THE DEVELOPMENT OF AN EDUCATIONAL MEASUREMENT SYSTEM TO BRIDGE THE GAP BETWEEN MEASUREMENTS ON GRAPHENE MICRODEVICES AND UNDERSTANDING THE UNDERLYING CONCEPTS

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Graphene – a single atomic layer of graphite – is discovered experimentally at the University of Manchester in 2004 [1]. Graphene exhibits extraordinary electronic properties that are distinct from graphite. This opened the research field of 2D materials, and led to the Nobel Prize of Physics for the pioneers Andre Geim and Konstantin Novoselov in 2010 [2]. Graphene is not only a fundamentally interesting material system, but also a promising material for applications in microchips, flexible electronics, electro-optical sensors, biosensors, and possibly future field-effect transistors [3-4].

At The Hague University of Applied Sciences, we are currently developing an educational measurement setup for electronic measurements on electrostatically gated graphene microdevices. This will enable undergraduate bachelor students Applied Physics to study graphene's unique electronic properties, and how its electrical resistance can be controlled by electrostatic gating. This will help students to learn the concept of field-effect transistors, and to characterize charge transport properties of graphene in relation to graphene's unique band structure.

In this poster presentation, I will provide an overview of the design of the educational measurement system, and I will show the current status of its realization. Moreover, I will give examples of learning objectives that undergraduate bachelor students Applied Physics can address by designing and performing experiments with this educational measurement system. For instance:

(i) 2^{nd} and/or 3^{rd} year's undergrads can study the Drude model and apply this theory on their electronic measurement data to determine electron and hole mobilities of graphene microdevices at room temperature.

(ii) 3^{rd} and/or 4^{th} year's undergrads can study the theory of graphene's band structure and charge scattering mechanisms, and explore the manifestation of charge transport in graphene by performing electrical experiments on graphene microdevices at room temperature.

These examples may initiate further discussions on how this educational measurement setup can enable students to enhance their experimental skills on microdevices as well as strengthening their understanding of the related underlying physical concepts.

[1] A.K. Geim, K.S. Novoselov (2007). The rise of graphene, Nature Materials 6, 183.
[2] https://www.nobelprize.org/prizes/physics/2010/summary/
[3] A.C. Ferrari et al. (2015). Science and technology roadmap for graphene, related two-dimensional crystals, and hybrid systems. Nanoscale 7, 4598.
[4] J. Zhao et al. (2024). Ultrahigh-mobility semiconducting epitaxial graphene on silicon carbide. Nature 625, 60.