iGii

The Future of Biosensing

Bioelectronics, biocomputing and photovoltaic cells

Introduction

As global healthcare shifts toward precision medicine and decentralised diagnostics, the role of biosensors has evolved from simple analytical devices into intelligent systems capable of real-time, autonomous decision-making.

This transformation is being driven by the convergence of three technological domains; bioelectronics, biocomputing and photovoltaic energy harvesting.

This convergence is made possible by recent material science breakthroughs, particularly the maturation of carbon-based nanomaterials which combine electrical conductivity, biocompatibility and surface adaptability in a single platform. These advances are enabling biosensors that are ultra-sensitive, robust and capable of embedding decision logic (biocomputing) and sustaining long-term operation without external power sources (photovoltaics).

Together, these innovations are setting the stage for biosensors that can manage energy and data transmission whilst being implanted into the human body or integrated into wearable systems.

Biocomputing interfaces – from data to action

As biosensors become more complex, the ability to interpret data at the point of measurement becomes critical. This is where biocomputing plays a key role as the integration of embedded computational logic within the sensing platform itself.

In traditional biosensor architectures, raw data is transmitted to external systems for interpretation. This model introduces latency and dependency on connectivity. Biocomputing aims to localise that intelligence, **enabling biosensors to perform on-board signal processing, data filtering and even basic decision-making**.

Such functionality is particularly useful in multiplexed systems where multiple biomarkers must be assessed simultaneously. For example, in immunosensor platforms designed for cardiac, inflammatory or infectious disease markers, embedded logic can prioritise outputs, detect anomalies or trigger alerts based on pre-programmed thresholds.

Additionally, biocomputing enables integration with actuation systems, such as drug delivery modules or electrical stimulation devices. This opens up the possibility of closed-loop therapeutic systems where sensing, decision-making, and intervention occur in real time without human oversight.

Photovoltaics for self-powered sensing

The integration of photovoltaic elements into biosensors is redefining what is possible in autonomous diagnostics. Powering biosensors has historically been a limiting factor, particularly in miniaturised or implantable systems where battery inclusion is impractical. Photovoltaic (PV) cells offer a compelling solution, enabling energy harvesting from ambient light to support continuous operation without external power sources.

Recent research has shown that **thin-film or flexible PV modules can be co-fabricated with electrochemical sensors, creating a compact, self-sustaining diagnostic unit**. These integrated systems can generate sufficient energy to power the sensing mechanism as well as low-power electronics for signal processing and wireless transmission. When coupled with energy-efficient transduction methods such as impedance spectroscopy or quantum capacitance-based sensing, the result is a biosensor that is truly self-sufficient.

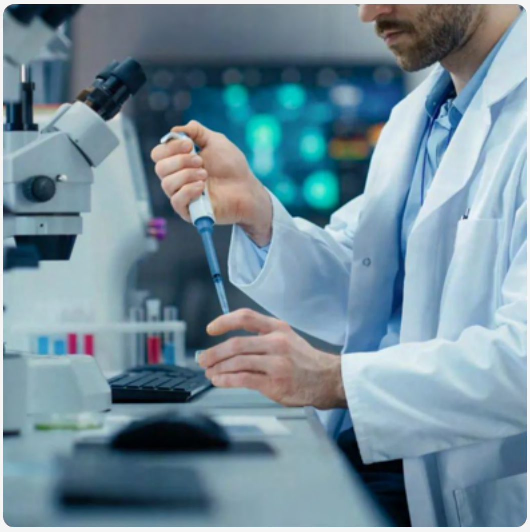
This innovation has particular relevance in low-resource or off-grid contexts, as well as for wearable health monitoring where uninterrupted functionality is essential. For instance, stress biomarker detection using salivary cortisol sensors powered by ambient light becomes feasible with this configuration, enabling continuous, passive health monitoring without user intervention.

New carbon-based transducers as enablers of intelligent biosensors

New carbon-based transducers are redefining the possibilities for next-generation biosensing, offering a combination of high sensitivity, structural flexibility and chemical versatility that outperforms many traditional electrode materials. Unlike standard carbon inks or noble metals, these advanced transducers are typically three-dimensional, highly porous and possess a surface architecture that supports efficient electron transfer and high analyte interaction.

One of their key advantages is the ability to undergo functionalisation without compromising their electrical or mechanical performance. Conventional chemical treatments, such as oxidation, often introduce structural defects that degrade conductivity. This balance between structural integrity and chemical adaptability can lead to the creation of biosensors capable of ultra-sensitive detection in physiologically relevant matrices.

Equally important is the mechanical compliance of these new carbon-based transducers. These carbon-based materials can be integrated into flexible formats without loss of function, making them ideal for skin-mounted wearables, implantable systems and fluidic devices that operate in dynamic biological environments. They retain signal fidelity over repeated use, and their anti-fouling properties further enhance their suitability for long-term monitoring applications.



Biocompatibility ensuring safe and effective biosensing

The convergence of energy harvesting, embedded computation and carbon nanomaterial-enabled sensing has the potential to unlock entirely new application domains across healthcare, biotechnology and environmental monitoring.

Neural interfaces

Flexible, biocompatible biosensors that can be implanted or placed on the cortical surface to monitor neurotransmitters or inflammatory markers in real time are already in medical trials. Systems using new carbon-based nanomaterials are particularly well suited for this due to their high signal-to-noise ratio and low impedance, enabling long-term and stable interfacing with neural tissue.

Wearable and implantable diagnostics

Self-powered sensors that continuously monitor stress hormones, inflammation markers or metabolic states are becoming increasingly viable. These devices can provide early warnings for clinical deterioration, guide therapy adjustments or simply offer insights into personal health rhythms. Their low power draw and high sensitivity make them ideally suited for integration into consumer health platforms or clinical monitoring systems.

Environmental and food safety monitoring

Portable, multi-analyte sensors based on carbon-based nanomaterials are being explored for detecting pathogens, toxins or spoilage markers in food and water. Their robustness and ability to function in complex matrices make them highly attractive for on-site testing in agriculture, manufacturing, or disaster response scenarios.

Unlocking the full potential of carbon nanomaterials for biosensing

Developing high-performance biosensors demands materials that are sensitive, reproducible and scalable. Gii delivers this on all fronts by offering high surface area, excellent conductivity and anti-fouling properties for reliable signal clarity.

Unlike noble metals or standard carbon electrodes, Gii is sustainably produced, highly reproducible and supports non-covalent functionalisation strategies that preserve its electrochemical integrity. This enables streamlined development of robust, label-free sensors across a wide range of diagnostic formats.

For innovators seeking a material that meets scientific and commercial demands, Gii is the definitive choice. It enables faster development, better performance, and secure, scalable supply through the iGii platform.

Choosing the right material for your biosensing application

Each biosensor material has unique strengths and trade-offs. Noble metals provide reliability and sensitivity but come at a high cost. Graphene offers versatility, yet production challenges persist. Other nanomaterials bring innovative functionality but may present biocompatibility or scalability issues.

The choice of biosensor material ultimately depends on the specific application, required performance metrics, and commercial viability. Emerging solutions, such as Gii, are set to redefine biosensor development, making high-performance, cost-effective, and scalable biosensors a reality.

For those seeking to balance sensitivity, cost, and scalability, novel carbon-based nanomaterials like Gii provide a compelling alternative to traditional noble metals, overcoming many of their limitations. If you are developing biosensing technologies and looking for the optimal material, now is the time to explore these next-generation solutions.

Get in touch today