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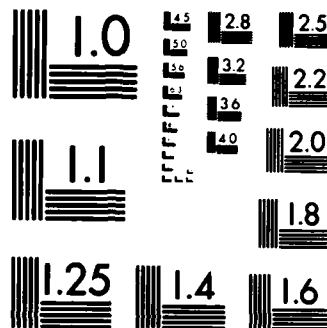
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TECHNICAL REPORT No. 15

Photo-Thermal Detection of the Onset of Photo-Chemical
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by

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Research Report

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

A. C. Tam
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**PHOTO-THERMAL DETECTION OF THE ONSET
OF PHOTOCHEMICAL NUCLEATION (LASER-SNOW) IN VAPORS**

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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.

Photo-thermal Detection of the Onset
of Photochemical Nucleation (Laser-Snow) in Vapors

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The phenomenon of photochemical nucleation of particles (also called "Laser-snow") has been observed by many workers, for example, in metal vapor systems¹ and in organic vapors.^{2,3} 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,^{1,2} or electrostatic deflection.³ 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)⁴ and by Optoacoustic Laser-beam Deflection (OLD).⁵

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.

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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.

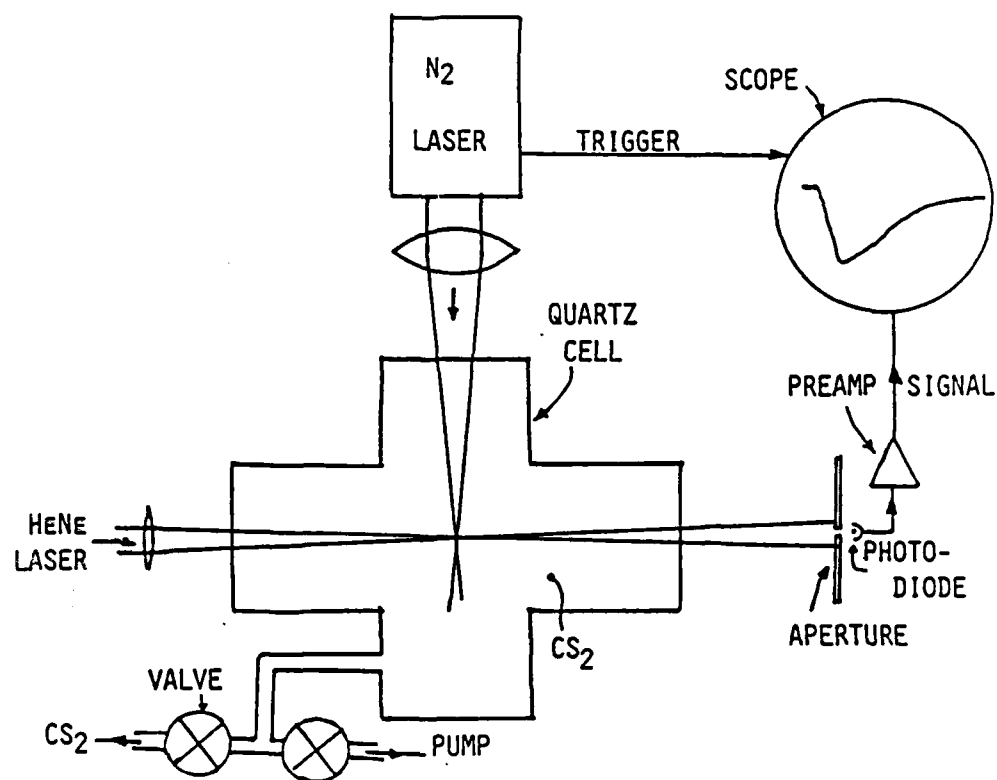


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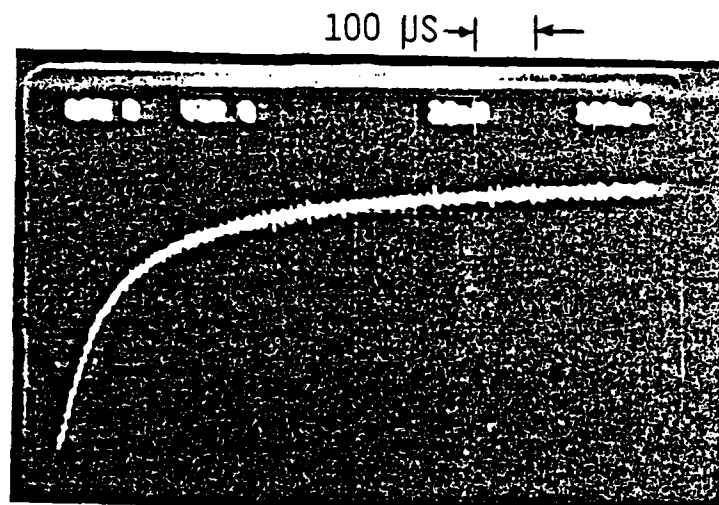


Figure 2. An observed thermal lensing signal.

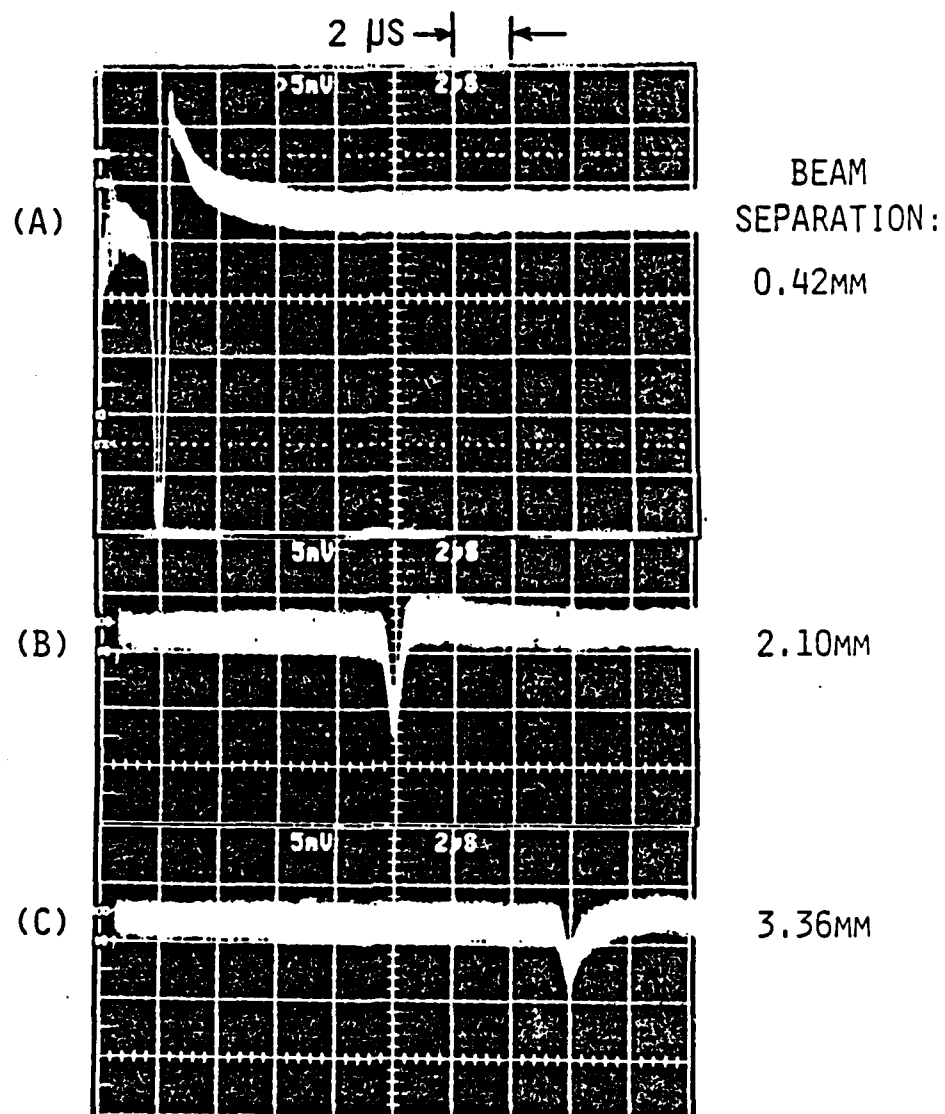


Figure 3. Observed optoacoustic laser-beam deflection signals for several vertical separations of the pump and probe beams.

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