Development of Paper Accelerometers for Cheap Applications

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Abstract:

The purpose of this project was to explore the use of paper in the fabrication of a micro electro-mechanical sensing device. To fabricate the sensors, we constructed a cantilever from paper with piezoresistive carbon ink painted on. Conductive silver ink was used to form the contacts. Both bamboo and cellulose paper were used for this process. The overall sensitivity of these micro electro-mechanical (MEMS) paper devices is approximately 120 μN/Ω compared to a similar silicon device, which is typically 80 μN/Ω. These paper MEMS sensors are cheap and easy to fabricate, often in less than one hour. A comparative silicon device would be far more time-consuming and would require the use of a clean room. Our paper MEMS devices would therefore find applications in less developed countries.

Introduction:

The implementation and use of MEMs has substantially grown in the last three decades [1]. MEMs are used in many important applications of today from engineering to medicine. These applications include; accelerometers, toys, airbags, analog devices, digital devices, and instruments. Silicon MEMs devices are the primary devices being used today. Fabrication of these silicon devices require many hours in both the lab and clean room. Decreasing the time of fabrication and eliminating the need for clean room usage would substantially reduce the cost of production. New MEMs technology using paper can lower this cost [2] without substantially lowering performance.

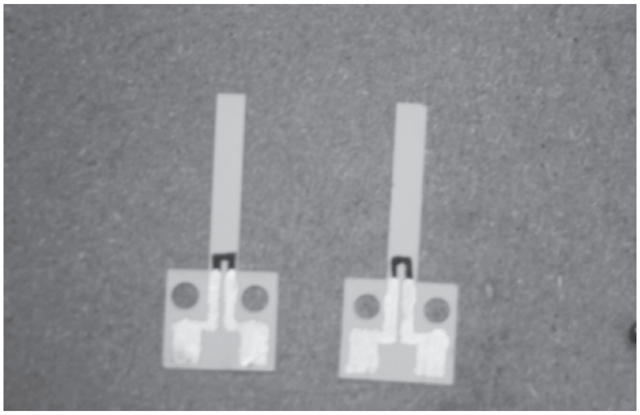

Figure 1: Paper cantilever device.

Experimental Procedure:

A cantilever was made from cellulose or bamboo paper using a laser cutter. The piezoresistive material graphite ink was painted on. Figure 1 shows the device. After the graphite ink dried, contact pads were fabricated using silver ink. The total fabrication time for each device was approximately one hour.

Figure 2 shows the setup of the Wheatstone bridge we used in measuring the device resistance. A series of resistance measurements was taken with different forces applied to the cantilever, for both the cellulite and the bamboo paper devices. The corresponding change in resistance was calculated and tabulated. Graphs of the change in resistance

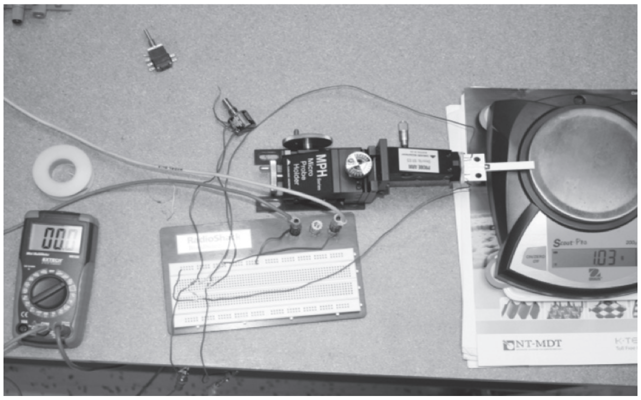

Figure 2: Wheatstone bridge used in measuring the device resistance.

versus force were made for the different devices. Additionally we calculated Young's modulus for both the cellulose and bamboo devices, and achieved readings of 5.5 gigapascals (GPa) for the cellulose and 2.5 GPa for the bamboo.

Results and Conclusions:

Figure 3 shows that the cellulose paper has a greater linear change in resistance. Figure 4 shows that the bamboo paper has a wider range in force in micro-Newtons (μN).

The cellulose paper is excellent in measuring the sensitivity of the slightest change in force. The bamboo is twice as thick as the cellulose and can measure 2 μN more in force compared to the cellulose.

Future Work:

In the future, we will use trichlorosilane vapor to make the paper hydrophobic, which would aid when working in moist or humid conditions. We also could use more layers of paper glued together, thereby increasing the overall stiffness and sturdiness of the cantilever. Finally, testing the resistance on various lengths of paper cantilever would be advantageous.

Acknowledgments:

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References:

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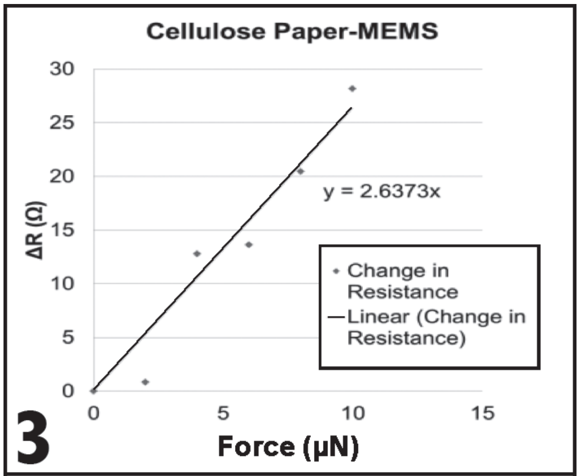
[2] Patel, Prachi. "Paper Accelerometer Could Mean Disposable Devices." IEEE spectrum. (2011): In Print.



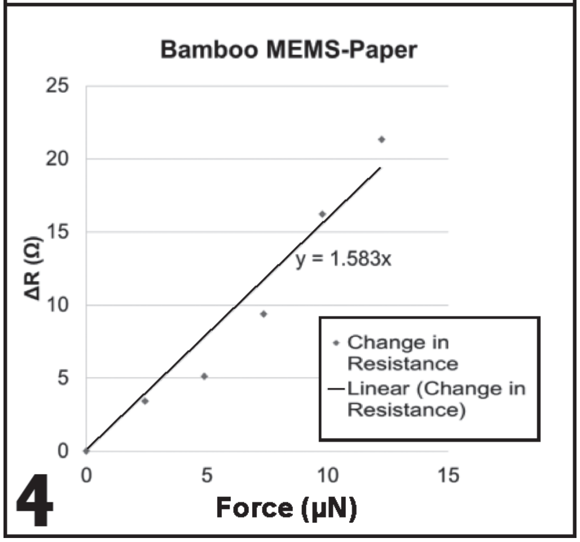


Figure 3: Linear change in resistance for cellulose paper.

Figure 4: Range in force for bamboo paper, in μN.