# SUSTAINABLE MATERIALS, PROCESSES AND SYSTEMS FOR ENERGY TRANSITION

## 2D thermoelectric materials for wearable electronic

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| **Funded By** | C.N.R. - CONSIGLIO NAZIONALE DELLE RICERCHE [P.iva/CF:02118311006] |
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| **Context of the research activity** | 1. Synthesis and processing of 2D Transition-metal dichalcogenides (TMDCs) materials prepared by chemical vapor deposition (CVD) and electrochemical exfoliation techniques.<br>2. Characterization of the structure, morphology and thermoelectric (TE) properties of thin films based on 2D chalcogenides<br>3. Development of MEMS structure optimized for thermal conductivity measurements of films based on a few monolayers (MLs) of 2D materials. |
| **Objectives** | Scholarship funded by Consiglio Nazionale delle Ricerche – Istituto per la Microelettronica ed in Microsistemi Bologna (CNR-IMM Bologna)<br>Main seat to carry out the research: CNR-IMM (Bologna)<br>Supervisor: Fabiola Liscio (liscio@bo.imm.cnr.it<br><br>TE materials can directly convert thermal energy into electrical energy, making them essential elements for developing sustainable energy-efficient technologies. TE performance of the materials at a specific temperature T is evaluated by the dimensionless figure of merit ZT= sS2T/¿, where s, ¿ and S correspond to the electrical and thermal conductivity and the Seebeck coefficient, respectively. These parameters are strongly coupled each other and dependent on the material's band and crystal structure. It is very challenging to improve them without affecting negatively the others. Materials characterized by low dimensionality present several advantages and provide opportunities to overcome these limitations. The lower ¿ and a tunable band gap in 2D TMDCs offer excellent potential for TE applications with lightweight, flexibility, and competitive performance as compared to standard bulk TE materials.<br>The scope of this thesis will be to develop very thin films only few ML-thick of 2D TMCDs, with high ZT values, to be integrated into wearable electronic platforms.<br>The TE materials will be prepared using both CVD, providing 2D layers with high crystal quality and control over composition, orientation and thickness, and electrochemical exfoliation, which will allow the cost-effective and high-throughput deposition of 2D TMCDs on large area substrates at reduced thermal budget. |

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| | The structure and morphology of thin films will be investigated by X-ray diffraction and electron microscopy techniques.<br>Fine control of the TE parameters will be assured by performing a complete TE characterization (S, s and ¿) on the same sample using a unique chip beyond state of the art, which will be developed during the thesis. Indeed, ¿ measurements of films based on a few MLs of 2D materials are still challenging. Therefore, an innovative MEMS platform will be developed based on ultrathin dielectric membranes with the aid of specific design optimizations for the microsystem |

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| **Skills and competencies for the development of the activity** | • Perferrably Master degree in Physics or Chemistry<br>• Experience in laboratory<br>• Ability to work and think independently<br>• Motivation enthusiasm and passion |