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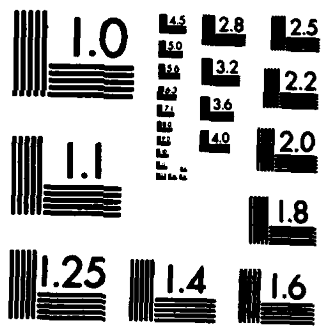

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FINAL REPORT

Title of Project: Investigations of Photochemistry Using Holography and Photoacoustic Spectroscopy

Task Number: NR051-782

Contract Number: N00014-81-C-0418

Principal Investigators: Gary C. Bjorklund
Donald M. Burland
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Institution: International Business Machines Corporation
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5600 Cottle Road, San Jose, CA 95193

Funding Period: August 1981 - July 1984

Description of Project

The work supported by this contract had as its primary goal the development of a holographic technique for the investigation of the details of photochemical reactions. The technique involves imbedding a molecule whose photochemistry we wish to study into a polymer or other host material. By exposing this system to the radiation from interfering laser beams one can produce a hologram in the material. By following the growth in scattering efficiency of the hologram as a function of time, one can study the underlying photochemistry producing the hologram. The holographic technique is particularly useful in investigating two-photon photochemical process, *i.e.*, processes that require the stepwise absorption of two photons.

To broaden the range of two-photon materials that can be investigated, we have developed and utilized photoacoustic spectroscopic techniques. In photochemical processes, the sample is excited with a light source. Light is absorbed in the material and part of the incident energy is re-emitted and can be detected with conventional photon detectors. Part is converted via chemical reactions and can be monitored by detecting chemical products and reaction intermediates, for example, by holography. Part of the absorbed energy, however, is normally lost via radiationless de-excitation. If the light source is pulsed or modulated, this radiationless process results in a periodic release of heat which leads to the production of acoustic waves. Detection of the acoustic waves then can be used to gain information about these otherwise inaccessible radiationless processes.

Significant Results

1. Theoretical Description of the Hologram Growth

   In order to use the information obtained from holographic experiments to unravel photochemical reaction mechanisms, it was necessary to develop a complete theoretical treatment describing the relationship between reaction kinetics and holography.

2. Photochemical Reactions from Highly Excited Triplet States

   One of the most important uses of the holographic technique is the investigation of photochemical reactions that occur from triplet states other than the lowest one. The holographic technique allows one to follow selectively the photochemical reaction from a particular excited triplet state, even in the presence of interfering reactions from lower triplet states.

3. Use of Holographic Technique to Measure Photochemical Quantum Yields

   A holographic technique has been developed to measure the quantum yield for product formation from excited triplet states of molecules embedded in polymer hosts. The technique involves a simple measurement of the time taken for the hologram to reach its maximum diffraction efficiency. This measured yield can be directly related to a photochemical quantum yield.

4. Development of a Pyroelectric Thin-film Calorimeter for Photoacoustic Spectroscopy

   A thin film pyroelectric transducer has been developed for photothermal studies. The sensitivity and time response of this transducer are two orders of magnitude better than other transducers conventionally used in photothermal studies.

5. Use of Pyroelectric Thin-film Calorimeter to Measure Radiative and Nonradiative Processes

   A technique has been developed to measure and compare both radiative and nonradiative processes. The technique is sensitive enough to be used on samples that are only a monolayer thick.

Scientific Personnel Supported by this Project

Dr. D. M. Burland, Research Staff Member

Dr. G. C. Bjorklund, Research Staff Member

Dr. H. Coufal, Research Staff Member

Dr. P. A. Brugger, Post-doctoral Scientist

Dr. P. Hefferle, Post-doctoral Scientist

Dr. U. Schmitt, Post-doctoral Scientist

Mr. R. K. Grygier, Research Associate

List of Publications

1. D. M. Burland and Chr. Bräuchle, "The Use of Holography to Investigate Complex Photochemical Reactions," *J. Chem. Phys.* 76, 4502 (1982).

2. D. M. Burland, "Application of Holography in the Investigation of Photochemical Reactions," *Accts. Chem. Res.* 16, 218 (1983).

3. U. Schmitt and D. M. Burland, "The Use of Holography to Investigate Reactions from Higher Excited States," *J. Phys. Chem.* 87, 720 (1983).

4. Chr. Bräuchle and D. M. Burland, "Holographic Methods for the Investigation of Photophysical Properties," *Ang. Chemie.*

5. H. Coufal, "Photothermal Spectroscopy Using a Pyroelectric Thin Film Detector," *Appl. Phys. Lett.* 44, 59 (1984).

6. H. Coufal, "Photothermal Spectroscopy of Weakly Absorbing Samples Using a Thermal Wave Phase Shifter," *Appl. Phys. Lett.*, to be published.

7. R. K. Grygier, P.-A. Brugger and D. M. Burland, "A Determination of the Photochemical Quantum Yields from Two Excited Triplet States of Biacetyl Using Holography," *J. Phys. Chem.*, to be published.

8. H. Coufal and W. Lee, "Time Resolved Calorimetry of 39 nm Te-films During Laser Annealing," *Chem. Phys.*, to be published.

9. H. Coufal and P. Hefferle, "Photothermal Analysis of Thin Films," *Chem. Phys.*, to be published.

10. H. Coufal, T. J. Chuang and F. Trager, "Spectroscopy of Adsorbates by Transient Laser Calorimetry," *Chem. Phys.*, to be published.

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