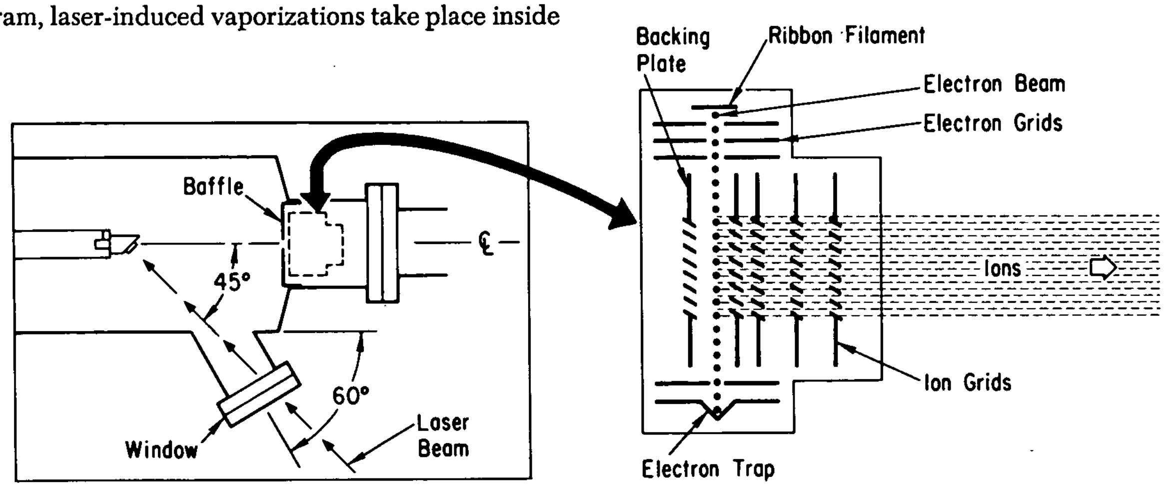
NASA TECH BRIEF

Ames Research Center

Laser Mass Spectrometer

Studies of the effect of incident energy on the surfaces of solids have been made with a time-of-flight mass spectrometer which has been equipped with a laser-powered vaporization source. As indicated in the diagram, laser-induced vaporizations take place inside a large vacuum chamber rather than in the ion source compartment of the mass spectrometer; this arrangement permits a large cross-sectional area of sample to be exposed to incident beams of energy and provides a large expansion volume to reduce the effect of outgassed vapors on the operation of the mass spectrometer. The baffle between the vacuum chamber and the ion source provides moderate differential pumping, but it can be removed when an open ion source is preferred.



Samples of solid materials are introduced via a vacuum lock and positioned along the axis of the vacuum chamber at distances from several centimeters to one meter from the ion source; the capability of the mass spectrometer to measure the thermal velocities of individual mass species is improved when the sample is located a long distance away from the mass spectrometer ion source. Vapors or ions liberated from the surface of the sample enter the ion source colinearly with the axis of the flight tube of the mass spectrometer through the backing grid of the ion source. If only uncharged species are to be admitted into the mass spectrometer, charged species are deflected by electrodes placed in front of and to the side of the backing grid.

The usual operational circuitry of the mass spectrometer has been modified to permit gating on and off for specific time intervals. The gating feature is useful for setting up instrumentation and for making adjustments prior to examination of transient events. Moreover, the gating circuitry is extremely useful for studies of short-lived species; since the spectrometer

(continued overleaf)

is gated "on" only during the interval when the species are generated, it is possible to truncate the persistent effects of the noncondensable, long-lasting gases that are usually produced simultaneously.

The total ion current in the mass spectrometer resulting from each vapor pulse is recorded along with the mass spectrum to provide a quantitative basis for comparing the vaporization characteristics of various materials subjected to identical radiant energy pulses. The laser (or gate pulse) triggers a transient recorder and causes the integrated value of the total ion current to be displayed continuously on a monitoring scope; simultaneously, the mass spectrum appears on an output scope and is photographed during the gated interval. The integrated output obtained from the transient recorder is then switched to the output scope so that it can be recorded in the same photo to give a single record of integrated total ion current plus mass spectrum for each laser-induced vapor pulse. Alternatively, several individual mass-peak intensities versus time can be stored and subsequently displayed as desired.

The instrumentation described above has been found especially useful for studies of the behavior of graphitic heat-shield materials; attempts have been made to correlate the vaporization characteristics of a number of graphite-type materials with their ablation performance. The common practice of focusing the laser beam as a small point on a sample surface has been avoided in these studies; typically, power densities of the order of 100 to 200 kW/cm^2 have been used, and since the front surface of the specimen is essentially enveloped by the laser beam, the heat flow on the surface of the material is practically one-dimensional. In initial experiments with graphitic materials exposed to 0.5-ms pulses of 1.06-micrometer laser energy (sample loadings of about 60 joules/cm^2), the mass spectra exhibit no perceptible line broadening or degradation in resolution resulting from the thermal velocities of the vapors. Although the resolution of ions generated external to the ion source is typically poorer than those produced internally by an electron sheet, the resolution of the thermal ions produced by laser heating proved to be quite adequate; moreover, the sensitivity of the spectrometer to thermal ions was found to be very high.

Notes:

1. Mass spectra of graphitic materials show that C_3 is the dominant vapor product with only very small amounts of C_1 and C_2 species.
2. Requests for further information may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: TSP 72-10571

Patent status:

NASA has decided not to apply for a patent.

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