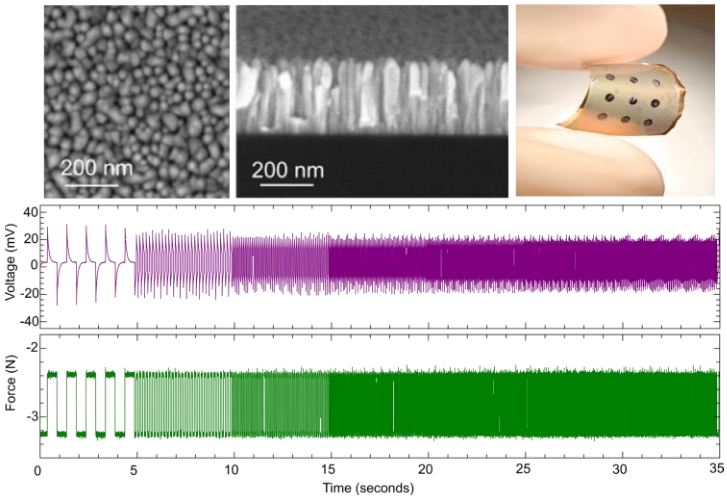
NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2024-2025

Title: Sputtering growth of ZnO for flexible piezoelectric energy harvesters

General Scope:



In recent decades, there has been significant progress in biomedical devices that can be implanted in the human body for diagnostic and treatment purposes. The miniaturization of these devices is critical to reduce their impact on human activities. However, these devices mostly rely on batteries which presents a challenge in reducing their size while prolonging their operational lifespan. Recent advancements in piezoelectric energy harvesters (PEHs) offer a solution for creating energy-autonomous devices by converting mechanical energy from human movements into electricity. Yet, traditional bulky-type energy conversion systems are not suitable for this application due to incompatible contact with soft tissue and curved surfaces. Therefore, thin, flexible, and lightweight PEHs are essential.

In the meantime, numerous research teams have focused on developing nanomaterial-based flexible PEHs. These devices not only generate electric power from tiny mechanical vibrations and irregular deformation but also can function as self-power sensors capable of detecting mechanical bio-movements. The challenge lies in selecting materials with high piezoelectric coefficients, with good flexibility and mechanical stability, for fabricating a fully flexible structure.

ZnO, a wurtzite piezoelectric semiconductor, is of high interest for this application as it is bio-compatible, and its relative ease of forming nanostructures on various substrates through standard, industrial-compatible growth techniques. Although hydrothermal growth is a simple and cost-effective technique for synthesizing ZnO nanostructures, it often results in impurities that degrade piezoelectric performance. Magnetron sputtering, the widely used deposition technique with reasonable running costs and feasibility of mass production, should offer higher quality ZnO material quality due to its high vacuum deposition conditions.

Research topic and facilities available:

In this work, we will focus on developing the sputtering growth and device processing to fabricate flexible ZnO PEHs. The student will explore the sputtering of ZnO on various substrates i.e. Si and copper foil by using the radio frequency sputtering technique. The objective is to synthesize high-quality ZnO in a controlled morphology and desired crystal orientations. The optimal growth conditions necessary to achieve ZnO nanocolumns and films with high piezoelectric coefficients will be determined. The student will investigate the structural, electrical, optical, and electromechanical properties of the ZnO films as a function of the deposition parameters. The comprehensive film characterization such as surface roughness, crystallography, piezoelectricity, and electrical resistivity will be performed with various techniques (SEM, AFM, PFM, electrical, etc) available at Néel Institute. In addition, the student will be involved in the development of flexible ZnO/polymer composite films through encapsulation and transfer processes. Together with the team, the student will participate in the large-scale characterization of electrical and electromechanical properties. The piezoelectric properties of ZnO will be studied and correlated with the electrical and electromechanical properties of large-scale piezo harvesters.

Possible collaboration and networking: Néel (NPSC, Optima, EpiCM) and CEA/Grenoble
Possible extension as a PhD: No funding is available, but we support the PhD grant applications.
Required skills: Material science, Semiconductors, Nanomaterials, Solid State Physics
Starting date: Feb./March 2024 (4-5 months), please apply 2 months before the starting date.

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