1. **Name of the Institution: University of Jammu**

2. **Title of the Project:** Synthesis and characterization of Nickel based nanowires for developing self-charged supercapacitors

3. **Name of the PI:** Dr. Sandeep Arya

- **Designation:** Sr. Assistant Professor
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4. **Name of the Co-PI:** Nil

5. **Details of Staff Engaged:**

- **Name:** Ms. Sonali Verma
- **Appointed as:** Project Assistant for 1 year
- **Qualification:** M.Sc. Physics
- **Contact No:** 9622364801
- **Email:** verma.sonali2204@gmail.com
- **Date :** 16-06-2022 to 15-06-2023

6. Brief synopsis of the project:

This project proposal aims to demonstrate and develop some self-charged supercapacitors that can act as electrochemical capacitors (ECs), as well as novel pseudocapacitors devices and will be studied to enhance the energy storage capacity. The primary target of the project is to produce a nanowires based supercapacitor in which an additional or combined layer will be introduced for self charging phenomenon. Hence, no external electric actuation will be required for charging the proposed nanowires based supercapacitors. In addition, higher capacitance will be achieved by using redox-active coating such as piezoelectric materials, metals and electro-conducting polymers (ECPs), etc. As a result, this combination will lead to highly reversible surface redox reaction with high electrochemical capacitance. These new devices, well adapted for peak power demand and storage with improved energy capacity, will enhance the energy efficiency and consequently will increase the competitiveness of industries.

The following objectives were undertaken for the proposed work:

i. To synthesize Ni based nanowires by adding some dopants such as S, Se, Te, etc into it via chemical electrodeposition technique. During deposition, the effect of various growth conditions such as time of deposition, applied potential, concentration of precursors, pH and temperature of reaction on the electrochemical properties of the synthesized nanowires will be studied.
ii. To investigate the structural, morphological and electrochemical performance of the synthesized nanowires different characterization techniques such as FE-SEM, HR-TEM, XRD, EDX, FTIR, Raman, XPS, etc are studied.
iii. To test the synthesized nanowires as supercapacitor electrode by evaluating the cyclic voltammetry (CV), galvanostatic charge discharge (GCD) test, and electrochemical impedance spectroscopy (EIS), etc. The performance of the tested nanowires will be compared with the other reported work.
iv. To fabricate and demonstrate a nanowires based supercapacitor for practical applications. The enhanced performance of the tested device will be reported in the form of a research paper in a reputed journal.

7. Work Done Report:

During this project, several experiments were conducted to develop advanced supercapacitors for wearable electronics. In Experiment 1, a novel self-charging supercapacitor was created using lead-free perovskite piezoelectrodes and a PVA-KOH film as the electrolyte, with $NiSnO_3$ and $FeSnO_3$ as the electrodes. This device demonstrated high flexibility, stability, and a maximum voltage of 266 mV through self-charging. Experiment 2 involved a thermoelectric-powered supercapacitor using Ni-Mn composite nanowires and a quadripartite gel electrolyte, achieving a high specific capacitance of 556 F/g and a maximum voltage of ~60 mV from a temperature difference. Experiment 3 focused on synthesizing $BaNiO_3$ perovskite nanoparticles for supercapacitor electrodes, which showed high specific capacitance, excellent conductivity, and 97% cyclic stability over 5000 cycles. In Experiment 4, a self-charging asymmetric supercapacitor was developed with NiO and MnO_2 thin films on polyester, demonstrating high durability, 100% capacitive retention after 7500 cycles, and a maximum voltage of 380 mV achieved through mechanical deformation. These studies highlight significant advancements in flexible, robust, and self-powered supercapacitors for future wearable device applications.

8. Outcome of the Project:

On the basis of above discussed experiments, following 4 research papers were successfully published:

- S. Verma, B. Padha, S. Arya, Thermoelectric-powered supercapacitor based on Ni-Mn nanowires driven by quadripartite electrolyte, *ACS Applied Energy Materials*, 5 (7), 9090-9100, 2022.

