Affordable and Practical Technology for Fabrication of Electrochemical Biosensor Transducers – From Concept to Application

Vasa Radonic
Ivana Kundacina
Biosense Institute, Dr Zorana Djindjica 1, Novi Sad, Serbia
vasarad@biosense.rs

Abstract

Electrochemical biosensors enable rapid, sensitive, and selective detection of targets in small liquid samples. They integrate biorecognition elements such as antibodies, aptamers, or enzymes with electrochemical transducers. These sensors are low-cost, simple, and suitable for miniaturization. However, fabricating scalable gold electrodes remains challenging. Gold is ideal for biosensors due to its stability and affinity for thiol-modified biomolecules, but traditional fabrication methods—like chemical and physical vapor deposition, photolithography, and screen or inkjet printing—require cleanrooms, expensive equipment, and generate waste. They also produce thin or fragile films and often demand high temperatures, limiting substrate choices and increasing costs. This course introduces various fabrication techniques, including a novel, low-cost method using hot lamination of 24-karat gold leaf on PVC sheets, followed by laser ablation to define electrode geometry. These gold leaf electrodes (GLEs) offer high conductivity, enhanced surface area, mechanical durability, and reproducibility. We will demonstrate their characterization using SEM, 3D profiling, contact angle measurements, and electrochemical techniques like cyclic voltammetry and impedance spectroscopy. Various functionalization strategies will also be explored, confirming compatibility with aptamers, antibodies, and bacterial proteins. Applications include single and multiplex biosensors for detecting pathogens, heavy metals, and tumour biomarkers. Finally, we propose a strategy to reduce nonspecific binding and matrix effects, improving accuracy in complex samples. This accessible and scalable approach addresses key fabrication challenges, advancing the use of electrochemical biosensors in environmental monitoring, healthcare, and food safety.

References

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Figures

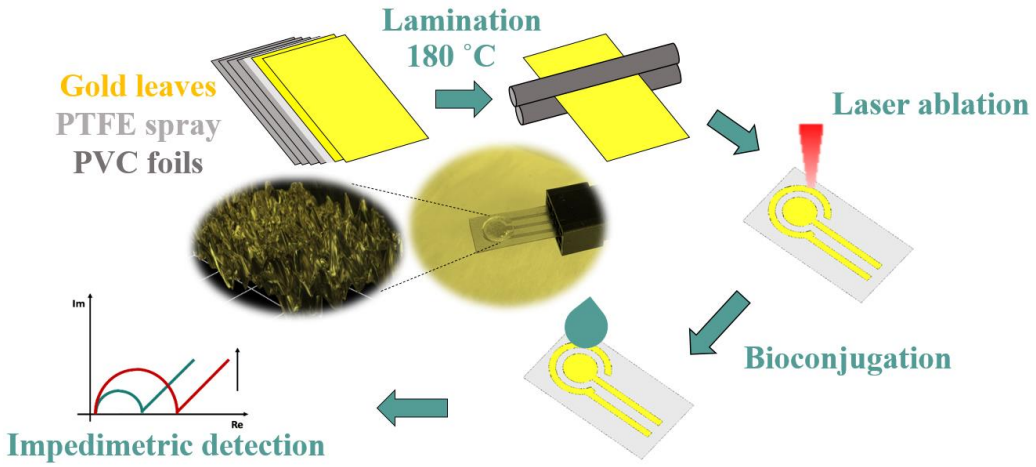

Figure 1: Fabrication and electrochemical characterization of gold leaf electrodes with high surface roughness.