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Nanostructure-based Fibres and Inks for Flexible and Wearable Photonic Devices

Associated Centre in ADIRAC: Centre for Advanced Materials

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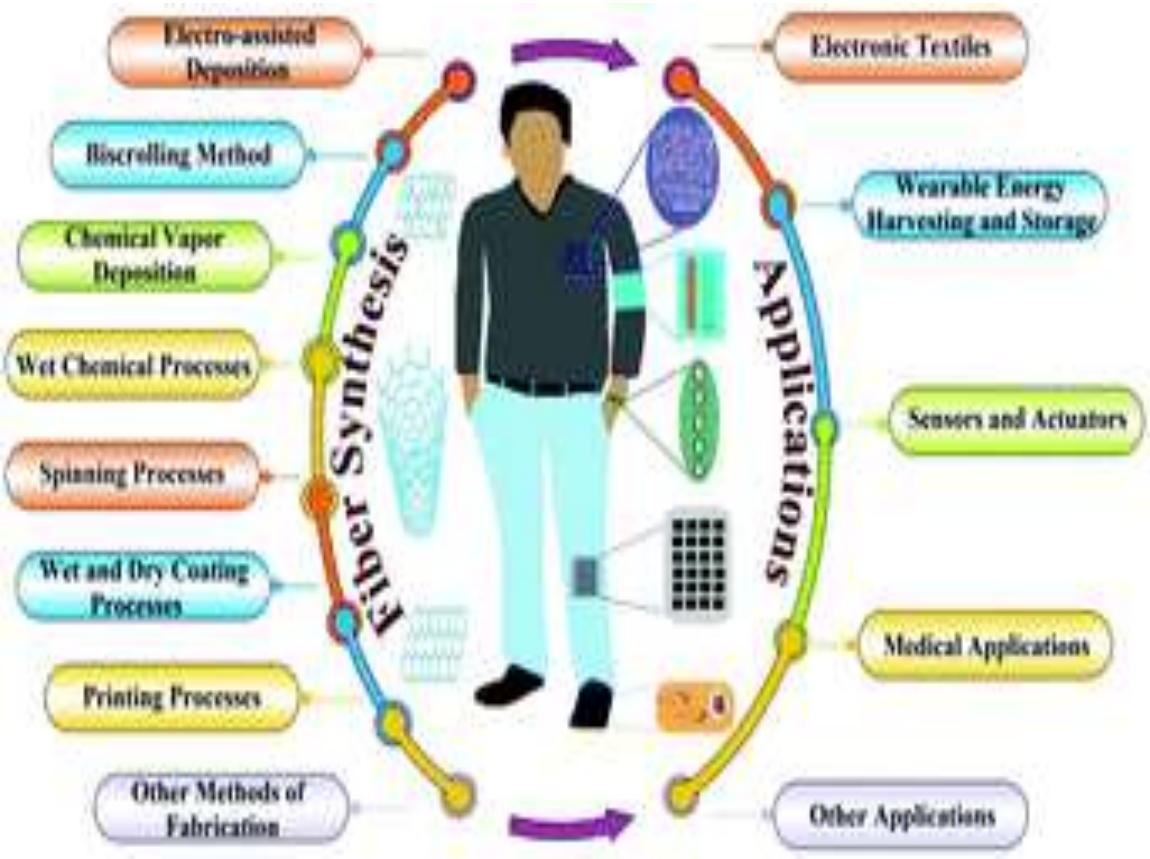
Project Description and its implementation

Aim of the project:

The present project is to realize flexible and printable devices with two-dimensional materials-based fibers and inks. The scope is to understand the fabrication strategies of the potential materials.



Methods of fabrication for fibre based devices

Introduction:

The textile electronics are revolutionary with the inclusion of novel technologies using functional materials that enable computing, digital components and electronics for advanced functionalities of communication, eco-friendly energy conversion, generation and storage of energy, monitoring and recording various human activities, and protection of wearer from environmental hazards. Recently, stretchable-wearable devices have been successfully demonstrated in different fields such as health monitoring, wearable gadgets, and therapeutic devices with demanding properties such as light-weight, flexibility, washable, large-area with excellent electrical conductivity, electrochemical and mechanical properties that can be easily woven into conventional textiles. More care is necessary in the fabrication of flexible devices as they are in touch with the human body and is a part of their outfit. The recent advancements in material science has led to the breakthrough development of polymer fibers with properties such as light-weight, high flexibility and low-cost and with advancements in weaving technology, it has been used as structured materials in textile.

Synthesis methods:

Electro-assisted deposition method includes different processes such as electrospinning, electrochemical reduction, electropolymerizing, electroless deposition, electrophoretic deposition, electrophoretic self-assembly and electrostatic self-assembly. Hydrothermal and solvothermal approaches are simple wet chemical methods having advantages such as cost-effectiveness, simplicity, scalability and are widely exploited for growing materials in high-temperature aqueous solutions at high vapour pressures. To introduce new functionalities into yarns, the nanofibers are well known additives which could be well accomplished by biscrolling method. Experimental studies showed the existence of various simple wet chemical methods for the synthesis of carbon-based fibers. Modified Hummers method is usually engaged in the synthesis of graphene sheets by reducing GO with hydrazine from graphite powder and also used to produce graphene oxide. The graphene and carbon nanotubes have been used as base materials to spin continuous conducting fibers with diameters in micrometers and hundreds of meters in length either by dry or wet spinning process for the promising electrode material.

Flexible Devices

E-textile will soon replace conventional textile especially in sports, medical monitoring devices, accessories, fashion and so on. The nanostructured multifunctional yarns that can be woven could be well-integrated to develop flexible, durable smart clothing compared to that of thin film or bulk composites. The study of interfaces in devices that are based on these materials is another interesting area that needs to be explored. The palette of 2D materials such as TMDs, black phosphorus and topological insulators certainly hold great promise in the field of wearable electronics with their outstanding properties that could be tuned with the number of layers. These materials have great capability owing to their self-limiting character which makes them emerging candidates to form a major research area expanding from nanoscale towards two-dimensionality thereby opening new windows to understand their properties in potential wearable electronics. This has great impact on the translation of properties of layered materials for the advancement of textiles with respect to manufacturing, cost and device fabrication.

Research Collaborator:

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A-DIRAC

List of publications and Outcome:

Wang, Zhenhong, Jia Guo, Yue Zhang, Jun Liu, Joice Sophia Ponraj, Sathish Chander Dhanabalan, Tianyou Zhai, Xinke Liu, Yufeng Song, and Han Zhang. "2D GeP-based photonic device for near-infrared and mid-infrared ultrafast photonics." Nanophotonics 9, (2020) 3645-3654 https://doi.org/10.1515/nanoph-2020-0248

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Arjunkumar, B., G. Ramalingam, M. Ramesh, Joice Sophia Ponraj, and K. Venkateswara Rao. "Investigation of Uni-Directional Nanorods Composed Microspheres and Branched TiO2 Nanorods Towards Solar Cell Application." Materials Letters 273, (2020): 127900. https://doi.org/10.1016/j.matlet.2020.127900

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