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EDITORIAL

Focus on sensor interfaces

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Sensors are a diverse and well-established element of the analytical science armoury. They provide both a research focus and new routes to viable analysis. Their impact is particularly significant for the biological sciences and within biomedicine. The archetypal pH sensor—now so taken for granted—and the first-generation electrodes for pO_2 and pCO_2 have delivered crucial measurements for decades at clinical point of care in acute medicine. Together with electrolyte sensors, these now constitute a commercial market worth billions of euros. What is remarkable is that for most of these devices, the inherent sensor chemistry has remained unchanged—a testament to pioneers such as Leland Clark and John Severinghaus. Why have many of these fundamental designs survived so unscathed into the modern era? Beyond any transduction principle used, or chemistry sophistication, what was really understood back then was that it was the correct construction and interfacing of the functional elements that mattered. The chemistry was not always new; it was the additional barrier and component interactions that needed to be refined for practical optimisation. This applied both to the device itself and to the interface between it and the biological matrix, since the latter influences performance and is rightly considered a part of the sensing cascade.

As regards to more recent technical developments, sensor research has not just evolved new transduction mechanisms; it has also established methods to integrate different interactive phases that together make up the eventual, monolithic device—essentially a refinement of interfaces. These phases have been variously solid/solid, as in ion-selective field-effect transducers (ISFETs); solid/liquid, as in traditional ion-selective and gas sensors with internal electrolyte; monomolecular layers on solid surfaces, as in optical waveguides. In all cases, the interface has an important conditioning effect on reactivity and affinity.

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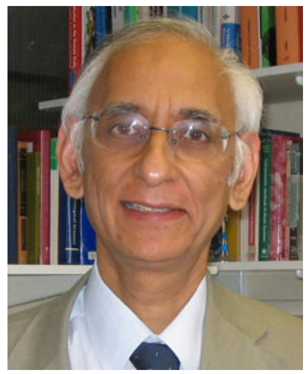
A need to remain attentive to the interface issue at sensors has not gone away. Despite decades of research effort, our understanding here is fragmentary. Certainly, we have learned to harness multiple, complex phases for measurement, but it can also be argued that such efforts still border on the empirical. This really is a measure of the challenge presented by fundamental problems, which can go unrecognised. The world of clean-room physics has well highlighted the scale of this challenge, encapsulated in Wolfgang Pauli's remark that "surfaces were the work of the devil". What we do have now, however, is a surge of precision forming technologies which allow more predictable structures to be made and ultimately better understood. Help has come from multiple domains: coating and film technology, molecular engineering, self-assembly, surface patterning, nanofabrication and microsystems technology (MST), among many.

The advent of biosensors has additionally given sensors an extended analytical reach and has catalysed interest, but they now provide potent examples of new interfacial processes. So, while practical analysis has been extended to organics of increasing complexity, taking in metabolites through proteins/peptides to nucleic acids, the incorporated biointerfaces, and their internal cross-talk, has allowed for further insights into sensing interfaces generally. Many generic aspects of these transcend the individual sensing modality, be it potentiometric, electrochemical, optical or microgravimetric. A better way to understand this area for the future is to encapsulate it as *common processes, diverse manifestations*.

The importance of interfaces for sensing can be ascribed not only to the presence of structural discontinuities in a sensor, but now to a new era of extreme miniaturisation. With the advent of nanowires and other nanostructures for sensing, surfaces begin to play an even greater part in performance. Quite new transduction possibilities have been identified, including surface-induced impedimetric change at nanowires and mechanical stress at microcantilevers. Scaling down size in this way is certainly a technical sophistication, but makes it more difficult to deal with the interface, especially that with the biomatrix. The latter presents a scale of interfacial colloidal and cellular assault on the sensor which in the past could be limited by say a protective interface—a polymer, but with nanodevices the barrier itself can become intrusive. So again, the premium is on a better understanding of the interface; adventitious bioreactions from the sample matrix will then also be better understood, and hopefully alternative routes set up to improve biocompatibility. One exciting prospect is that, as size diminishes, there will be common cause with nanomaterials science—already grappling with such problems—to accelerate progress. However, the resolution of analytical challenges, stability, sensitivity, selectivity, and so on will remain the domain of the specialist sensor researcher. Progress in interfaces would especially benefit continuous monitoring sensors; not only is there particular biological value in undertaking real-time monitoring, but it is a distinctive feature of a sensor capability.

This special issue provides a mix of original articles and short reviews and gives a snapshot of how inroads are being made into questions about the interface by way of sensor research. The various articles cover micro/nanostructured interfaces, the liquid–liquid interface, biolayers and different transducer embodiments, together with descriptions of biomatrix-related challenges. Indirectly, they set out elements of the puzzle that is the interface, which—if understood in a more fundamental way—could pay dividends for both fundamentals and applications.



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