GUEST EDITORIAL

Advances in Microfluidic Biosensing Applications

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MICROFLUIDICS IS A PROminent technology used for revolutionizing bioassays through miniaturization and integration and by utilizing several unique phenomena at the micrometer and nanometer scales. Over the past decade, microfluidics has been instrumental in the field of biosensing due to its high precision in fluid handling and superior signal-amplification capabilities. Microfluidics allows for parallelization and multiplexing in bioassays with exceptionally high sensitivity and rapid quantifications. Hence, microfluidics is a promising technology for advancing biosensing techniques and approaches.

For this special issue of *IEEE Nanotechnology Magazine*, four teams of leading researchers in their respective fields were invited to report on recent advances in microfluidics as well as integration for biosensing applications. An important step in sensing is the efficient extraction and purification of biomolecules, such as proteins. In the first article, Ruba Khnouf and Crystal Han discuss microfluidic immunoassays coupled with isotachophoresis, a promising method for protein extraction, purification, and quantification. Isotachophoresis-based microfluidics increases sensitivity and enhances the limit of detection, which is achieved by accelerating the protein-antibody interaction. However, the technology is still in its infancy, and additional developments are required. The authors consider the opportunities and limitations of the technology and summarize the improvements required for achieving the multiplexed sensing of several proteins, which ultimately can be utilized for diagnostics.

In general, a major challenge in diagnostics originates from the low concentration of biomolecules within the sample; therefore, preconcentrating biomolecules prior to sensing is a must. Integrating microfluidics with preconcentration methods is an interesting approach used for ultrasensitive measurements. Jongmin Kim, Sarah Sahloul, Ajymurat Orozaliev, Vu Q. Do, Van Sang Pham, Diogo Martins, Xi Wei, Rastislav Levicky, and Yong-Ak Song summarize the integration of electrokinetic methods with microfluidic point-of-care platforms for enhancing biosensing capabilities. The authors examine microfluidic on-chip ion concentration polarizations and present the technology's capability for multiplexed biosensing. Further, they demonstrate the technology as a liquid biopsy approach used with early cancer diagnostics, which is realized by preconcentrating microRNA and exosomes on hybridization microarrays.

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Aside from creating ultrasensitive microfluidic biosensing platforms, an interesting method utilized for developing cheap and disposable diagnostic tools suitable for use in low-income communities, or perhaps for home use akin to pregnancy tests, has also evolved. In the next article, Priyanka Naik, Siddhant Jaitpal, and Debjani Paul track the history of paper-based protein assays and examine the advances in paper-based microfluidics used for different inexpensive biosensing applications, including DNA analysis, cell cultures, and blood diagnostics. The authors highlight clinical validations and discuss the challenges and future outlook of the technology.

Finally, a current hot topic in the field is label-free and real-time biosensing, where biomolecules can be quantified in real time without using preprocessing steps; thus, the dynamics of biosystems can be revealed without the use of artificial alterations. The final article, by Chuanyu Wang, Yuxin Cai, Alana MacLachlan and Pengyu Chen, evaluates advances in the integration of microfluidics using novel nanoplasmonic components for label-free ultrasensitive biosensing. The authors summarize innovations in microfluidic plasmonic sensing platforms, highlight diagnostic applications in immune cytokines detection, and discuss the method used for achieving integrated nanoplasmonic microfluidic biosensors for multiplexed real-time measurements in clinical samples.

This issue of *IEEE Nanotechnology Magazine* reviews recent developments in microfluidic biosensings and provides a future outlook for the field. We hope to see the additional progress of microfluidic biosensing platforms empowered by the continued utilization of nanotechnology advances. The next issue of *IEEE Nanotechnology Magazine* will focus on recent improvements in microfluidic automation and manipulation. N

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