Effect of Bending on Flexible Temperature Sensors

Ain Evelyn Lee, Victor Ong, Farbod Amirghasemi, Ali Soleimani, Michael Lee, Maral Mousavi

The Buckley School, Sherman Oaks, CA

Viterbi School of Engineering, University of Southern California, Los Angeles, CA , USA

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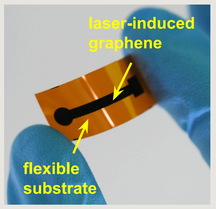
Background

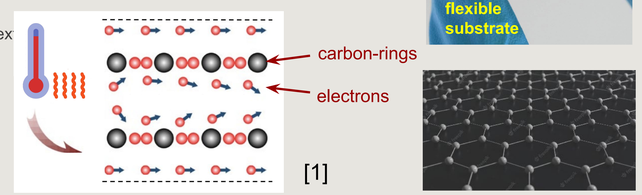
Body Temperature Monitoring

Conventional Thermometers
- rigid
- bulky
- point measurements

Flexible Temperature Sensors
- wearable
- continuous real-time measurements

Laser-Induced Graphene
- mechanically flexible
- highly conductive
- electrical **resistance decreases** as temperature increases





[1]

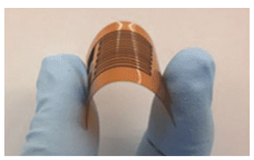
→ laser-induced graphene is suitable to be used as a flexible **resistive temperature sensor**

Objective

Problem: Resistive temperature sensors are not only sensitive to temperature but also to mechanical deformations. [2]

$$R = \frac{\rho L}{A}$$

where
R = resistance
ρ = material resistivity
L = length
A = area



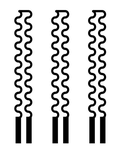
[3]

Objective: Investigating the effect of mechanical deformation caused by bending on the performance of flexible LIG temperature sensors

Methods & Results

Fabrication

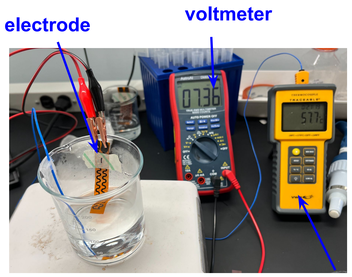
Design → **Laser Engraving** → **Laser-Induced Graphene Sensors**



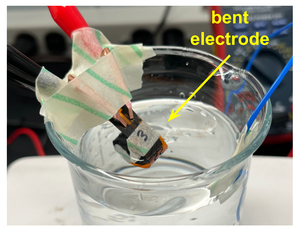
CO2 laser cutter

polyimide film [4]

Testing



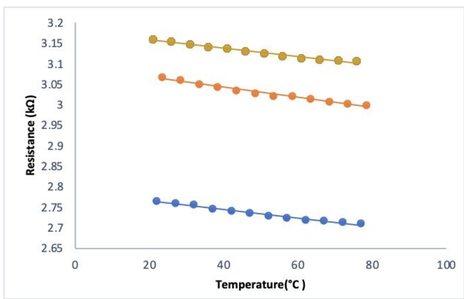
The resistance of the electrode at each temperature was recorded with every 5°C increase.



The experiment was repeated with the electrode bent.

Results

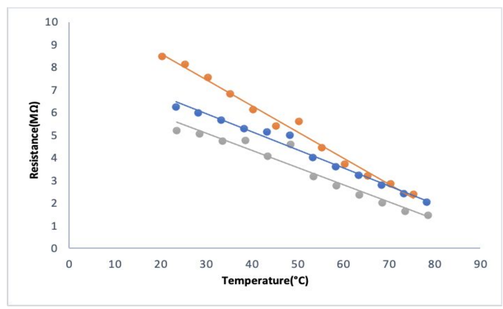
Not Bent / Flat:



trial	#1	#2	#3
Slope	-0.001245	-0.0001018	-0.001045
R^2 value	0.9828	0.984	0.9845
Relative Standard Deviation	-11.2334		

While the resistance of the three electrodes were each across different ranges, they had consistent slopes.

Bent:

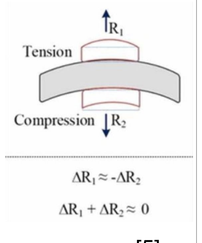


trial	#1	#2	#3
Slope	-0.1155	-0.07599	-0.07998
R^2 value	0.9892	0.9814	0.9442
Relative Standard Deviation	-24.0602		

Bending electrodes increased overall resistance, slope, and relative standard deviation. Nonetheless, the graphs maintained a linear trend.

Conclusion
- Bending laser-induced graphene temperature sensors caused an increase in overall resistance and a greater slope.
- Still, the sensors were able to maintain a nearly linear decrease in resistance with increase in temperature.
- Laser-induced graphene based temperature sensors are able to give reliable measurements in temperature when mechanical deformation is caused by bending.

Future Directions
- Test more complex deformations such as bending + stretching and twisting on laser-induced graphene temperature sensors
- Compensate for changes in resistance by employing a back-to-back design



[5]

- Use a more flexible substrate than polyimide film such as polydimethylsiloxane (PDMS).

[6]

References

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