Next-Generation Sepsis Diagnostics: Cutting-Edge Advances in Integrated Photonics

Early and accurate sepsis diagnosis remains one of the most critical challenges in modern healthcare. Incorporating the detection of blood protein biomarkers into routine clinical assessment, alongside identification of active infection, is expected to improve both diagnostic accuracy and patient outcomes. Recent advances in integrated photonic sensing are paving the way for rapid, sensitive, and multiplexed detection of sepsis-related targets. This edition highlights the latest breakthroughs from our research teams within the EU project AMBROSIA, showcasing technological progress on photonics chips characterization as well as first steps on the surface biofunctionalization and biosensing measurements with microfluidics for real-time monitoring.

Technical insights in Photonic Biosensing

The AMBROSIA consortium has developed a new bimodal plasmo-photonic sensor that combines the advantages of plasmonic enhancement with interferometric detection. This architecture enables strong light-matter interaction through aluminium-based plasmonic structures, resulting in sensitive and label-free biosensing capabilities that are well-suited for point-of-care diagnostics. Characterization of the plasmo-photonic sensors demonstrates extremely high refractive index sensitivity, validating both the design and fabrication strategy. The bimodal waveguide approach supports robust signal interrogation while maintaining compatibility with integrated photonics manufacturing processes. These advances significantly expand the potential of photonic sensors for sensitive and precise diagnostics.

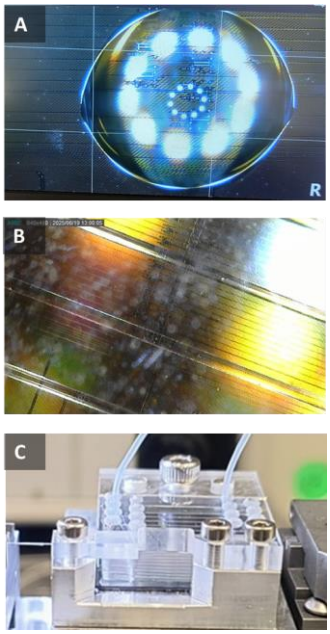

Figure 1. (a) Biofunctionalization of bimodal waveguides sensors; (b) Microfluidic aligned with sensors; (c) AMBROSIA approach for targets monitoring.

Detection of Sepsis Relevant Targets

The potential of the novel plasmo-photonic technology for biosensing is being assessed by the researchers of ICN2, focusing on developing reliable biofunctionalization strategies that employ specific receptors (antibodies) for several biomarkers. The surface chemistry adopted by our team ensures selective biomarker recognition, preserving the bioreceptor integrity, a crucial step toward real-sample testing and clinical translation. The plasmo-photonic sensor

has successfully demonstrated label-free detection of *Pseudomonas aeruginosa* and MRSA PBP2a surface protein under standard laboratory conditions, reaching few cfu/mL and detectability in the low ng/mL range for antigens. These promising results underscore the potential of the technology for early sepsis detection, including pathogen identification and antimicrobial resistance profiling.

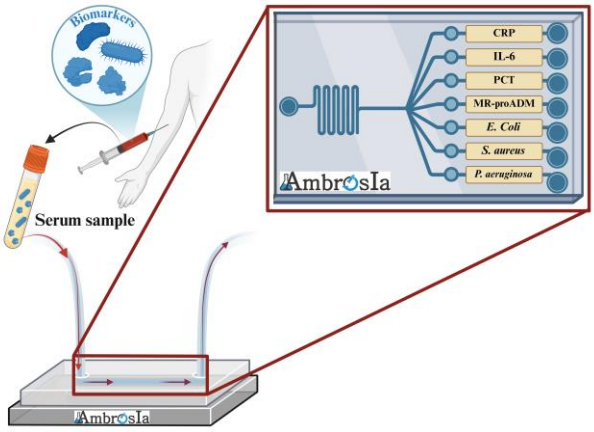

Figure 2. Representation of the AMBROSIA approach for sepsis diagnosis.

A key element in the sensor performance is a carefully optimized surface biofunctionalization strategy. In our case, the sensor surface was chemically modified with a silane layer, enabling the stable immobilization of specific antibodies. These antibodies selectively recognize the target proteins/bacteria in the detection assays. To minimize nonspecific interactions on the surface and ensure high analytical performance, the remaining reactive regions were thoroughly blocked through the addition of appropriate blocking agents. This controlled and reproducible functionalization process is essential for achieving reliable biosensing responses.

Ongoing research is focused on evaluating the detection of other prevalent bacteria and the panel of sepsis biomarkers, including protein-related ones such as C-reactive protein (CRP), Interleukin-6 (IL-6), midregional proadrenomedullin (MR-proADM), and procalcitonin (PCT). Another key step involves refining the established detection protocols in human serum. This phase is critical for evaluating sensor performance under clinically relevant conditions and for defining standardized procedures for future diagnostic applications.

Broader Implications for Sepsis Diagnostics and Outlook

By combining plasmonic enhancement with integrated photonic design, the proposed technology offers a promising approach to faster and highly sensitive sepsis diagnostics. The continued progress achieved within the AMBROSIA consortium highlights the transformative potential of integrated photonic technologies in clinical diagnostics. As we move forward, our teams remain committed to advancing sensing performance, and accelerating the transition toward a practical, point-of-care device for sepsis diagnosis.

About AMBROSIA

Duration:
Jan 2023 – Dec 2026 (48 Months)

Coordinator:
Aristotle University of Thessaloniki

Project website:
URL: http://ambrosia-h2022.eu/

Social Media:

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