PHOTO-THERMAL DETECTION OF THE ONSET OF PHOTO-CHEMICAL NUCLEATION (LASER-SNOW) IN VAPOR(U) IBM RESEARCH LAB SAN JOSE CA A C TAM ET AL. 28 DEC 84 TR-15
Photo-Thermal Detection of the Onset of Photo-Chemical Nucleation (Laser-Snow) in Vapor.

A. C. Tam
I. Hussla
H. Sontag

International Business Machines, Corp.
5600 Cottle Road
San Jose, CA 95193

Office of Naval Research
800 N. Quincy Street
Arlington, VA 22217

This document has been approved for public release and sale; its distribution is unlimited.

Submitted for presentation in the conference on Laser and Electro-Optic (CLEO '85), May 1985 in Baltimore.

Nucleation, aerosol, photo-chemistry, photo-thermal, carbon disulphide, thermal lens, laser beam deflection

The phenomenon of photochemical nucleation in vapors is studied by two optical photothermal methods, namely thermal lensing and optoacoustic laser-beam deflection. These new studies provide information on the onset of the process of photo-nucleation.
Photo-Thermal Detection of the Onset of Photo-Chemical Nucleation (Laser-Snow) in Vapor

by

A. C. Tam
I. Hussla
H. Sontag

IBM Research Laboratory
San Jose, California

Reproduction in whole or part is permitted for any purpose of the United States Government

This document has been approved for public release and sale, its distribution is unlimited
### TECHNICAL REPORT DISTRIBUTION LIST, GEN

<table>
<thead>
<tr>
<th>No.</th>
<th>Office of Naval Research Attn: Code 413 800 N. Quincy Street Arlington, VA 22217</th>
<th>Naval Ocean Systems Center Attn: Technical Library San Diego, California 92152</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dr. Harold E. Guard Dept. of the Navy Office of Naval Research Arlington, VA 22217</td>
<td>Naval Weapons Center Attn: Dr. A. B. Amster Chemistry Division China Lake, California 93555</td>
</tr>
<tr>
<td>1</td>
<td>Naval Civil Engineering Laboratory Attn: Dr. R. W. Drisko Port Hueneme, CA 93401</td>
<td>Dean William Tolles Naval Postgraduate School Monterey, CA 93940</td>
</tr>
<tr>
<td>1</td>
<td>Superintendent Chemistry Division, Code 6100 Naval Research Laboratory Washington, DC 20375</td>
<td>U.S. Army Research Office Attn: CRD-AA-JP P. O. Box 12211 Research Triangle Park, NC 27709</td>
</tr>
<tr>
<td></td>
<td>Defense Technical Information Center Building 5, Cameron Station Alexandria, Virginia 22314</td>
<td>Mr. Vincent Schaper DTNSRDC Code 2830 Annapolis, Maryland 21402</td>
</tr>
<tr>
<td>12</td>
<td>DTNSRDC Attn: Dr. G. Bosmajian Applied Chemistry Division Annapolis, Maryland 21401</td>
<td>Mr. John Boyle Materials Branch Naval Ship Engineering Center Philadelphia, Pennsylvania 19112</td>
</tr>
<tr>
<td></td>
<td>Naval Ocean Systems Center Attn: Dr. S. Yamamoto Marine Sciences Division San Diego, California 91232</td>
<td>Mr. A. M. Anzalone Administrative Librarian PLASTEC/ARRADCOM Bldg. 3401 Dover, New Jersey 07801</td>
</tr>
</tbody>
</table>
Dr. Henry Freiser  
Chemistry Department  
University of Arizona  
Tucson, AZ 85721

Dr. Gregory D. Botsaris  
Department of Chemical Engineering  
Tufts University  
Medford, MASS 02155

Dr. J. H. Hargis  
Department of Chemistry  
Auburn University  
Auburn, ALA 36849

Dr. Ronald S. Sheinson  
Code 6180  
Naval Research Laboratory  
Washington, DC 20375

Dr. Edward J. Poziomek  
Chief, Research Division  
Chemical Research and Development Center  
ATTN: DRDAR-CLB  
Aberdeen Proving Ground, MD 21010

Dr. Lynn Jarvis  
Code 6170  
Naval Research Laboratory  
Washington, DC 20375

Dr. Richard Hollins  
Code 385  
Naval Weapons Center  
China Lake, CA 93555

Dr. Christie G. Enke  
Department of Chemistry  
Michigan State University  
East Lansing, MICH 48824

