Piezoresistive Flexible Sensors Made from Functional Polymer Films Decorated with Conductive Nanoparticles for Smart Monitoring and Renewable Energy Applications

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Présentation du laboratoire d'accueil (ou Institut) et du PROJET

This project is part of an interdisciplinary and international collaboration bringing together experts in nanomaterials, sensor technology, and engineering from the University of Technology of Troyes (UTT, France), Eindhoven University of Technology (TU/e, The Netherlands) and Hanze University of Applied Sciences (HUAS, The Netherlands). It presents an innovative, integrated approach including design, fabrication, characterization, and integration of flexible sensors dedicated to wind turbine blade monitoring, aiming to advance smart monitoring and renewable energy research. The sensor will be composed from a functional polymer films decotrated with conductive nanoparticles. A new approach of fabrication will be developed during this internship based on additive manufacturing method combined with colloidals deposition of silver or gold nanoparticles.
The internship will take place at UTT in the clean rooms of the L2n Lab. The Reaserch Unit L2n is a laboratory associated with the CNRS (EMR 7004) whose activities are centered on nano-optics, a fast-growing field associated with numerous scientific, technological and socio-economic issues, including energy, telecommunications, health and safety. The aim is to observe, understand, manipulate and use light on a nanometric scale.
L2n is one of the largest teams in Europe working exclusively in nano-optics and nanophotonics, from fundamental developments to technology transfer and innovation. L2n relies on its Nanomat' technology platform (part of the RENATCH$^+$ network) and its NANO-PHOT Graduate School, particularly in nano-optics and nanophotonics.

Context of the project:
Wind turbines represent a key technology for the transition to renewable energy production. This clean energy sector requires condition monitoring to prevent unexpected shutdowns and economic losses. Sensor technology plays a vital role in early damage detection, measuring mechanical strain, movements, temperature, air pressure, and flow. While monitoring techniques for bearings and gearboxes have been adapted from other applications, suitable techniques for monitoring wind turbine blades are still lacking. Nevertheless, there is a growing interest in developing such techniques, especially those capable of measuring airflow during operation. Flexible pressure sensors have gained significant attention due to their potential applications in a range of promising fields, including human healthcare monitoring, smart robots, interactive electronic devices, among other possibilities. Therefore, embedded flexible sensors within wind turbine blades, particularly piezoresistive sensors, offer a promising solution for real-time detection of potential malfunctions. These sensors have been extensively studied and developed to measure strain and pressure based on piezo-resistivity (change in the electrical resistance when subjected to mechanical stress).
The long term target of this research and development project is to study the flow characteristics of the boundary layer, by measuring the velocity distribution.

DESCRIPTION DE LA MISSION

This internship offers an exciting opportunity to be part of this collaboration and contribute to the development of piezoresistive flexible sensors. As an intern, your primary objective is to develop sensors for potential integration into the surface of wind turbine blades. During the internship, you will be involved in the fabrication and characterization of pressure and/or flow sensors.
Fundamentally, piezoresistive pressure sensors comprise flexible substrate and conductive functional materials. The development of flexible electronics relies on the excellent conductivity exhibited by metal nanoparticles and nanowires, as well as carbon-based nanomaterials. Therefore, functional polymer films decorated with conductive nanoparticles will be synthesised and employed as the sensing element of the developed sensor. For the flexible substrate, polymer films with high flexibility, such as PDMS, PMMA, PET, PU, and PVC, are widely used to develop micro-sensors.
In essence, the sensor design will encompass a polymer coated with conductive nanoparticles (with silver being a potential choice) serving as the core sensing/functional element. This will be accompanied by upper and lower electrodes for electrical measurements, as well as top and bottom polymer substrates. Initially, your focus will be on exploring the potential applications of conductive nanoparticles, functional polymers, and the assembly of polymer-nanoparticle structures in flexible electronics, and how to make the best use of the available technologies to develop a viable sensing system.
A key aspect of the internship involves investigating the sensor repeatability and ability to detect various mechanical forces. Additionally, you will investigate its stability, durability, and response time. To achieve this, you will conduct structural, electrical, and mechanical analyses on the developed sensors. These assessments will help evaluate the sensors' performance for the specific application. Furthermore, the performance will be tested using a wind tunnel and the range and stability of sensor resistance changes under airflow will be explored (experiment available at HUAS).
This internship presents a dynamic experience in the pursuit of renewable energy solutions, providing a valuable platform to expand your knowledge and skills in the field of nanomaterials, sensor technology, and renewable energy applications. The internship will take place in the clean rooms of the laboratory of Light Nanomaterials & Nanotechnologies (L2n) in Troyes, France.

PROFIL RECHERCHÉ

We our looking for an MTE student with theoretical and practical knowledges of materials physics and chemistry, including photopolymers and metallic nanoparticles. Practical knowledge in additive manufacturing and surface functionalization is an added advantage.

MODALITÉS DE STAGE

Date de début de stage :	01/02/2024
Durée du stage :	*6* mois
Lieu de prise de poste :	UTT, Troyes
Niveau :	BAC +4/+5
Domaine :	*MTE*

Avis du Directeur d'unité

Avis :

Classement du DU x/x

Si le sujet est en lien avec la thématique d'un Institut, indiquer ci-dessous l'avis motivé du directeur de l'Institut concerné :

Classement x/x (classement Institut, quelle que soit l'UR)