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Low-temperature photoconductivity in SrO*†

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Photoconductivity measurements have been made on single-crystal samples of SrO which were "as received," irradiated at room temperature with γ rays, or irradiated at temperatures down to 77 K with 1.5-MeV electrons or 1.5-MeV protons. The measurements were made over the spectral range from 2 to 6.2 eV and at temperatures from 63 to 180 K. F^+ centers introduced into the samples by particle irradiation produce a photocurrent which measurement indicates is carried by electrons. The free-electron yield from F^+ centers increased sharply between 63 and 100 K from which it is estimated, using a two-level model, that the thermal activation energy for release of free electrons is 0.12 ± 0.01 eV. The two-level model also gives a value of 5×10^6 for the ratio τ_R/τ_0, where $1/\tau_0$ is the pre-exponential frequency factor for thermal ionization and τ_R is a temperature-independent lifetime for decay from a relaxed excited state of the F^+ center. As the incident photon energy increased towards the band edge there was a sharp rise in the photoresponse in both irradiated and unirradiated samples. The photoresponse reached a maximum at an energy of 5.4 eV, and then decreased sharply as the incident photon energy increased further.

I. INTRODUCTION

Recently, the alkaline-earth oxides, and in particular, simple defects in these materials, have been the subject of many studies.[1,2] We are concerned in this paper with low-temperature photoconductivity and associated optical-absorption measurements made on SrO over the spectral range from 2 eV to the band-gap energy at about 6 eV. The temperature dependence and spectral response of photoconductivity give a sensitive method of investigating both the electronic structure of defect centers and the band edge of a crystal,[3] and we shall be concerned here with both of these aspects.

SrO has the rocksalt structure characteristic of alkali halides. The doubly charged oxygen vacancies which are produced when currently available SrO is irradiated with either protons or neutrons each trap, in general, only a single electron to form F^+ centers.[4] The vibronic properties of the non-Gaussian and asymmetric F^+ absorption band, which is located at 3.1 eV, have been investigated by Hughes and Webb.[5] A temperature-dependent luminescence band centered near 2.5 eV has also been reported for the F^+ center.[5,6] The two-electron center, the F center, has been produced by additive coloration of SrO with excess strontium.[7] The F band is reported near 2.5 eV.

On the basis of charge considerations alone it might be expected that F centers in alkaline-earth oxides would produce photoconductivity in a manner similar to F centers in alkali halides but that F^+ centers, being positively charged, would not produce photoconductivity at ordinary temperatures. The experimental results reported so far indicate, however, that the situation is not as straightforward as this viewpoint suggests. In MgO the F band and F^+-band overlap at 5.0 eV. Roberts and Crawford[8] reported that γ irradiation just prior to mounting a sample in the cryostat was necessary to detect photoconductivity in MgO which had been irradiated with electrons or neutrons. It was tentatively concluded from these measurements and others made on additively colored samples that the photocurrent originated from F centers. However, as Roberts and Crawford have indicated, and as we shall see below in Sec. IV, the magnitude of the photocurrent from a center depends on the product of the quantum efficiency for the production of free carriers and their mean range once released. If either of these parameters increases the photocurrent will increase. From this viewpoint photocurrent originating from F^+ centers in MgO cannot yet be ruled out. A similar uncertainty exists for BaO. Rose and Hensley[9] have shown recently that the F-band and F^+-band overlap in this material also, so that the origin of a photoconductivity band observed by Dash[10] at 2.0 eV in x-irradiated BaO is still uncertain. On the other hand in both CaO and SrO the F band and the F^+ band are separated in energy, and it is possible to investigate each band individually. Measurements[11] on electron-irradiated CaO have shown that both F centers and F^+ centers produce photoconductivity in this material. Recent experimental results[12] have also shown that F^+ centers in SrO can produce photoconductivity in a way very reminiscent of F centers in alkali halides. A more complete report of the experiments on SrO is given here including an extension of the spectral range of the measurements.

