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Department of Bioelectronics

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Nanobio engineering for medicine of the future

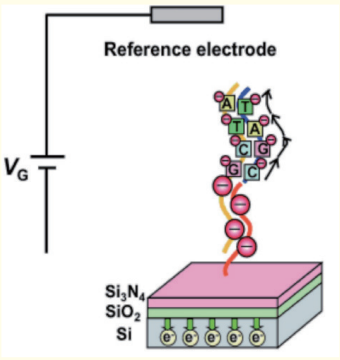
1. **Bioelectronics for next-generation DNA sequencing**
2. **Devices for early cancer diagnosis**
3. **Organic bioelectronics for point-of-care testing**
4. **Smart gel-based "Artificial Pancreas" to treat diabetes**
5. **Quantitative dental caries diagnosis by micro pH sensor**
6. **Detection of extracellular nano-particles for liquid biopsy**
7. **FET-based gas sensors for VOCs for healthcare**
8. **Design and synthesis of functional molecules**

1. Sakata T, Miyahara Y: DNA sequencing based on intrinsic molecular charges, Angew Chem Int Ed 45(14), 2225, 2006.
2. Matsumoto A, Sato N, Sakata T, Yoshida R, Kataoka K, Miyahara Y: Chemical-to-electrical-signal transduction synchronized with Smart Gel volume phase transition", Adv Mater 21(43), 4372, 2009.
3. Goda T, Toya M, Matsumoto A, Miyahara Y: Poly(3,4-ethylenedioxythiophene) bearing phosphorylcholine groups for metal-free, antibody-free, and low-impedance biosensors specific for C-reactive protein, ACS Appl Mater Interfaces 7(49), 27440, 2015.
4. Matsumoto A, Tanaka M, Matsumoto H, Ochi K, Moro-oka Y, Kuwata H, Yamada H, Shirakawa I, Miyazawa T, Ishii H, Kataoka K, Ogawa Y, Miyahara Y, Suganami T: Synthetic "Smart Gel" provides glucose-responsive insulin delivery in diabetic mice, Sci Adv 3(11), eaaq0723, 2017.
5. Ratanaporncharoen C, Tabata M, Kitasako Y, Ikeda M, Goda T, Matsumoto A, Tagami J, Miyahara Y: pH mapping on tooth surfaces for quantitative caries diagnosis using micro Ir/IrOx pH sensor, Anal Chem 90(7), 4925, 2018.

By studying the interaction between biomolecules such as DNA, proteins and cells, and semiconductor materials and devices, our research focuses on detection of biomolecules and their functions. Our interdisciplinary research involves materials science, chemistry, device technology and medicine, and its output centers on the development of highly-sensitive biosensors while also providing bases for exploring the imminent future of medicine, including homecare and telemedicine.

Next-generation DNA-sequencing technologies

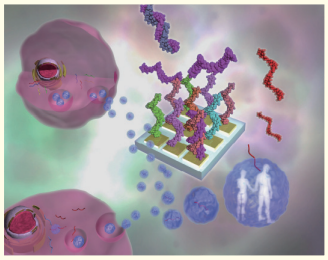
Changes in the charge density on a solid surface as a result of DNA-DNA hybridization is transduced into the potentiometric signal of a field-effect transistor (FET) device. A single-base change was detectable by coupling with primer extension reactions on the gate. This approach allowed for detection of single nucleotide polymorphism (SNP) and even DNA sequencing.



Semiconductor-based DNA sequencing

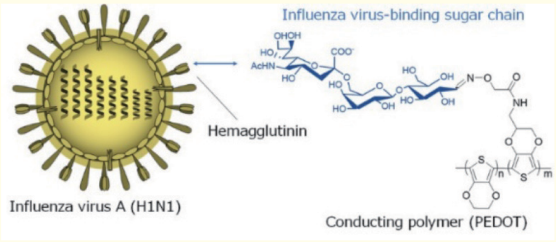
Devices for early cancer diagnosis

A gold electrode surface serving as an extended gate was chemically modified with self-assembled monolayers (SAM) of alkanethiol with different termini. Potentiometric signals for adsorption of proteins on the SAM layer can be detected and investigated quantitatively. Specific recognition of proteins is also possible using antibodies and other capturing molecules.



Conducting polymer-based biosensing and bioelectronics for ubiquitous testing

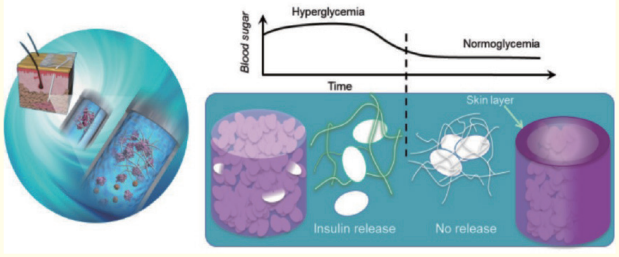
Conductive polymers possess electronic and ionic conductivities in biological environments. They are attractive materials for point-of-care applications because of their processability and mass productivity. By attaching bioreceptors to the polymers, they can be used for specific biosensing.



Functionalization of conducting polymers for biosensing

Smart gel-based "artificial pancreas" for the treatment of diabetes

A new paradigm for developing an inexpensive and easy-to-access type of artificial pancreas can better address the well-recognized unmet medical needs in diabetes. These needs include long-term glycemic management, avoidance of hypoglycemia and improvement of patients' quality of life.



Schematics of smart gel-based "artificial pancreas"