African Theoretical Physics Flagship Letter of Intent

Kwadwo Anokye Dompreh

Department of physics, School of Physical Science,

College of Agricultural and Natural Sciences

University of Cape Coast

Working group: Condensed Matter and Materials Physics

Subgroup: Advanced 2D materials and hetero-structures

Abstract

The nanoribbons of two dimensional materials such as graphene has been verified theoretically and experimentally to be a good source of acoustoelectric current. This has specific applications in acoustic wave filter as tunable gate-controlled quantum information devices and phonon spectrometers as well as in the development of sound batteries. This has prompted the necessity to investigate other nanoribbons as such silicene, germanene, black phosphorene and many others. In view of this, we propose setting up an African center that can collaborate using theoretical, experimental and computational means to understand the materials properties of all known nanoribbons. This borders on the use of fundamental and applied physics in relation to acoustoelectric effect (AE), acoustomagnetoelectric effect (AME) acoustothermal effect (ATE) and acoustomagnetothermal effect (ATME) in Nanoribbons. Other materials such as Carbon nanotubes, Quantum dots/ Wells and graphene superlattices are also of intense interest. We further propose investigating what happens when the nanoribbons are used to form heterostructures. Since it is predicted that due to weak Van der waals forces, their heterostructures will be a good source of Gunn diodes.

Introduction

The interaction of acoustic phonons with charge carriers in bulk semiconductors and two dimensional materials are an active field of study [1]. This phenomenon leads to an absorption or amplification of acoustic phonons.

When a Non-quantized electric field with a drift velocity is applied to a material and the drift velocity exceeds the velocity of sound amplification of acoustic phonons occurs, whereas absorption of the acoustic phonons occurs [2]. Recent theoretical/experimental studies of absorption of acoustic phonons in graphene nanoribbon due to landau damping [1] has open an insight into the use of nanoribbons for generating acoustoelectric current. This is used in a variety of ways which links academia to industry [3].

How can Africa become an effective actor in this Global market of acoustoelectrics?

We propose to mount an African theoretical/computational/ experimental group that can

- Promote research on nanoribbons and other 2D systems
- Built a joint Master and Ph.D programmes
- link the gap between academy and industry
- Set up a interdisciplinary research activity from theory to experiment on nanoribbons materials
- Support student mobility between the consortium members
- Improve employability and entrepreneurship of especially youth and women" as mentioned in 2063 Africa Agenda.
- Training of young researchers to build "human capital" and technological "know-how" in Africa.

African countries involved in the flagship should agree to:

- Collaborate and share ideas, equipment with Ghana being the host for the theoretical centre.
- Within Memorandum of understanding other countries with more equipment for research can host the experimental studies
- scientists and experts should mount joint projects within working groups
- Member groups should rise fundings from African Union, governments, NGO, Industrials to assist

Reference

1. Dompreh, K.A., Adu, K.W., Sakyi-Arthur, D. et al. Acoustoelectric current in graphene nanoribbon due to Landau damping. Sci Rep 11, 17913 (2021). https://doi.org/10.1038/s41598-021-95896-6
2. Poole, T. & Nash, G. R. Acoustoelectric current in graphene nanoribbons. Sci. Rep. 7(1), 1–9 (2017).
3. Mensah, S. Y., Allotey, F. K. A. & Adjepong, S. K. Acoustoelectric effect in a semiconductor superlattice. J. Phys.: Condens. Matter 6(34), 6783 (1994).