Dr. Timothy L. Rose  
EIC Laboratories, Inc.  
111 Chapel Street  
Newton, Massachusetts 02158
Research Report

PHOTO-THERMAL DETECTION OF THE ONSET
OF PHOTOCHEMICAL NUCLEATION (LASER-SNOW) IN VAPORS

A. C. Tam
I. Hussla
H. Sontag

IBM Research Laboratory
San Jose, California 95193

LIMITED DISTRIBUTION NOTICE

This report has been submitted for publication outside of IBM and will probably be copyrighted - accepted for publication. It has been issued as a Research Report for early dissemination of its contents. In view of the transfer of copyright to the outside publisher, its distribution outside of IBM prior to publication should be limited to peer communications and specific requests. After outside publication, requests should be filled only by reprints or legally obtained copies of the article (e.g., payment of royalties).

IBM Research Division
Yorktown Heights, New York • San Jose, California • Zurich, Switzerland
PHOTO-THERMAL DETECTION OF THE ONSET
OF PHOTOCHEMICAL NUCLEATION (LASER-SNOW) IN VAPORS

A. C. Tam
I. Hussla
H. Sontag

IBM Research Laboratory
San Jose, California 95193

ABSTRACT: The phenomenon of photochemical nucleation in vapors is studied by two optical photothermal methods, namely thermal lensing and optoacoustic laser-beam deflection. These new studies provide information on the onset of the process of photo-nucleation.
The phenomenon of photochemical nucleation of particles (also called "Laser-snow") has been observed by many workers, for example, in metal vapor systems and in organic vapors. Although this laser-snow effect seems to occur generally under the right excitation, temperature and pressure conditions, the phenomenon remains poorly understood. One problem is a lack of method for detecting the onset of photo-nucleation of particles, which has up to now been detected, e.g., by light-scattering, or electrostatic deflection. We believe that photo-nucleation should result in a large amount of heat released at the excitation laser beam, due, for example, to heat of condensation, and hence should be detectable by noncontact photothermal means. We report here a first experiment for such detections by using Thermal Lensing (TL) and by Optoacoustic Laser-beam Deflection (OLD).

The present experiment is performed in a carbon disulphide vapor at room temperature and reduced pressures. The experimental arrangement is shown in Fig. 1. A pulsed nitrogen laser of energy 1 mJ and duration 8 ns is focused by a lens of 8 cm focal length into a quartz cell containing the vapor. A HeNe laser beam is also focused into the cell perpendicular to the excitation beam so that the two laser foci can be overlapped, or be vertically displaced from each other. The overlapped case is for TL study, and the vertically displaced case is for OLD. This unusual arrangement of perpendicular pump and probe is used here, since we want to use a large cell (10 cm diameter) to avoid any
focused laser light being incident on cell walls or windows possibly resulting in wall-assisted nucleations, and we want to monitor the nucleation dynamics in the excitation beam with high spatial resolution. An observed TL signal for the carbon disulphide vapor at 67 Torr pressure is shown in Fig. 2. The signal is characterized by a fast rise time (quick heat production at the probe region), and slow decay time (slow heat dissipation). The magnitude of the TL signal is a measure of the amount of heat released due to the photochemical process excited by the pulsed excitation laser. We observed that both the magnitude and the rise/decay times of the signal change significantly at a carbon disulphide pressure of 30 Torr. This appears to correspond to the onset of photo-nucleation at the present experimental conditions.

Figure 3 shows an OLD signal for 300 Torr of carbon disulphide. The variation of the OLD signal with the vapor pressure also exhibits significant changes at the onset of photonucleation. Further, the OLD signal can be observed for vertical displacements of many mm, and a plot of the OLD signal delay versus the vertical displacement provides a very accurate value of the sound velocity at the particular pressure and temperature. These new results in organic vapors are never previously measured by all-optical means.

This work was supported in part by the Office of Naval Research.
REFERENCES


FIGURE CAPTIONS

Figure 1. Photothermal studies of photo-nucleation as produced by pulsed nitrogen laser in carbon disulphide vapor and probed by a coincident or displaced HeNe beam.

Figure 2. An observed thermal lensing signal.

Figure 3. Observed optoacoustic laser-beam deflection signals for several vertical separations of the pump and probe beams.
Figure 1. Photothermal studies of photo-nucleation as produced by pulsed nitrogen laser in carbon disulphide vapor and probed by a coincident or displaced HeNe beam.
Figure 2. An observed thermal lensing signal.
Figure 3. Observed optoacoustic laser-beam deflection signals for several vertical separations of the pump and probe beams.