II. PHOTOCONDUCTIVITY MEASUREMENTS

Low-temperature photoconductivity measurements were made using a cryostat developed from one described previously.[13] Crystals were held between two plane parallel electrodes 8 mm long and 3 mm wide which were located in a copper chamber bolted to the tail of the cryostat. Dry helium gas could be admitted to the chamber to produce good thermal contact between the sample and the cryostat. Temperatures were measured with a copper-constantan thermocouple. Incident light fell on the crystal through the front electrode which was made of fine phosphor-bronze wire gauze. The back electrode was made of copper foil and was insulated from ground with a thin sapphire plate. This electrode was connected to the input of a Cary 401 vibrating-reed electrometer which was used in the "rate-of-charge" mode. Both electrodes were blocked with thin sapphire plates to prevent charge entering or leaving the crystal. The output of the electrometer was fed to a potentiometric recorder. With the system described above the background-noise level was well below 10^{-16} A. Measured photocurrents were typically about 10^{-14} A and individual measurements were made with the crystal illuminated for a few seconds at a time. The direction of the applied electric field, which was produced by dry cells, could be easily reversed after individual measurements to prevent polarization effects in the sample.

The light source used was either a xenon lamp or, for ultraviolet measurements, a deuterium lamp. Light from these lamps was dispersed by a McPherson 218 monochromator with a linear dispersion of 2.3 nm mm^{-1}. The slits were set 1.5 mm or 2 mm wide. A front-silvered mirror focused light from the monochromator on the crystal sample. A fraction of the light intensity falling on a sample was separated using a MgF_2 beam splitter and was monitored by a 6256S photomultiplier. The photomultiplier was calibrated in a separate experiment by placing a Molectron pyroelectric radiometer at the sample position. The radiometer had a calibration traceable to the Natl. Bur. of Stds. (U.S.). It is estimated that the absolute measurement of the light intensity falling on a sample could be made to about 8%.

III. SAMPLE PREPARATION

Crystals of nominally 99.95%-pure SrO were obtained from W. and C. Spicer Ltd. and were approximately 10 × 5 × 2 mm in dimensions. Just prior to irradiation, or making optical and photoconductivity measurements, the crystals were polished on alumina-impregnated lapping disks, which removed surface contamination and which gave the surfaces a good optical polish. Optical absorption spectra were taken with a Cary 14 spectrophotometer.

The optical density of a typical unirradiated crystal at 77 K was similar to that reported by Bessent *et al.*[4] The optical density increased from about 0.1 at 700 nm to over 2 at 5.5 eV. There was no obvious absorption peaks in the spectrum except for a small band which could be sometimes detected at about 5.7 eV and which seemed to correspond to an exciton band.[14]

The crystals could be irradiated at 77, 195, or 300 K with either 1.5-MeV protons or 1.5-MeV electrons. We show in Fig. 1 the absorption spectrum at 77 K of a crystal which had been irradiated at about 195 K with 1.5-MeV protons to a dose of about 2×10^{17} protons cm^{-2}. The irradiation produced the asymmetric F^+ band with a peak at 3.1 eV, which has been seen previously.[4,5] It can be seen that although the optical density at the peak of the F^+ band is about 0.7, there is no evidence of the F band at 2.5 eV. This behavior is in contrast to that observed in CaO, where the F band would be easily observed at this stage. Proton irradiation at 77 K seemed to introduce the F^+ band at about twice the rate of irradiation at 195 K. We did not find it possible, however, to produce a measurable F^+ absorption band in samples irradiated with 1.5-MeV electrons at 77 K even up to doses of 5×10^{17} electrons cm^{-2}. Low-incident current densities were always used to prevent the samples being heated during irradiation. In these

