Research Report

Researcher Name	Gospodinka GICHEVA
Home Institute	University of Mining and Geology "St. Ivan Rilski"
Nationality	Bulgarian
Host Researcher	Sergey KULINICH
Host Department	Tokai University, Research Institute of Science & Technology
Research Period	From: December 2020 To: June 2021
Research Field	laser ablation in liquids, metal oxide nanoparticles, biosensors

Research Theme at Tokai University

Title: Developement of biosensors based on nanomaterials prepared via laser ablation in liquid

Abstract:

Currently, only invasive methods are used both in Japan and worldwide for measurement of glucose level, for which blood is to be obtained by a needle. This is a rather painful procedure which causes discomfort for patients and takes time. Therefore, development of fast, flexible, wearable sensors for non-invasive sweat analysis is highly desirable for the society and is a real 'hot topic' nowadays.
The goal of this research project is to produce prototype wearable sensors for glucose and lactate detection in sweat with higher selectivity and sensitivity. The project combines expertise of two groups at Tokai University that develop nanomaterials produced via laser ablation in liquid phase and work actively on biosensors for medical applications. Based on this combination, a synergistic effect is expected in this short-term project, giving rise to prototype sensors with improved characteristics.
To achieve the above challenging goal, the following key progressive objectives should be met: (i) preparation of nanomaterials via laser ablation in liquid; (ii) their separation, characterization, surface-modification; (iii) fabrication of flexible and wearable sensing electrode; (iv) testing of the newly prepared sensors as detectors of glucose and/or lactate ions in sweat by performance of cyclic voltammetry measurements.

Results / Achievements:

Please write a summary of your research results / achievements. Also, please share your research papers/articles, books, poster presentations if there is any.

During the research period, the team managed to successfully prepare p-type metal-oxide nanoparticles (ZnO, SnO_2, and mixture thereof) using the method of laser ablation in liquid.
The newly obtained nanomaterials were characterized by a set of advanced chemical and surface-analysis and optical methods (XRD, SEM, XPS, UV-vis spectroscopy).
For the purpose of the study, a flexible poly dimethyl siloxane (PDMS) sheet with a thickness about 1 mm was prepared to serve as the basis of wearable sensor device. The team then designed a shadow mask which was later used to deposit contact electrodes Au/Ti or Ag via sputtering.
The electrodes were prepared as described below:
1) Drop-cast of Ag/AgCl ink which will play the role of reference electrode.
2) Sputtering of Pt metal which will serve as counter electrode.
3) Drop-cast of nanomaterial prepared by lased ablation which will serve as the working electrode.
The next step of the research plan involved preparation of solution that simulates artificial sweat (with different glucose concentrations) for testing the newly developed sensors. The team investigated the impact of ZnO, SnO2 and core/shell structures (and their properties) on the sensitivity and detection limit of glucose. Optimization of newly prepared sensors is planned as follow-up studies.