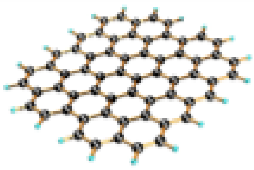

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INSTITUT NATIONAL DES SCIENCES APPLIQUÉES DE TOULOUSE

Datasheet: graphite-based sensor

Karine Dandy, Rachele Iffrig

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Abstract

This project aims to compare the sensitivity of a handmade graphite sensor to that of a commercial flex sensor for strain variation detection. This project is based on the publication from Wei et al. “Pencil drawn strain gauges and chemiresistors on paper” (1). We developed our handmade graphite sensor by depositing graphite on paper. The sensor pins are connected to a PCB mounted on an Arduino shield. The whole fabrication process was done at INSA Toulouse except for the Arduino shield.

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1 Main features of the graphite-based sensor

Figure 1 shows the dimensions of the sensor. The graphite is deposited onto 160g paper using a pencil. This sensor can be made with different types of pencil, in our project, we used 2B, H and HB pencils. The difference between these pencils is the quantity of graphite they contain. The more graphite they contain, the softer they are. The softest one studied here is the 2B and the hardest one is the H.

This sensor has been developed to be low-tech, low-cost with low power consumption.

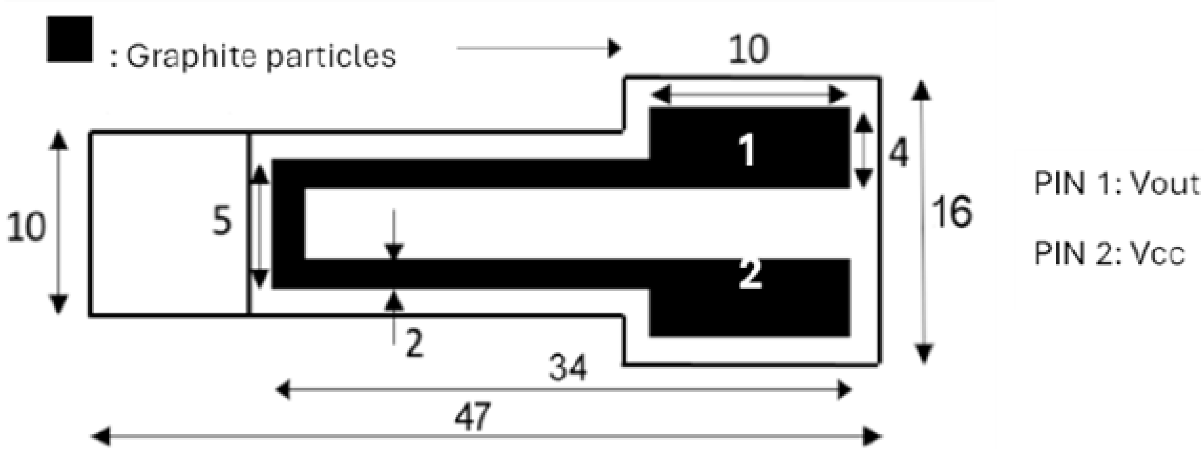

Figure 1 – Representation of our graphite-based sensor. The units are in mm. Extracted from the work of Paul Besnard and Niels Brun, available on GitHub.

2 Working principle of the graphite-based sensor

This graphite-based sensor works similarly to a strain gauge and can detect mechanical deformations in tension or compression. It can measure resistances of the order of the giga-ohm. The working principle relies on the relationship between the average nanoparticle distance and the resistance. Due to the granular property of the graphite, in tension, the layer stretches, increasing the distance between the nanoparticles (Figure 2). According to the percolation theory, the material's conductivity is then reduced, and its resistance increased. In compression, the distance between the nanoparticles is reduced, and the resistance decreases as more electrical paths are present.

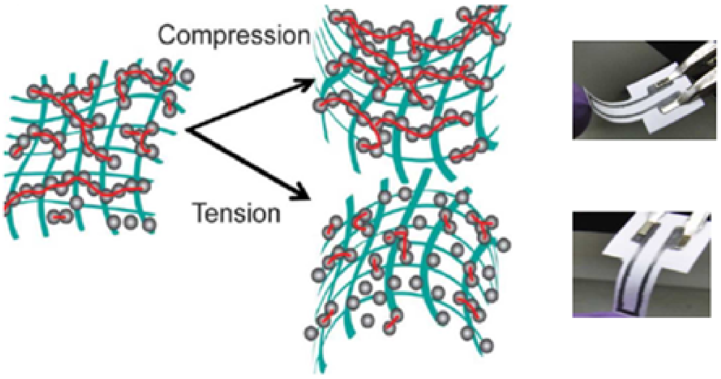

Figure 2 – Working principle of the graphite-based sensor in compression and tension. Extracted from (1).

The electrical circuit used can be found in the README file.

3 Working conditions

This graphite-based sensor can measure deformations up to 0.006, at room temperature. This sensor can be made with other papers and graphite pencils in order to improve its sensitivity. We highly recommend the use of thin papers and harder graphite pencils.