  DOI: 10.1021/acsaem.2c01586

  SCIE Indexed, **Impact Factor: 6.959**

- B. Padha, S. Verma, S. Arya, Fabric-based wearable self-powered asymmetric supercapacitor comprising lead-free perovskite piezoelectrodes, *Advanced Materials Technologies*, 2200079, 2022.

  DOI: 10.1002/admt.202200079

  SCIE Indexed, **Impact Factor: 8.856**

- AN Janjua, A Ahmed, A Singh, AK Sundramoorthy, SJ Young, YL Chu, S Arya, Synthesis, Characterization, and Implementation of $BaNiO_3$ perovskite

nanoparticles as thin film supercapacitor electrode, *Energy Storage*, 6(4), e630, 2024.

DOI: https://doi.org/10.1002/est2.630

SCIE Indexed, **Impact Factor: 3.2**

- P Mahajan, S Verma, B Padha, A Ahmed, S Arya, Manganese Oxide and Nickel Oxide Thin Films on Polyester to enable Self-Charging Wearable Supercapacitor, *Journal of Alloys and Compounds*, 968, 171904, 2023.

  DOI: 10.1016/j.jallcom.2023.171904

  SCIE Indexed, **Impact Factor: 6.2**

9. **Recommendations:** This work could be further extended for commercial use provided a sufficient facilities and infrastructure is available.

10. **Coloured photographs with captions indicating progress of work/activities:**

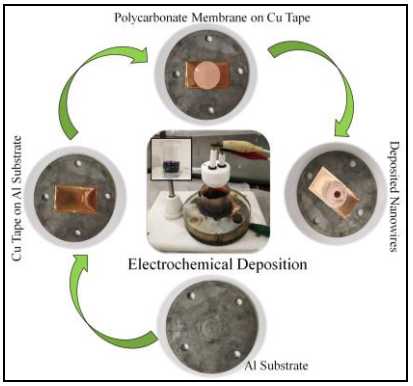

Fig. 1. Systematic of synthesis of Ni-Mn nanowires via electrochemical deposition.

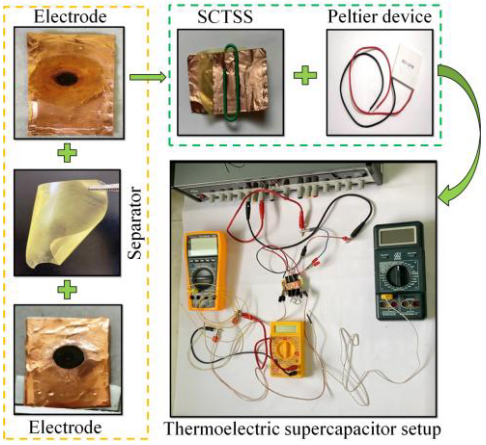

Fig. 2. Systematic of fabrication of self-charging thermoelectric symmetric supercapacitor.

