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Luminescence Lifetime Imaging of Oxygen, pH, and Carbon Dioxide Distribution Using Optical Sensors

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Abstract:

We present a modular system for time-resolved two-dimensional luminescence lifetime imaging of planar optical chemical sensors. It is based on a fast, gateable charge-coupled device (CCD) camera without image intensifier and a pulsable light-emitting diode (LED) array as a light source. Software was developed for data acquisition with a maximum of parameter variability and for background suppression. This approach allows the operation of the system even under daylight. Optical sensors showing analyte-specific changes of their luminescence decay time were tested and used for sensing pO_2, pCO_2, pH, and temperature. The luminophores employed are either platinum(II)-porphyrins or ruthenium(II)-polypyridyl complexes, contained in polymer films, and can be efficiently excited by blue LEDs. The decay times of the sensor films vary from 70 µs for the Pt(II)-porphyrins to several 100 ns for the Ru(II) complexes. In a typical application, 7 mm-diameter spots of the respective optical sensor films were placed at the bottom of the wells of microtiterplates. Thus, every well represents a separate calibration chamber with an integrated sensor element. Both luminescence intensity-based and time-resolved images of the sensor spots were evaluated and compared. The combination of optical sensor technology with time-resolved imaging allows a determination of the distribution of chemical or physical parameters in heterogeneous systems and is therefore a powerful tool for screening and mapping applications.

Key-words: Optical sensor films, Time-resolved imaging system, Microsecond decay time sensors