Miniature Optical Sensors for Detection of Water and Air Contamination

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Fabricated sensor prototypes have been automated and neural networks implemented for contaminant classification. Sensitivities of the order of several ppb have been achieved using steady-state light measurements. Current work is focused on implementation of time-resolved measurements, which will result in significant improvement of the most important sensor parameters.

The configuration of the optical sensor prototype utilizing arrays of LEDs as excitation sources and LEDs and/or photodiodes as photodetectors is shown in Fig. 1. Based on this approach, we fabricated several prototypes. Improvements of characteristics measured from the three most recent sensor prototypes are shown in Table 1. Based on our preliminary results, we identified problems that have yet to be resolved in new sensor designs, which will be our next step toward achieving the targeted features along with solutions that can be provided by various advanced technologies, as outlined in Table 2.

Such technologies are being investigated in a current project on the development of integrated III nitride-based photodiode structures for high-temperature jet engine fire detectors used in U.S. Air Force applications.

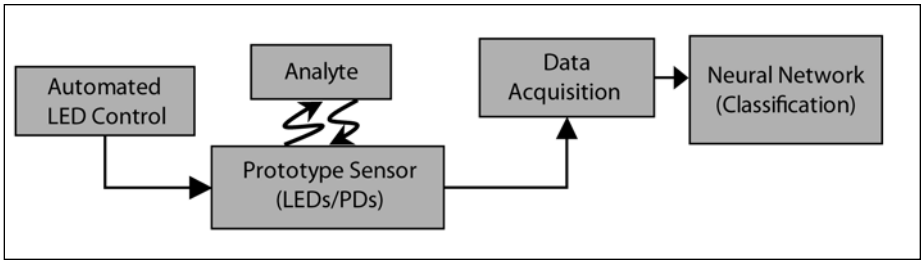

Figure 1. Optical Sensor Configuration

Table 1. Detection Limit and Dynamic Range of the Three Most Recent Sensor Prototypes

Parameter	Proto-5	Proto-6	Proto-7
Detection limit (ppm)	~20	~25	0.08
Dynamic range	1.25	20	25

Table 2. Main Features of the Optical Sensor Targeted by the Current Research

Feature/Capability	Provided by	Benefit
Miniature size	Chip-based design, RF MBE growth of III nitrides	*In situ*, in-line operation
High speed	III nitrides, automated electronic control, ANN	Real-time measurements
High sensitivity	Wide spectral range, time-resolved measurements	Early hazardous material detection
High specificity	Multi-wavelength design, time-resolved measurements, ANN	High classification rate, minimum false alarms
Multifunctionality	Wide spectral range, multi-wavelength design, ANN	Extended field of applications
Ruggedness/strength	III nitrides, solid-state design	Applications in super ambient environments
Low cost	Solid-state chip-based multi-wavelength design	Affordability, applicability, extended field of applications, disposable sensors

Publications

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(Continued on page 126.)

Miniature Optical Sensors for Detection of Water and Air Contaminations

(Continued from page 101.)

Boukadoum, M., K. Tabari, A. Bensaoula, and D. Starikov. "Comparison of the Noise Immunity of a LED-Based Multi Band Optoelectronic Sensor when Using FDMA and CDMA to Code the Excitation Source," IEEE Asia-Pacific Conf. on Circuits and Systems, Tainan, Taiwan, Dec. 2004.

Starikov, D., N. Medelci, R. Pillai, A. Bensaoula, C. Joseph, and Z. Mouffak. "III Nitride-Based Optical Sensors Integrated with TOF Mass Spectrometer for Aerosol Characterization," 51st AVS Intl. Symposium, Anaheim, CA, Nov. 14–19, 2004.

Starikov, D., C. Boney, R. Pillai, and A. Bensaoula. "Visible-Blind UV/IR Photodetectors Integrated on *Si* Substrates," 2006 MRS Spring Meeting, San Francisco, CA , April 17–21, 2006. (*Abstract submitted, oral presentation requested*.)

Starikov, D., Starikov, C. Boney, R. Pillai, and A. Bensaoula. "Solar-Blind Dual-Band UV/IR Photodetectors Integrated on a Single Chip," NSTI Nanotech 2006, Boston, MA, May 7–11, 2006. (*Abstract submitted; oral presentation requested*.)

Patents

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Starikov, D. and A. Bensaoula. "Single-Chip Integrated Dual-Band Visible/Solar Blind Photodetectors with Resolved Sensitivities in UV and IR Bands and Method for Fabrication of the Same," U.S. Patent Application, Docket No. 09.002.02, 2005. (*Pending.*)

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Funding and Proposals

See companion reports "Development of Micro Column Arrays (MCA) for Thermal Management Applications," pp. 15-18, "Investigation of III-Nitride Materials for Space-based Solar Cells," pp. 50-52, and "Micro Column Arrays (MCA) for Thermal Management of Spacecraft Environments," pp. 99-100, for related publications, presentation, and proposals arising out of the 2001–2003 Post-Doctoral Aerospace Fellowship Project.