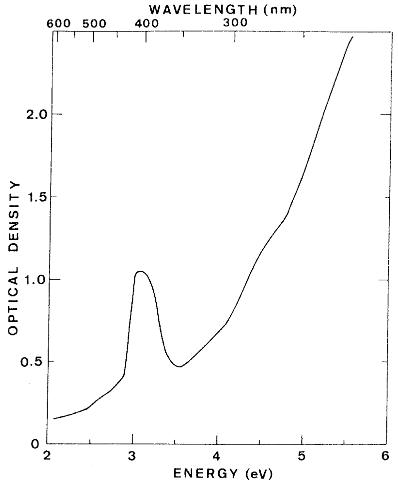

FIG. 1. Optical-absorption spectrum at 77 K of SrO which has been irradiated at 195 K with 1.5-MeV protons to a dose of approximately 2×10^7 protons cm^{-2}. The main feature introduced by irradiation is the asymmetric F^+ band located near 3.1 eV.

experiments, in which the sample was attached to a small cryostat located in the Van de Graaff extension tube, it was necessary to warm the sample to room temperature before transferring it to the optical cryostat. This method was used because it was necessary to transfer an irradiated sample to the photoconductivity cryostat at room temperature. However, no measurable F^+ band was produced even in a sample which was irradiated at 77 K with 1.5-MeV electrons to a dose of 5×10^{16} electrons cm^{-2} and then measured without warm up. Nevertheless, as we shall see in Sec. IV, F^+ centers introduced by electron irradiation produce an easily detectable photocurrent because of the sensitivity of the photoconductivity technique. The reason for using electron-irradiated samples in our experiments was that incident electrons produce mainly individual vacancies throughout the bulk of the crystal, whereas incident protons produce a high density of damage near the surface. For this reason, it was not found possible to make completely satisfactory photoconductivity measurements on proton-irradiated samples.

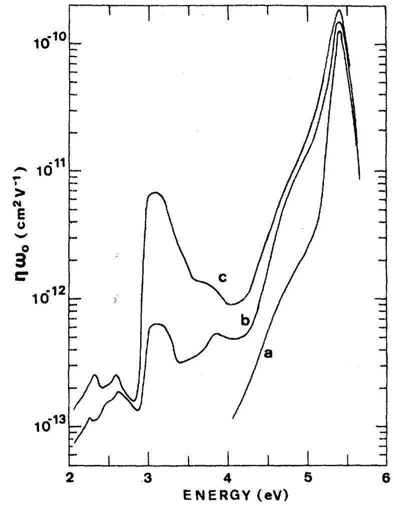

FIG. 2. Spectral dependence of the photoresponse $\eta\omega_0$ for SrO. An unirradiated sample measured at 77 K, curve a; a sample which had been irradiated at 195 K with 1.5-MeV electrons to a dose of approximately 1 $\times10^{17}$ electrons cm^{-2} and measured at 77 K, curve b; the same sample as curve b measured at 105 K, curve c.

IV. EXPERIMENTAL RESULTS

In this section we first describe the interpretation of our experimental data. We then describe in detail the photoresponse of electron irradiated samples and finally we present results obtained from γ-irradiated samples and proton-irradiated samples.

The photocurrent I_λ, when N_λ quanta per second of wavelength λ are falling on a sample between plane parallel electrodes, is given by the equation[3]

$$I_\lambda=(\eta\omega_0)_\lambda eVN_\lambda/d^2\,, \qquad (1)$$

as long as the mean charge-carrier range ω_0V/d, in the direction of the applied electric field V/d, is much less than the thickness of the crystal d. Here, η is the free-carrier yield, that is, the number of free charge carriers produced per incident photon; ω_0 is the mean range of the carriers in the direction of a unit applied electric field; V is the voltage applied across the sample; and e is the electronic charge. Equation (1) can be rearranged to collect all the measurable quantities on the right-hand side to give

$$(\eta\omega_0)_\lambda=(I_\lambda/N_\lambda)(d^2/eV)\,, \qquad (2)$$

where we call $(\eta\omega_0)_\lambda$ the photoresponse of the crystal at wavelength λ. The requirement that the mean carrier range be small compared to the thickness of the crystal can be tested by insuring that the photocurrent is directly proportional to the potential applied across the sample.[3]