4 Results obtained with the graphite-based sensor and the commercial sensor

The Excel file containing all the data can be found in our GitHub.

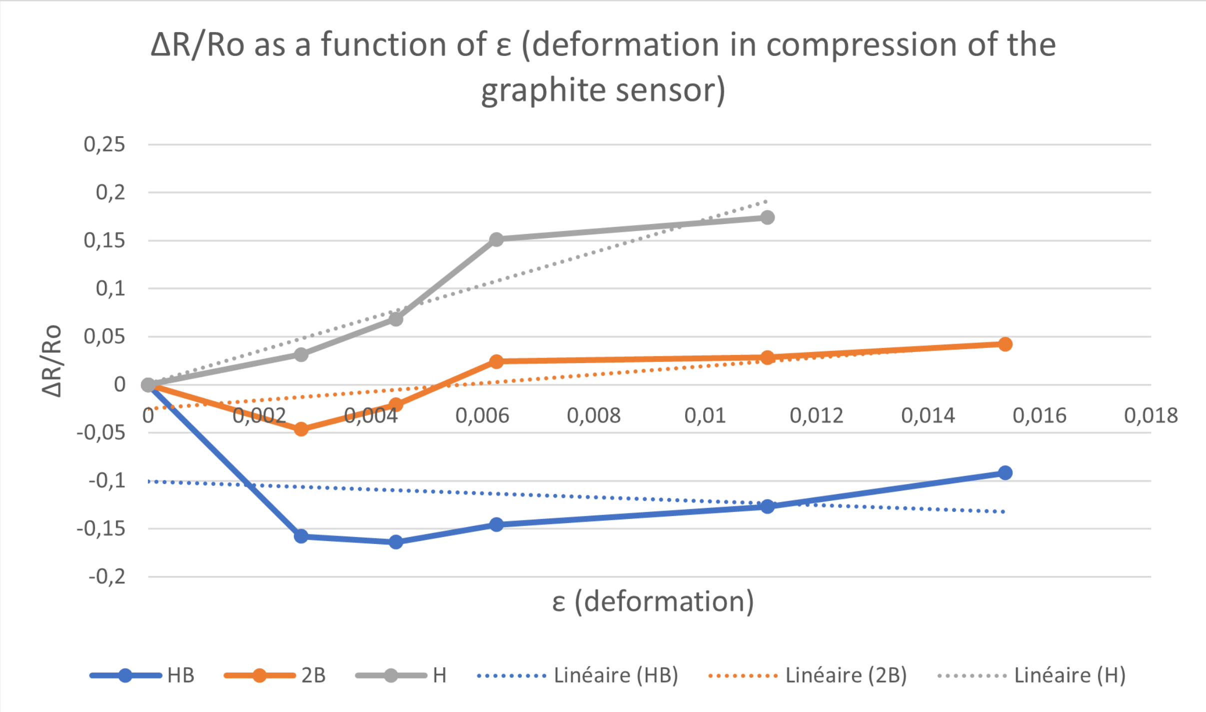

Figure 3 – Results obtained for the graphite-based sensor for a deformation in compression.

