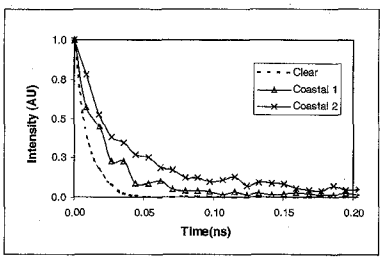
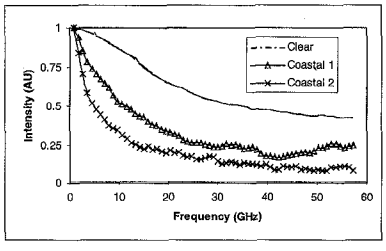


CThO28 Fig. 1. Impulse response functions calculated by Monte Carlo simulations for three different water types: clear, $b = 0.037\ m^{-1}$, $\omega_0 = 0.247$; coastal 1; $b = 0.219\ m^{-1}$, $\omega_0 = 0.551$; coastal 2: $b = 0.4\ m^{-1}$, $\omega_0 = 0.8$. Petzold phase functions for coastal and clear water, respectively, were used in the simulations.[4]



CThO28 Fig. 2. Fourier transform of the impulse response functions shown in Fig. 1. From the data, it is evident that the higher-frequency components are attenuated as the scattering coefficient increases.

realistic water optical properties and relevant system parameters to predict experimental trends. The parameters varied in the simulations include the scattering coefficient (the total scattered power per unit incident irradiance and unit volume of water), b, and the single scattering albedo (ratio of scattering to total attenuation), ω_0. The three curves in Fig. 1 represent the calculated impulse response of the water due to three different water types as measured by Petzold[4]—from clear (less scattering) to turbid (more scattering) water. The corresponding frequency spectra of the curves in Fig. 1 are shown in Fig. 2. The results indicate that the water impulse response and corresponding frequency spectra are strongly dependent on water clarity. As the degree of optical scattering increases (increasing ω_0), the pulse spreading increases, and the frequency content is reduced. The goal of the tank experiments is to validate these trends and to calibrate the Monte Carlo simulation to predict future modulated pulse lidar experimental results.

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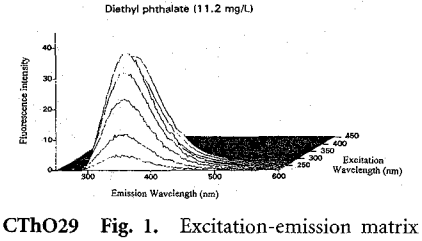
CThO29

Tunable UV-laser-induced fluorescence spectroscopy of trace plastic compounds dissolved in seawater

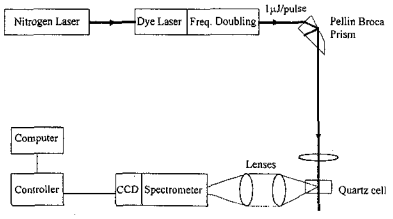
Caiyan Luo, Valerie Nase, Dennis K. Killinger, Jennifer Boehme,* Paula G. Coble,* *Department of Physics, University of South Florida, Tampa, Florida 33620*

UV-laser-induced fluorescence (LIF) spectroscopy is a well-known technique to detect and measure trace compounds in the air or in liquids. Previous LIF work was usually conducted with a fixed-wavelength laser (i.e., excimer or argon) or a low-power white-light source (i.e., xenon lamp and spectrometer). Although such techniques are very sensitive under ideal conditions for a single compound, they often suffer from background interference, which can hamper the detection of many species. A new fluorescence technique called excitation-emission matrix (EEM) provides enhanced identification of one compound among others by tuning the excitation wavelength and measuring the emitted fluorescence spectrum over a wide spectral range. Such a technique is able to display and measure multiple EEM peaks to aid in the positive identification and detection of one compound among several competing compounds. For example, Fig. 1 shows an EEM spectrum of a trace compound (11.2 mg/L of diethylphthalate) obtained with a cw xenon light spectrometer as the excitation source. Our calculations indicate that one can enhance the sensitivity of the system by several orders of magnitude through the use of a tunable, pulsed UV laser as the excitation source and a gated detection. Toward this end, we have developed two LIF EEM systems. The one for laboratory experiments uses a high-power Nd:YAG-pumped OPO (Spectra Physics, model 730) to generate 1–10 mJ/pulse in the UV; this system has been used to map the EEM spectra but suffers sometimes from bleaching of the compounds due to the high fluence. A second, more compact LIF EEM system has also been developed for *in situ* measurements of seawater (Fig. 2). The laser source is a small 10- to 30-Hz nitrogen-pumped dye laser (Laser Science, Inc.), which is frequency doubled to get 1 μJ/pulse UV radiation tunable from 200 to 350 nm. The laser beam is focused into a quartz cell containing the sample under study to induce fluorescence. The fluorescence is focused into a 0.5-m spectrometer, measured by a cooled CCD camera, and processed by a computer. Preliminary experiments have been performed to test the sensitivity of the system. Figure 3 shows the measured EEM spectra for a superbond epoxy hardener that was leached for 24 h into water, and then the epoxy sample was removed. As can be seen, the EEM LIF system is able to detect the trace epoxy chemical compounds that were leached dissolved into the water. These results are very encouraging and suggest that the system may potentially be used for the detection of other trace plastic-type compounds dissolved in water. Further measurements are being planned.