In Fig. 2(a) we show the photoresponse of an untreated SrO sample at 77 K over the spectral range from 2 to 6 eV. It can be seen that the photoresponse was immeasurably small until the incident-photon energy was at least 4 eV. Then, as the photon energy increased further, the photoresponse increased sharply by more than three orders of magnitude until the photon energy was about 5.4 eV. The photoresponse then decreased abruptly by two orders of magnitude and became immeasurably small again at 5.8 eV. Although the apparatus could detect photoconductivity for photon energies out to about 6.2 eV, no photoconductivity could be detected in SrO above 5.8 eV. However, the minimum detectable photoresponse was comparatively large at 6.0 eV because the output of the light source and monochromator fell rapidly at energies above 5.0 eV. The resolution of the apparatus at 6.0 eV was about 0.1 eV. The photocurrent at 5.4 eV was the same for either direction of the applied electric field and was constant in time for constant illumination. The photocurrent was proportional to the applied electric field up to 1500 V cm^{-1}, and was also proportional to the incident light intensity within an experimental error of a few percent. The abrupt increase in photoresponse observed at about 5.3 eV indicated that the incident photon energy was approaching the band gap of the sample. We shall discuss these results in more detail in Sec. V.

In Figs. 2(b) and 2(c) we show the photoresponse over the spectral range from 2 to 6 eV of a sample of SrO which had been irradiated at 195 K with

1.5-MeV electrons to a dose of approximately 1×10^{17} electrons cm^{-2}. Curves b and c in Fig. 2 show the photoresponse at 77 and 105 K, respectively. The most prominent feature introduced by electron irradiation was the temperature-dependent and asymmetric band located at 3.1 eV, which can be shown to be due to F^+ centers by comparing it to the F^+ optical-absorption band, as we demonstrate in Fig. 3. In Fig. 3(a) is shown the photoresponse of an electron-irradiated sample in the vicinity of 3.1 eV and in Fig. 3(b) is shown the F^+ absorption band measured on a proton-irradiated sample. Both curves, which were measured at 110 K, were normalized at 3.1 eV. It can be seen that these curves coincide over the whole F^+ band except near the high-energy tail, where the photoresponse from a band located at 3.9 eV, which can be seen in Fig. 2, overlaps the F^+ band.

The photocurrent at 3.1 eV was directly proportional to the applied electric field up to 1500 V cm^{-1} within an experimental error of a few percent. Typically an applied electric field of 500 V cm^{-1} was used during the measurements. In addition the photocurrent at 3.1 eV was also directly proportional to the incident light intensity, within a few percent, as the intensity varied by a factor of about 50.

It can be seen in Fig. 2 that as the temperature increased from 77 to 105 K, the photoresponse of the F^+ band grew by over an order of magnitude, whereas the photoresponse away from the F^+ band was almost independent of temperature over the same range. The detailed temperature dependence of the F^+ photoresponse over the range from 63 to 180 K is shown in Fig. 4. At 63 K the F^+ band was almost indistinguishable from the background photoconductivity and above 180 K the dark current became so large that accurate photocurrent measurements could not be made. The inset in Fig. 4 shows how the thermally stimulated current, or dark current, increased with temperature. For this experiment the sample had been illuminated at 77 K with ultraviolet light for about 90 min to fill available traps in the crystal. It can be seen that none of these traps empty in the region of the abrupt increase in F^+ photoresponse at about 80 K. The sharp increase in photoresponse between 63 and 100 K is characteristic of a thermally assisted ionization such as occurs, for example, for the F center in KCl at about 120 K.[3] Above 110 K an F^+ center in SrO which has absorbed a photon, frees a charge carrier with essentially unity probability, and the temperature dependence of the photoresponse is due mainly to the temperature dependence of the mean range of the carriers. The data in Fig. 4 will be discussed more fully in Sec. V.