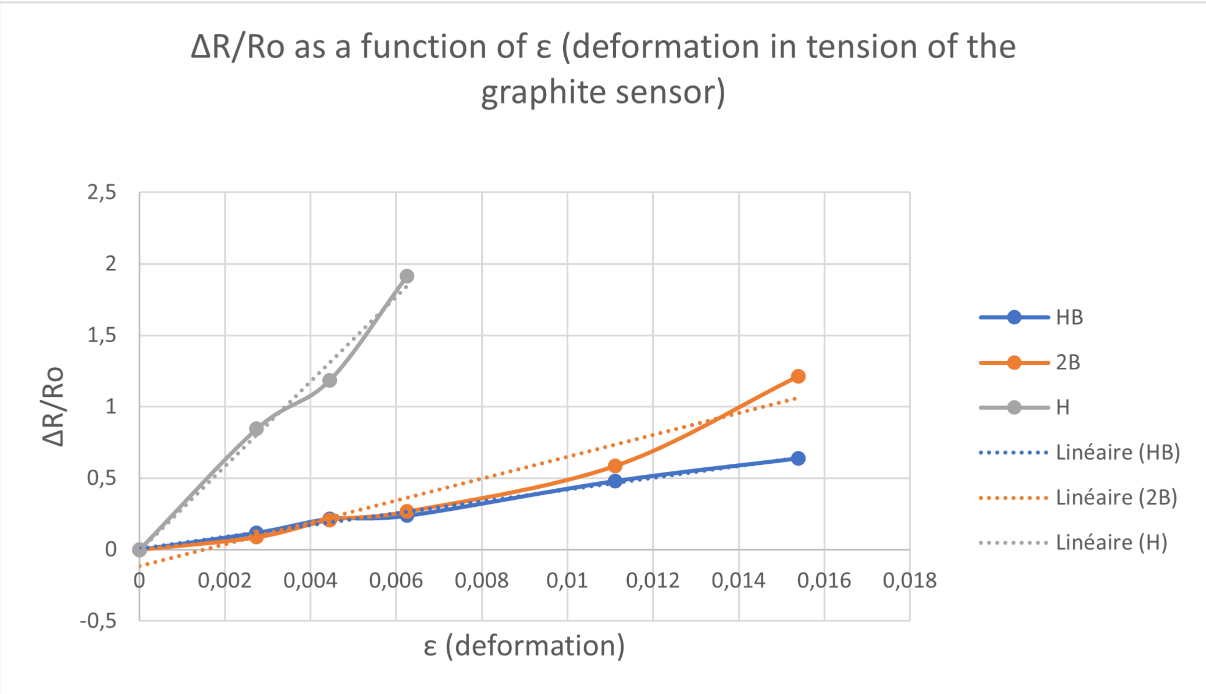

Figure 4 – Results obtained for the graphite-based sensor for a deformation in tension.

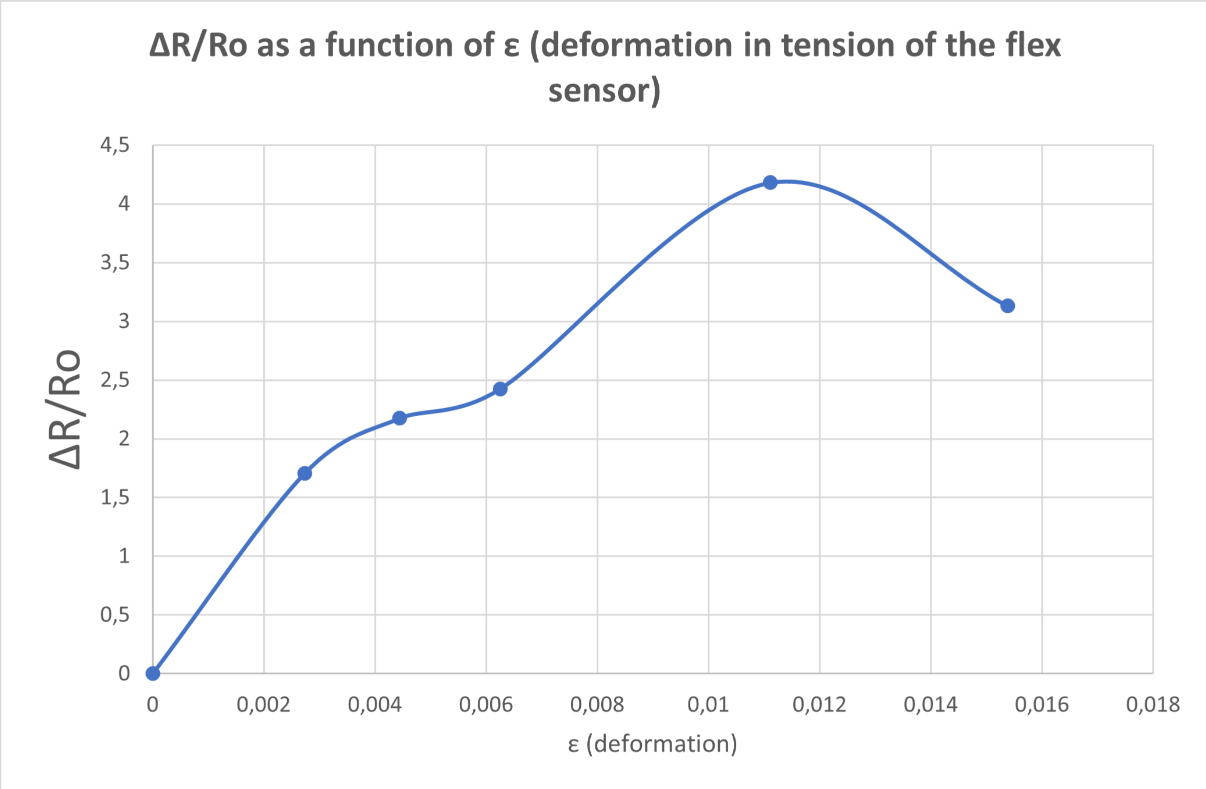

Figure 5 – Results obtained for the commercial flex sensor for a deformation in tension.

As shown in Figures 3 and 4, the hardest pencil (the H) is the most sensitive sensor. The same conclusion was found by Wei et al. The commercial sensor is more sensitive than our handmade graphite sensor. However, it is limited to tensile deformation measurements. There are other pencils that are harder than the H, the 2H for instance, which could potentially enhance the results. Measurement errors may have influenced our results, or we may have omitted other unknown factors. Nevertheless, a potential application for this technology can be observed when using hard pencils. With further material and experimental modifications, our handmade graphite sensor could be optimized.

References

[1] C.-W. Lin, Z. Zhao, J. Kim, and J. Huang, “Pencil drawn strain gauges and chemiresistors on paper,” *Scientific reports*, vol. 4, no. 1, p. 3812, 2014.