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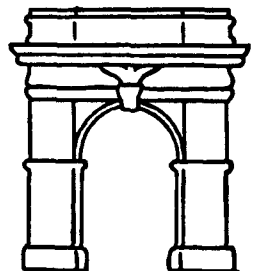
RADIATION AND SOLID STATE LABORATORY
Physics Department
New York University

Progress Report II

THE EFFECTS OF HIGH ENERGY RADIATION ON INSULATORS

April, 1963

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NEW YORK UNIVERSITY
DEPARTMENT OF PHYSICS

United States Signal Corps, Fort Monmouth, New Jersey

Contract No. DA 36-039 SC-89180

Project No. 3A99-25-004

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TABLE OF CONTENTS

	Page
Personnel	iii
CONTENTS:	
I. Positrons as Probes in Solids II Lattice Vibrations	1
II. Ionization by X-Rays in Anthracene Determined by the Method of Persistent Internal Polarization	3

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Progress Report No. 2

Part I. Positrons as Probes in Solids II Lattice Vibrations^{1,2}

We have initiated a study of the annihilation characteristics of positrons in solids with the objective of determining the parameters influencing the interaction between charged particles and solids at low energies. The dynamic behavior of charged particles in solids and hence, e.g., the transient effects of radiation in such solids can be observed directly for positrons where the annihilation spectra are influenced by the processes underlying the interaction of positrons with the solids in which they annihilate. The research summarized here considers the influence of lattice vibrations on the annihilation cross sections of positrons in insulators.

In a previous publication the volume and temperature dependence of the long life time component τ_2 in the positron annihilation spectrum, as found at low and intermediate temperatures in van der Waals solids and liquids, was shown to be essentially a free volume effect. That is, the overlap of the positron wave function with the lattice and hence the annihilation rate of the positrons with electrons bound in the lattice decrease with increasing volume. The theory is extended to include the effects of lattice vibrations on the overlap. It is shown that at

¹This work was supported in part by the Institute for Exploratory Research, U. S. Army Signal Corps.

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constant volume the annihilation rate increases as the mean square amplitudes of the lattice vibrations so that at high temperatures, the temperature coefficient of the annihilation rate becomes inversely proportional to the elastic constants of the lattice. As a consequence distinct effects of phase transitions on positron annihilation rates are expected in some substances.

Part II. Ionization by X-Rays in Anthracene Determined by the Method of Persistent Internal Polarization

Sample: The crystals under investigation are single anthracene crystals 1 mm thick and 1 cm on a side obtained from the Harshaw Chemical Company.

The crystals are pressure mounted with one face in contact with a conducting glass (electrode face: E) and the other face in contact with a 0.0006" mylar barrier which in turn is pressed against the conducting face of a piece of conducting glass (barrier face: B). Thus, one face of the crystal is in direct contact with an electrode and the other has a thin insulator interposed between it and the electrode.

Nature of the Experiments: The scheme of the experiments is, as a first step, to polarize the sample by applying an electric field and concomitant X-ray irradiation. Second, to remove the irradiation and field and to connect the electrodes to ground with the sample in the dark (dark decay). Third, to connect one electrode of the sample to the grid of a voltage calibrated electrometer circuit, irradiate the sample with U.V. light and measure the released polarization per unit area (coulombs/cm²). The sample face which was at ground during polarization is selected to be connected to the electrometer grid.

Summary of Results:

I. "Polarization curves." In a series of experiments, the time of polarization (X-Ray and field application of 4000 V/cm) was varied from 1 to 60 mins. In each case the sample was shorted in the dark for 30 seconds after polarization and the charge then released by U.V.

illumination. As an example, a polarization curve is given in the accompanying figure. Each point was obtained by polarizing for the specified amount of time and then by releasing the polarization charge by U.V.

Four polarization curves--charge readout versus polarization period--were obtained, one for each of the following cases:

<u>X-Ray on Face</u>	<u>Field Applied</u>
E	$E^+ B^-$
E	$E^- B^+$
B	$B^+ E^-$
B	$B^- E^+$

The curves fell rather close to each other with a maximum polarization at 60 minutes being about 2×10^{-9} coul/cm². These results are different from those of the previous findings in two respects. In those it was observed that under X-Ray irradiation the polarization finally obtained was of the same order as that obtained with light which is expected if illumination is carried out for a long enough period of time. In the present experiment, the polarization obtained after 60 minutes of X-Ray irradiation was only 5% of the U.V. polarization and did not seem to rise considerably any more. Furthermore, the new arrangement was more than 10 times more sensitive than the previous arrangement. In spite of this, we did not measure larger polarization. This shows that there is still some unknown and so far unexplained feature in our procedure which has to be taken care of. In investigating the reasons for this behavior, we have

found that the polarization observed was not totally due to X-Rays but partially to some other source. This additional source of polarization was not observed previously but became noticeable in our present arrangement because of its higher sensitivity.

We suspect that the reason for the relatively small polarization obtained with X-Rays is due to imperfect alignment of the apparatus in the X-Ray beam. This time we have used more complicated equipment, and it may be that the focussing of the X-Ray beam into the polarized material was imperfect. We are installing an arrangement to center the crystal in the X-Ray beam.

II. In order to get some information about the relatively weak effect of X-Rays, the following experiment was carried out. A crystal was polarized with field and concomitant ultraviolet light to saturation with a yield of 4×10^{-8} coul/cm². After this light polarization, the electrodes were grounded out, and the sample was irradiated with X-Rays for several minutes. X-Rays should at least partially discharge the polarization. This was tested by releasing the remaining polarization after X-Ray irradiation by light. It was found that the X-Rays had discharged the sample only to a small extent. This seems to support our assumption that the X-Rays were not well centered in the crystal.

This latter method has the advantage that no external fields are applied, and the effects of X-Rays take place only under the internal field persisting in the crystal after light polarization. This method excludes all spurious effects caused by X-Rays and external fields.

RISE CURVE

Pol. Volt. 400 V

30 Sec Dark Decay

