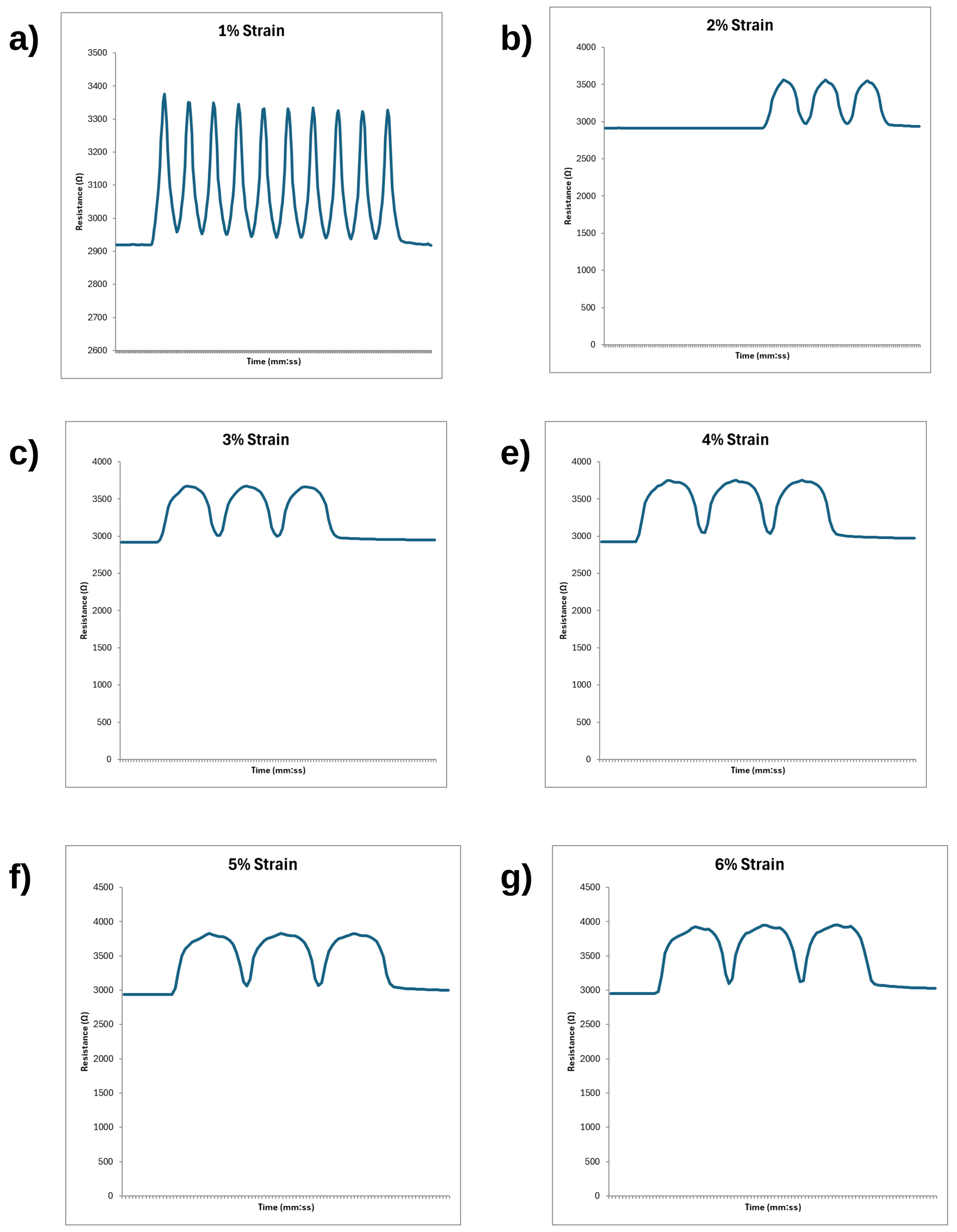

Figure 9. Data collected from peak strains a). 1.0% strain b). 2.0% strain c). 3.0% strain d). 4.0% strain e). 5% strain f). 6.0% strain

- Checked with a multimeter to ensure it meets the resistance goal of approximately 0.5-2 kΩ
- The sensor is then tested by mounting the motion tape individually onto a tensile cyclic load frame
- Peak strains of 1.0-6.0% were applied at a constant rate of 0.1 mm/s, while a multimeter attached to the multi-strand wires recording the electrical resistance
- All data is collected and synchronized using BenchVue software.

