Effect of laser radiation on particle tracks in solid dielectrics

V. V. Kushin, V. K. Lyapidevskiĭ, and N. B. Khokhlov

Engineering Physics Institute, Moscow

(Submitted 30 June 1983)
Zh. Eksp. Teor. Fiz. **86**, 1357–1359 (April 1984)

Short laser pulses are observed to affect the tracks of heavy charged particles in solid dielectric detectors. The laser radiation can alter the parameters of a track and even completely destroy it, while the dielectric itself retains its detecting properties. The laser-radiation exposures (in terms of energy) required for observation of the effect are measured. This effect should make it possible in principle to determine the time at which a particle enters the detector to an accuracy corresponding to the duration of the laser pulse.

An important problem in the study of the mechanism by which charged-particle tracks form in solid dielectrics is to determine the effect of various factors on processes in the track. This problem is also of practical significance, since external agencies can appreciably alter the characteristics of solid-dielectric detectors.

As we know, the strongest influence on the tracks is exerted by thermal effects (annealing), ultraviolet irradiation, and chemical agents.[1] For such processes the change in the structure of a track occurs over a long time (a matter of hours). However, there are a number of physical problems (e.g., in the study of fast processes) for which it is necessary to act on the track over a short period of time. For this reason we have studied the effect of short laser pulses on charged-particle tracks in dielectrics.

We studied various polymers: cellulose nitrate (Kodak LR 115), cellulose acetate (Cellit-T), amyl diglycol carbonate (CR-39), a polyester fiber (lavsan), and polycarbonate. Samples of the materials were bombarded by ions from ^{4}He to ^{56}Fe at energies in the range of 0.5–6 MeV/nucleon. The samples were then exposed to a single CO_2 laser pulse lasting 10^{-6} sec. The tracks were revealed by the usual chemical etching.

The experiment established that the action of laser radiation on a particle track changes the parameters of the track. The change, which amounts to a decrease in the preferred etching rate along the track, enables one to tell which particles entered the detector before the laser pulse and which ones entered after the pulse. The exposure (in terms of the energy of the laser radiation) at which the effect is observed depends on the type of material and the specific ionization loss of the particle energy. When the exposure energy is increased far enough, the track is destroyed (i.e., the track is not revealed by chemical etching). For the materials studied the tracks were destroyed at exposures $J = 0.4$–3.6 J/cm^2. The material itself retains its detecting properties. For example, an additional ion bombardment after the laser pulse showed that the tracks formed were no different from those in control samples.

The results of the experiment can be illustrated by a plot of the diameter of the etched track *versus* the energy of exposure to the laser radiation (Fig. 1). The material was bombarded by particles perpendicular to the surface. It follows from the graph that the minimum exposure energy required to change the parameters of the track is 0.3 J/cm^2. At values $J \geqslant 0.5$ J/cm^2 (curve 1) the track is destroyed (i.e., the track is not revealed by a two-hour etching). Further etching, however (curve 2), reveals tracks with a smaller diameter. These curves indicate that the laser radiation does not destroy the

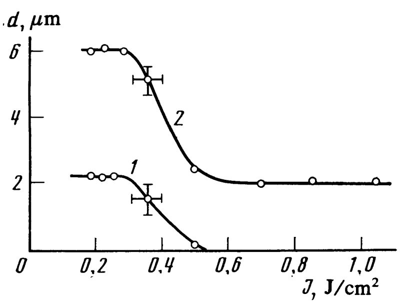

FIG. 1. Diameter of etched α-particle tracks in cellulose nitrate *versus* the energy of exposure to laser radiation. Curve 1 is for a 2-hour etching, curve 2 for a 6-hour etching.

FIG. 2. Appearance of α-particle tracks in a control sample (a) and in a sample exposed to a laser pulse (b).

 0038-5646/84/040792-02$04.00

entire track (the range of the particles is 8 μm) but only its initial part, to a depth of about 2 μm beneath the surface. The character of the changes in the track depend only weakly on the exposure in the range $J = 0.5–1$ J/cm^2.

These results are illustrated by the photographs in Fig. 2. The experimental procedure was first to bombard the sample with α particles at an angle of 45° to the surface, then to expose the sample to a laser pulse, and finally to again bombard the sample with α particles at an angle of 45°. To distinguish the tracks of particles entering before and after the laser pulse, the sample was rotated by 90° about the axis of the particle beam before the second bombardment. In a control sample (Fig. 2a) not exposed to the laser pulse we see tracks oriented in two mutually perpendicular directions. In the test sample (Fig. 2b) we see tracks of only those particles which entered the detector after the laser pulse. The tracks themselves have the same characteristics as in the control sample. Similar results were obtained for all the materials studied.

The purpose of the present paper is not to give a detailed discussion but only to report a new physical effect which had not been observed previously. One can use this effect to put time markers on the tracks, i.e., to determine the time at which the particles enter the detector, if the duration of the laser pulse is shorter than that of the charged-particle pulse. By using not one, but several laser pulses distributed over time, one could measure the temporal spectrum or, in other words, mark the time during the measurements. Because laser pulses can be as short as 10^{-11} sec, such a possibility could break new ground in research on fast processes involving particle emission.

[1]R. L. Fleischer, P. B. Price, and R. M. Walker, Nuclear Tracks in Solids, Ch. 1, Univ. of California Press, Berkeley (1975).

Translated by Steve Torstveit