High-Throughput and Ultra-Sensitive Optical Bio-Nanosensors

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Abstract

New healthcare initiatives, such as personalized medicine, point-of-care and early disease diagnostics require breakthrough developments in biosensing technologies. Unfortunately, current biosensors are unsuitable because they are time consuming, costly, bulky and require advanced infrastructure and trained professionals. To meet the needs, Altug's lab (BIOS) is developing cutting edge on-chip optical bio-detection and spectroscopy systems by exploiting nano-scale photonics, nano/microfluidics, and nanotechnology.

In a recent work, BIOS introduced a high-throughput and label-free protein microarray technology with nearly one million sensor elements that enable reliable and quantitative detection of biomolecules. By coupling wide-field plasmonic arrays with a lens-free computational on-chip imaging they demonstrated hand-held, lightweight and low-cost diagnostic tools for point-of-care applications. The sensor is based on metallic nanohole arrays and exploits highly sensitive plasmonically enabled extra-ordinary optical transmission. BIOS showed that such optical sensors can detect live and intact viruses in biological media at medically relevant concentrations. By uniquely integrating nanofluidics and nano-optics on the same platform, they introduced a method to overcome mass-transport problem severely limiting sensor performance at low-analyte concentration and dramatically shortened required detection time.

BIOS is also working on an ultrasensitive and label-free mid-infrared biosensors which can fingerprint vital biomolecules such as proteins and lipids by accessing their chemical specific absorption bands. Engineering sculptured on-chip infrared nano-antennas that support strong light-matter interactions, the lab demonstrated that fundamental Beer-Lambert law can be overcome and the weak protein absorption signals can be enhanced by more than 10,000 times. By using extreme field concentration of nano-optics, BIOS showed real-time and in-situ monitoring of biomolecular interactions from ultra-low quantities of molecules. BIOS's technologies are opening up new paradigms in ultra-sensitive vibrational spectroscopy for biology.

BIOGRAPHY:

Hatice Altug received her Ph.D. degree in Applied Physics from Stanford University in 2007. In 2013, Dr. Altug joined EPFL as an associate professor of Biomedical Engineering. From 2007 to 2013, she has been a professor at Boston University Electrical and Computer Engineering and Biomedical Engineering departments. Dr. Altug is the recipient of Optical Society of America Adolph Lomb Medal, U.S. Presidential Early Career Award for Scientists and Engineers (PECASE), U.S. Office of Naval Research Young Investigator Award, U.S. National Science Foundation CAREER Award, Massachusetts Life Science Center New Investigator Award, IEEE Photonics Society Young Investigator Award. She received Intel Graduate Student Fellowship, IEEE Photonics Society Graduate Student Fellowship. She is the winner of the Inventors' Challenge competition of Silicon Valley in 2005, best paper and research excellence award by IEEE Photonics Society in 2005. She has been named to Popular Science Magazine's "Brilliant 10" list.