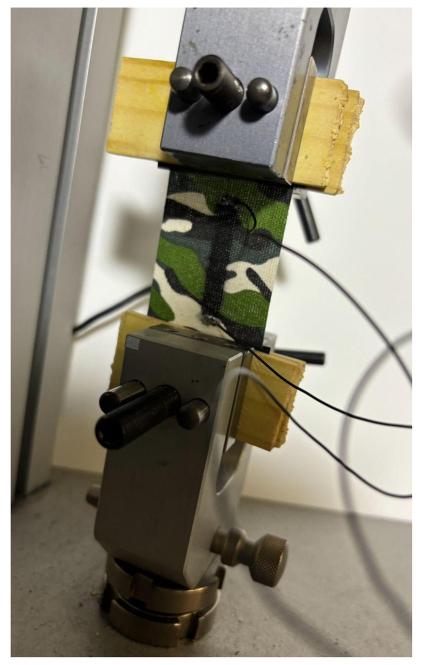

Figure 10. Motion tape placed into tensile cyclic load frame

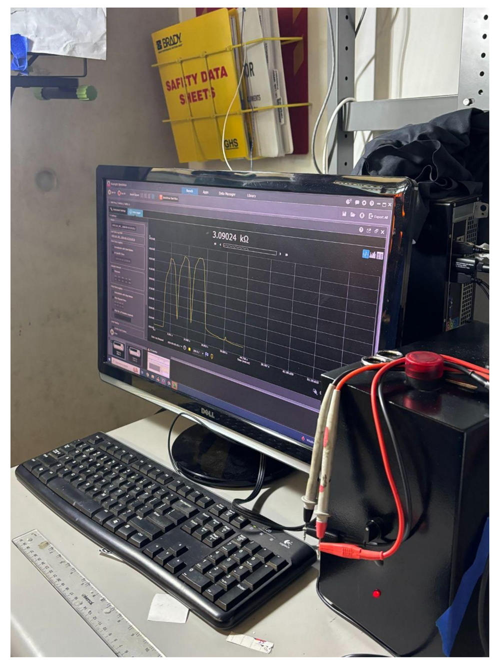

Figure 11. Data being collected on BenchVue software

Sensor Development

1. 2% Carbon Nano-Tube (CNT) sensors were fabricated using a 4x6 inch piece of K-tape that was then masked off with a tape mask opening of 4 x 0.5 inches where the first layer of ethanol would be placed.
2. CNT was layered on top where this process was repeated three times, with a 5-minute pause between each layer.

Figure 12. Motion tape once ethanol and CNT layers have been placed

3. The mask would then be removed, and the K-tape was left to dry overnight (approximately 8 hours).

4. Conductive ink is then applied to opposite ends of the CNT element, followed by soldering multi-strand wires to the inked areas.

Analysis

- Evaluate the graphs from the cyclic testing in order to determine whether or not the relationship between the strain and resistance stays linear
- Linear relationship means consistent and reliable sensors
- Current sensor reliable up until 6% strain

Conclusion

- Presented a self-adhesive, low-profile, conformable, and disposable wearable skin-strain sensor for monitoring muscle engagement with the use of CNT and Graphene.
- Ethanol layer ensures that during fabrication and when motion sensor is affixed to skin no CNT cracking is occurring during operation.
- Future work: Tensile testing results were inconsistent, indicating a need for further testing and need to secure a material that ensures consistent accuracy within resistance testing.

References and Acknowledgements

- Manna, K., Huang, H., Li, W., Ho, Y., & Chiang, W. (2016). Toward understanding the efficient exfoliation of layered materials by Water-Assisted Cosolvent Liquid-Phase exfoliation. *Chemistry of Materials*, *28*(21), 7586–7593. https://doi.org/10.1021/acs.chemmater.6b01203
- ARMOR Lab, Professor Loh, Yun-an Lin, and Elijah Wyckoff
- GEAR Program, Dr. Katya, and Sergio Godinez