VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Mehdi Feizpour**

The public defense will take place on **Monday 31st March 2025 at 4pm** in room **D.2.01** (Building D, VUB Main Campus)

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SERS-BASED LAB-ON-A-CHIP FOR MACHINE-LEARNING-ENABLED BACTERIAL SCREENING

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Abstract of the PhD research

Bacteria are ubiquitous in our environment, frequently encountering us through food, air, and medical procedures. While many bacteria are harmless or beneficial, pathogenic bacteria can cause severe infections, such as cerebrospinal fluid infections and hospital-acquired pneumonia (HAP). Accurate bacterial detection and identification in clinical samples are crucial for diagnosis, prognosis, and targeted antibiotic treatment. Traditional methods, including culture-based techniques, PCR assays, and MALDI-TOF-MS, are widely used. Although quantitative PCR (qPCR) provides results within hours, it remains too slow for critical conditions like HAP. MALDI-TOF-MS is favored for its speed and cost-effectiveness but is destructive and unsuitable for dynamic sample analysis or bacterial screening. The lack of rapid, cost-effective diagnostic tools often necessitates broad-spectrum antibiotic use, contributing to increased morbidity, mortality and antibiotic resistance.

Emerging technologies, such as colorimetric sensor arrays and electrochemical impedance spectroscopy, are being explored to address these challenges. Raman spectroscopy offers non-invasive, non-destructive bacterial screening via chemical fingerprinting. However, its inherently weak signal requires enhancement techniques like Surface-Enhanced Raman spectroscopy (SERS). While SERS shows promise for bacterial identification, challenges with stability, reproducibility and selectivity remain. Innovations in microfluidics integration, surface functionalization, machine learning processing, and surface tailoring are being investigated to overcome these limitations.

This PhD research aims to develop planar SERS substrates tailored for bacterial detection in their natural environment. Integrated within microfluidic chips, these substrates provide high control over bacterial suspensions. To enhance sensitivity and efficiency, SERS spectra are processed through a machine learning pipeline to identify optimal classifiers. The resulting SERS-integrated optofluidic platform enables stable, reproducible, and sensitive identification and screening of bacteria in complex samples, such as cerebrospinal fluid. This platform holds great potential to improve our understanding of bacterial biochemical interactions, reduce antibiotic susceptibility test turnaround time, and aid in the development of new antibiotics.