Advanced Bio Photonics: From Lasers to Biochips

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INTRODUCTION

The field of biomedical photonics has recently experienced an explosive growth due to the non-invasive or minimally invasive nature and the cost-effectiveness of photonic modalities in medical diagnostics and therapy. We describe the development of advanced photonics technologies including laser-induced fluorescence (LIF) spectroscopy, biosensors and biochips for medical diagnostics.

METHODS AND RESULTS

The optical diagnostic procedure based on LIF was developed for direct *in-vivo* cancer diagnosis without requiring biopsy. Laser-induced fluorescence (LIF) measurements were conducted during routine gastrointestinal endoscopy examinations of patients. The fiberoptic probe was inserted into the biopsy channel of an endoscope and lightly touched the surface of the tissue being monitored. The system was programmed to measure the fluorescence of the target tissue for each laser pulse. The LIF measurement was completed in approximately 0.6 second for each tissue site. We have developed a technique using the differential normalized fluorescence to enhance small but consistent spectral differences between the normal and malignant tissues. The results of this LIF approach were compared with histopathology results of the biopsy samples and indicated excellent agreement (98%) in the classification of normal tissue and malignant tumors of gastro-intestinal cancer in clinical studies involving over 100 patients.

The biochip is a novel device based on integrated circuit (IC) microchips using biological probes designed to detect specific medical gene biomarkers of disease. We have developed a novel integrated Multi-functional Biochip (MFB) which allows simultaneous detection of several disease end-points using different bioreceptors such as DNA, antibodies, enzymes, cellular probes) on a single biochip system. An important element in the development of the MFB involves the design and development of an integrated circuit (IC) electro-optic system for the microchip detection elements using the complementary metal oxide silicon (CMOS) technology. Probe recognition is based on the nucleic acid hybridization process (DNA probes) as well as on the immunological binding process (antibody probes). Biologically active probes are directly immobilized on optical transducers, which allow detection of fluorescent probe labels. The biochip has been developed to detect the gene fragments of *Tuberculosis* and the HIV gene system as well as the *p53* and *FHIT* proteins.

CONCLUSION

Lasers and microchips are important technological developments that have significantly accelerated the evolution of biomedical photonics. While the laser has provided a new technology for excitation, the miniaturization and mass production of integrated circuits, sensor devices, and their associated electronic circuitry made possible by the microchip has radically transformed the ways detection and imaging of molecules, tissues, and organs can be performed *in vivo* and *ex vivo*.