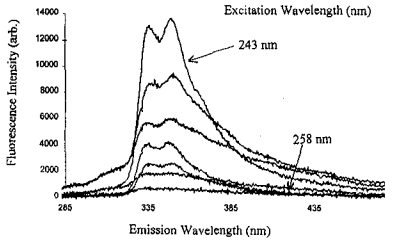
*Department of Marine Science, University of South Florida, St. Petersburg, Florida 33701



CThO29 Fig. 1. Excitation-emission matrix (EEM) spectra obtained with a tunable xenon lamp/monochromator source and CCD/spectrometer system.



CThO29 Fig. 2. Schematic of compact excitation-emission UV-laser-induced fluorescence spectroscopy system used to detect plastic compounds in seawater.



CThO29 Fig. 3. EEM measurements of superbond epoxy hardener solution for UV excitation wavelengths between 243 and 258 nm. The epoxy hardener was placed into water for 24 h, and the solution was used after the epoxy sample was removed.

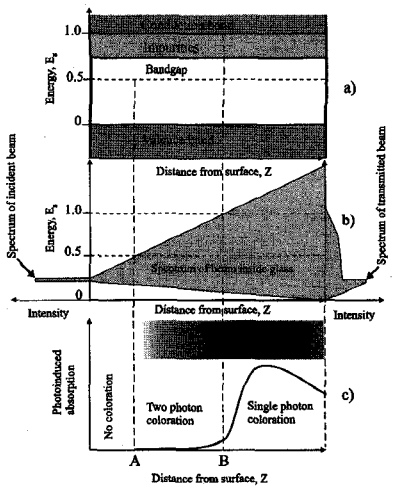
Optics and Materials for Data Storage

CThO30

Residual phenomena in silicate glasses under IR femtosecond laser pulses

O.M. Efimov, L.B. Glebov, S. Grantham, M. Richardson, *Center for Research and Education in Optics and Lasers, University of Central Florida, Orlando, Florida 32816*

Optical glasses show higher information density recording compared with the usual photomaterials. Different linear and nonlinear phenomena were used for this goal. The hologram writing based either on modification of refractive index of polychromic glasses[1] or on linear bleaching of color centers in silicate glasses[2] was reported. Image writing based on two-photon formation of color centers in silicate glasses[3] was also reported. In this paper, we



CThO30 Fig. 1. Diagram of photoinduced processes in a dielectric material under exposure to femtosecond IR pulses.

study a new mechanism of glass excitation[4] leading to modification of glass optical parameters that can be used for data recording.

The series of silicate glasses [BK7 borosilicate glass; photothermorefractive (PTR) silicate glass doped with silver, cerium, and fluorine; and high-purity $22Na_2O$-$3CaO$-$75SiO_2$] was used in the experiments. All glasses were irradiated by high-power, 850-nm, femtosecond laser irradiation ($\tau \sim 10^{-13}$ s). We have found that modification of optical parameters of glass results from the following processes (Fig. 1). The bandgap in silicate glasses is about four times greater than the energy of incident photons [Fig. 1(b)]. No coloration can be seen near the front surface of the sample [left part of Fig. 1(c)]. The spectral width of the laser beam is broadened in the process of the pulse transmission through the glass sample in the direction of the z axis [Fig. 1(b)]. This broadening is assumed to be linear in this diagram. Two-photon ionization of glass matrix occurs at intensity $>10^6$ W/cm^2 when the distance from the front surface (A in Fig. 1) is enough to increase the maximum energy of photons in the supercontinuum up to half of the bandgap (E_g). The process of single-photon ionization of glass matrix begins at $Z > B$ (Fig. 1), which corresponds to the distance from the front surface that is required for the UV edge of the supercontinuum to reach a maximum photon energy equal to the energy of the glass bandgap. The process of cerium ionization in PTR glasses starts when the ultimate photon energy in supercontinuum reaches 3.5 eV. This phenomenon is promising for binary data storage in PTR glasses.