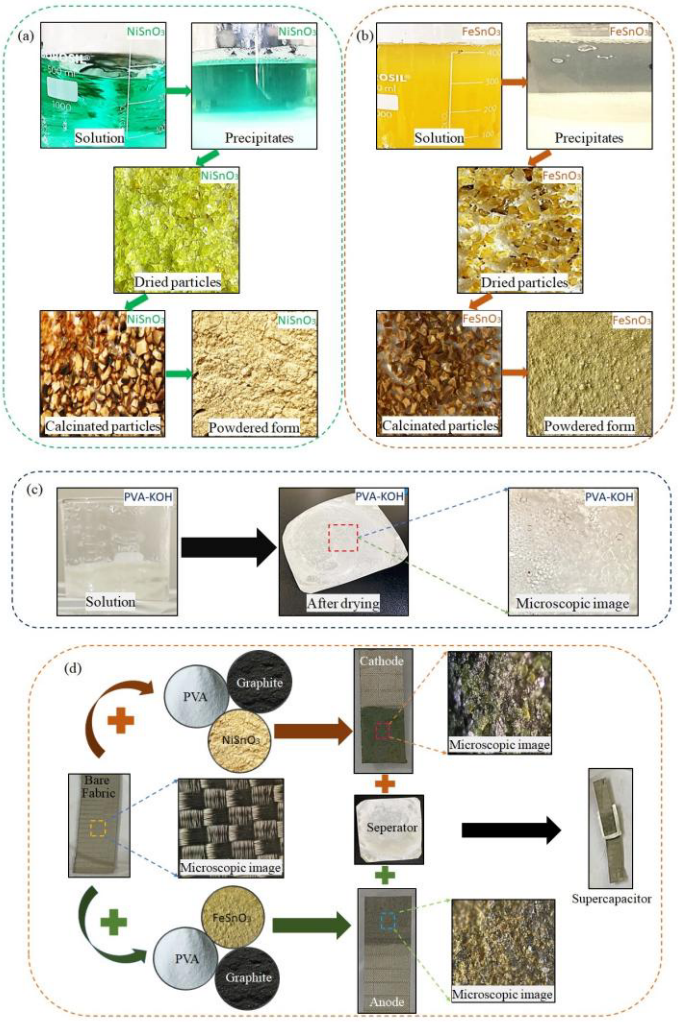

Figure 3: Sequential steps followed for- synthesis of (a) $NiSnO_3$ particles, (b) $FeSnO_3$ particles, (c) PVA-KOH gel electrolyte, and (d) fabrication of SCAPSC.

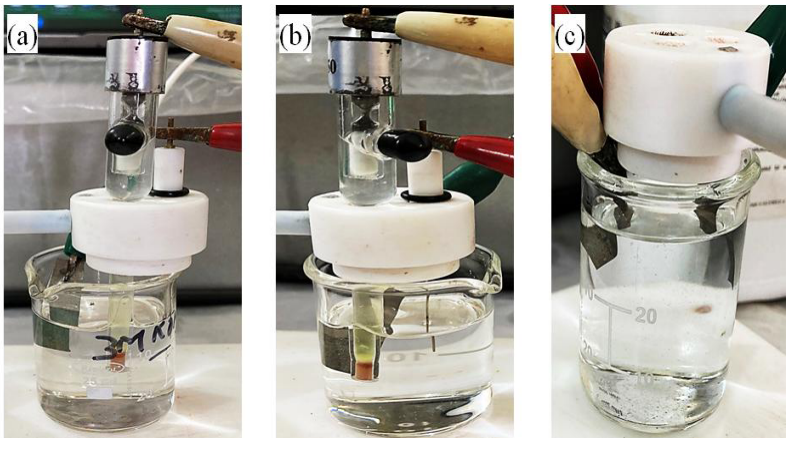

Figure 4: Three- electrode setup for (a) $NiSnO_3$-based electrode, (b) $FeSnO_3$-based electrode; (c) two-electrode setup for both electrodes in 3M KOH for electrochemical characterisations.

University of Jammu

UTILIZATION CERTIFICATE

It is certified that out of an amount of Rs.1,13,30,000/- sanctioned as grant-in-aid for **(13)** projects vide letter No. JKST&IC/SRSC-J/2019-20/792-97 dated 29/09/2021 to University of Jammu by JK Science, Technology & Innovation Council, Department of Science & Technology, Government of Jammu & Kashmir, out of which an amount of **Rs. 1,06,12,759/-** has been utilized for the purpose of "**Sponsored Research & Extension Programme**" for which it was sanctioned and an amount of **Rs. 9,87,521/-** that remains as balance including interest amount for **Rs.2,70,280/-** earned on the grant will be refunded to the funding agency.

Signature of Finance Office
University of Jammu

Head of the Institution
Registrar
University of Jammu

Auditor