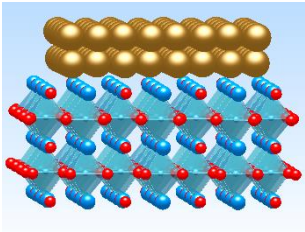
Emergent Piezoelectric Effect at Symmetry Engineered Heterostructures



Functional Electronic Materials Group

Discovered by Curie brothers in 1880, the piezoelectric effect can convert mechanical energy into electricity and vice versa in a linear manner. This effect is of fundamental interests, being strongly correlated with material phase transition, domain configuration and structure instability. Moreover, it has a significant impact on a range of technologies from mechanical energy harvesting, precise positioning, printing, to signal processing or material characterization, to name only few. The conventional piezoelectric effect originates from the bulk properties innate only to non-centrosymmetric dielectrics and was supposed to be forbidden in centrosymmetric materials. We have shown recently that in certain conditions an inversion symmetry breaking occurs in heterostructures consisting of centrosymmetric materials, generating interface piezoelectric effect.[1] This new piezo-effect, if properly understood and engineered, will not only significantly expand existing knowledge boundaries of electromechanical interaction, but also open new avenues for technological applications.

Of particular interest for this project is that the interface piezoelectric effect becomes relevant to a wide range of materials systems regardless of their pristine symmetry, spanning thus to oxides, 2D layered materials, organic-inorganic hybrid perovskites, conventional semiconductors (i.e., silicon, germanium) even to amorphous materials, etc. This distinctive feature not only offers us fertile playground to explore the detailed physics underlying this effect, but also enables unprecedent freedom to engineer and enhance the interface piezoelectric coefficient by exploiting various materials systems.

The main aim of the project is to gain a thorough understanding of this new electromechanical effects and to achieve an enhanced and even record-high piezoelectric coefficient by exploring diverse artificial heterostructures. Materials of interests includes but not limited to oxides and two-dimensional layered materials. The work will involve: preparation of high quality heterostructures by sputtering and pulsed laser deposition, basic characterization which will include structural and semiconductor measurements, functional, as well as macroscopic and microscopic characterisation using existing state-of-the-art characterization methods and home-build measurement systems. Part of effort will be allocated to the microscopic modelling and calculation of phenomenological theory. The successful applicant will work cooperatively with researchers in Functional Electronic Materials Group and over the Physics Department.

Professional duties and responsibilities:

- Epitaxial film growth and characterization using pulsed laser deposition and a broad range of experimental techniques including laboratory X-ray diffraction, dielectric impedance spectroscopy, atomic force microscopy, electronic transport and magnetic measurements.

- Performing data analysis and modelling the results.
- Preparing manuscripts for publication in peer-reviewed journals.
- Participating in local seminars as well as national and international conferences.
- Contributing to the overall activities of the research team and the department.
- Interacting with national and international collaborators.

Personal qualifications and skills:

- This position is only open to UK citizens or EU citizens settled in the UK due to funding restrictions. Applicants should have, or expect to be awarded, an undergraduate degree in Physics or a related discipline at a level of 2.1 or above.
- Good understanding and interest in condensed matter and/or materials physics.
- Strong analytical thinking and creative problem-solving skills.
- Ability to take initiative and to work independently and responsibly.
- Good team-working skills.
- Fluency and clarity in spoken English; good written English.

To discuss this project further contact:

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References

1 Ming-Min Yang et al. Nature 584, 377 (2020)