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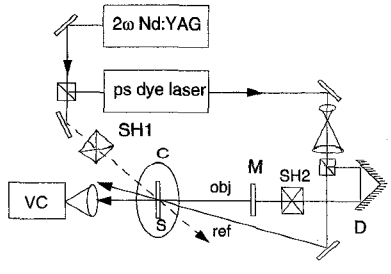
CThO31

Nondestructive readout and transient erasure of photon-gated hole-burning holograms

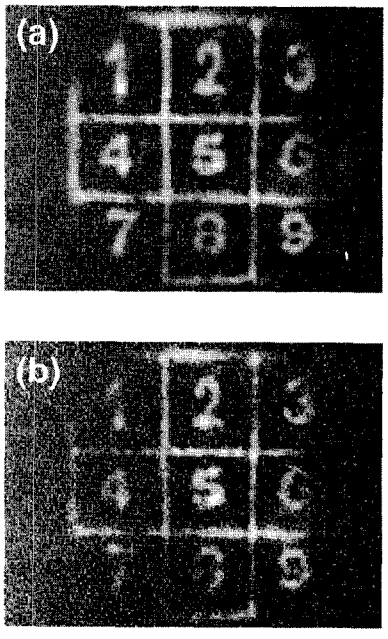
Aleksander Rebane, Daniel Reiss,*
Department of Physics, Montana State University, Bozeman, Montana 59717-3840; E-mail: rebane@physics.montana.edu

A considerable fraction of prospective practical applications of spectral hole burning for optical data storage and processing are depending on the possibility to record holograms that are resistant to extensive resonant light exposure during the readout. Nondestructive readout can be achieved by using photon-gated spectral hole-burning materials,[1] where a permanent spectral hole-burning process requires absorption of two photons of different color. We have recently shown that an organic material composed of Zn-tetrabenzoporphine with solid halocarbon additives in polystyrene film can be used for recording of two-color photon-gated holograms of picosecond time-domain signals.[2] In this paper, we present results on related organic hole-burning material that we apply for recording of image holograms with picosecond pulses. We show that such holographic images can be read out repeatedly and with high doses of illumination. Furthermore, it is possible to use an intense readout laser beam to saturate the absorption of the material at the resonance frequency where the hologram is recorded, without actually destroying the stored information. When the saturating beam is eventually closed, the hologram regains its original contrast and position in frequency domain. We discuss possible applications of this effect for producing a new type of spectrally selective light gate or switch.

Figure 1 shows the basic experimental setup. The hole-burning material is immersed in superfluid liquid helium in an optical cryostat. The resonant illumination light source is picosecond dye-laser pumped by a frequency-doubled mode-locked Nd:YAG laser. The 532-nm radiation of the pump laser is used also as the second illumination color to complete the gated hole burning.



CThO31 Fig. 1. Experimental setup. SH1, SH2: shutters to control laser beams. VC: video camera to capture hologram images: C: helium cryostat. S: sample. M: object image mask. D: variable delay.



CThO31 Fig. 2. Nondestructive readout of holographic images. (a) Hologram image immediately after recording with 6-s exposure with two colors. (b) The same hologram image after 3600-s readout with 10 times higher reference beam intensity. The extended readout illumination was applied to the left part of the image. Partial degradation of the hologram can be observed.

Figure 2 shows a hologram image immediately after recording (a) and after prolonged exposure to a readout beam (b). The amount of light absorbed during the extended readout exposure exceeds by a factor of 6000 the amount of light of the same wavelength used to write the hologram. We conclude that the effective gating factor is, in this case, $\sim 10^3$. We can use a 100–1000 times increased illumination intensity to saturate the absorption of the sample by pumping a considerable part of the population to a 10-ms-lifetime metastable triplet state. The hologram signal disappears at this particular frequency. However, when the saturating beam is closed, then the population in the sample ground state is restored, and the hologram signal is recovered. This provides a unique possibility for temporary erasure of frequency-selective holograms in given narrow frequency intervals. We discuss possible applications for parallel frequency selective optical signal switching and pulse shaping.

Physical Chemistry Laboratory, Swiss Federal Institute of Technology, ETH-Zentrum, CH-8092 Zurich, Switzerland; E-mail: reiss@phys.chem.ethz.ch

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