Miniature Multifunction Fluorescence Sensors on *Si* Substrates

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THE ISSO MINIGRANT PROJECT COMPLETED IN 2003 resulted in the development of a new III-nitride and *Si*-based compact sensor prototype device for measurement of variables in gaseous and liquid solutions. Additional external funding of the project completed development and fabrication of the chip-based multifunctional multi-wavelength optoelectronic chemical sensor. The most important features of this device are the miniature size (less than 10 mm diameter) and employment of nitride-based chips as both multi-band sources and photodetectors. Such a design removed the need for optical filters that significantly increase size and reduce stability of the sensor.

Capabilities of the sensor to detect and characterize various analytes are based on absorption, scattering, and fluorescence measurements that can be performed using different chip combinations. Signal patterns generated by different chip combinations are unique and are determined by the optical properties and concentration of the specific analytes.

Seven nitride-based 300 × 350 μm LED/photodetector chips with wavelengths in the range from 425 nm to 575 nm (Fig. 1a) were assembled and micro-bonded to an optically transparent substrate which was fabricated by coating a 9.5 mm sapphire wafer with a *Ti-Au* layer patterned using a photolithography process. Thin wire leads were then connected to the metal pads on the sapphire wafer providing the electrical connections to the chips (Fig. 1b).

In order to perform sensor testing, the structure was sealed and packaged into an aluminum housing (Fig. 1c). Testing was performed for the analytes presented in Table 1. Results (Fig. 2) indicate that all of the tested compounds can be detected and their concentrations evaluated with a sensitivity as high as a few

MINIATURIZATION—Discrete LEDS/photodetectors in the sensor (top) are shown with the chip-based sender (bottom) The sensor is less than 10 mm in diameter.

Table 1. Analytes Measured with the Multi-Wavelength Sensor

Analyte	Excitation wavelength (nm)	Emission wavelength (nm)
Fluorescein in Ethanol	482	514
Rhodamine B in Ethanol	543	565
Erythrosin B in water	529	554
Pyrene in water	335	390
Red Fluorescent Sulfate Micro-spheres	570	600

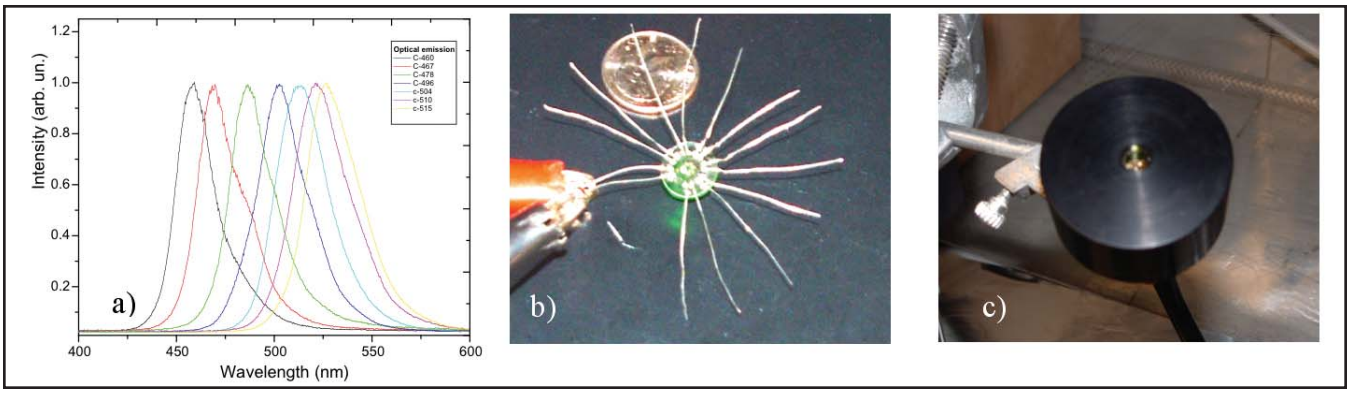

Figure 1. a) Emission Spectra; b) Multi-Chip Assembly; c) Packaged Sensor

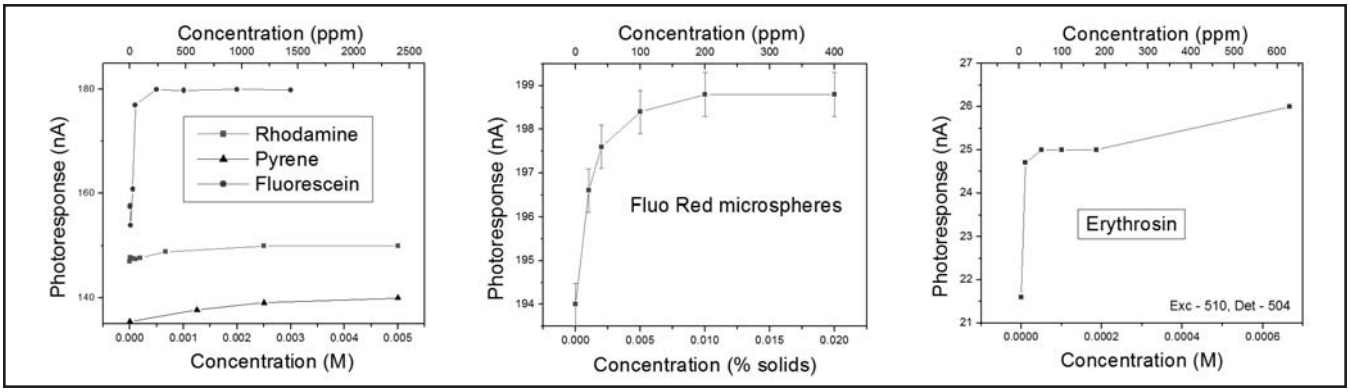

Figure 2. Fluorescence Signal Versus the Analyte Concentration Measured with the Multi-Wavelength Sensor

ppm. These compounds represent a small fraction of the total number of analytes that can be measured using the multi-wavelength sensor.

Future work will include tasks directed toward the reduction of sensor background noise by a proper selection of the component spectral characteristics. Automated control and acquisition circuits and a neural network-based method for analyte identification are being developed in collaboration with the Bio-Processing Laboratory at the University of Quebec at Montreal (UQAM).

Funding and proposals

Starikov, D. "Fully Monolithic Capillary Electrophoresis Optoelectronic Chemical Sensor." Texas ATP, Environmental Science and Engineering, Recycling, and Water Resources, Jan. 1, 2004-Jan. 1, 2006, $185,000.

OPTOELECTRONIC—Clement Joseph, pursuing a Ph.D. in electrical engineering, studies optoelectronic sensors for bio-chemical detection. In TCSAM labs, his duties include fabricating and testing sensor simulators.

FLUORESCENCE—Rajeev Rajan Pillai, M.S. in electrical engineering, utilizes an optoelectronic sensor for bio-chemical detection. Testing the sensor stimulators for accuracy, he pipettes samples to test for fluorescence.