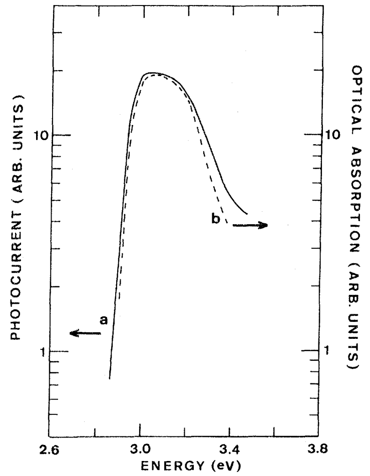

FIG. 3. Comparison of the spectral dependence of the photocurrent in electron-irradiated SrO, curve a; and the optical absorption of the F^+ band in proton-irradiated SrO, curve b. Both sets of measurements were made at 110 K.

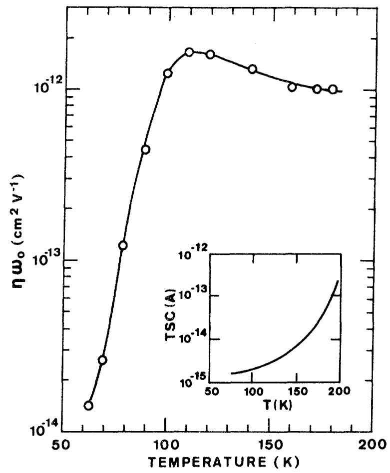

FIG. 4. Temperature dependence of the F^+-band photoresponse in electron-irradiated SrO. The measurements were made with an incident photon energy of 3.1 eV. The inset shows the thermally stimulated current (TSC) in an electron-irradiated crystal which had been illuminated with ultraviolet light at 77 K.

It was found that prolonged illumination in the F^+-band region at temperatures above about 90 K partially destroyed the photoresponse. It took about 1 min to reduce the photoresponse to half its initial value. However, the photoresponse could be restored by illuminating the sample with light of energy greater than 3.7 eV. Low-energy photons were not effective in restoring the photoresponse. Spectral-dependence measurements above 90 K, such as those presented in Figs. 2 and

3 were made by illuminating the crystal for several seconds with ultraviolet light following each measurement made in the region of the F^+ band. This bleaching effect is similar to experimental results found by Dash[10] in BaO. He found that the photoresponse of the 2.0-eV band could be enhanced if the crystal was simultaneously irradiated with ultraviolet light. One possible explanation of these results is that the ultraviolet light released charge carriers from comparatively deep traps and that these carriers repopulated bleached F^+ centers.

It has been suggested[15] that the $^2A_{1g}$ ground state of the F^+ center lies below the top of the valence band in the vicinity of the center. If this were the case, it is possible that the charge carriers excited by illumination into the F^+ band might be positive holes. We determined the sign of the charge carriers to be negative, however, using a technique due to Peria.[16] A sample was supported with the electric field parallel to the 5-mm dimension and perpendicular to the direction of the incident light. A section at the center of the sample 1 mm wide and the height of the sample was illuminated, while the right-hand electrode was held positive with respect to the left-hand electrode by an external battery. Although the mean range of the charge carriers was much less than the thickness of the crystal, the net result of illuminating the crystal was that a space-charge electric field was established in the crystal going from left to right across the illuminated region. The external electric field was removed and the photocurrent was measured as a function of the position of a thin band of light as the band was scanned across the crystal. The data shown in Fig. 5(a) was obtained. Note that the photocurrent was a maximum when the light was falling on the region of the crystal which had been illuminated with 3.1-eV light and which is delineated by the vertical arrows, and falls rapidly to zero outside this region. The central region of the crystal was then illuminated with 3.1-eV light again, with no externally applied electric field. During the first illumination period, electrons moved just beyond the right-hand edge of the illuminated region. During the second illumination period, these carriers remained trapped but carriers originating from centers just inside the right-hand edge of the illuminated region move towards the left under the influence of the polarization field, with the result that a dipolar space-charge region is established at the right-hand edge of the illuminated region of the crystal. This dipole layer could be located experimentally by monitoring the photocurrent as the crystal was scanned again with a narrow band of light. Figure 5(b) was then obtained. The photocurrent data of curve a has been reduced by a factor of 10 to accommodate it on the figure. The maximum in the photocurrent can be seen to have occurred at the right-hand edge of the region which had been illuminated with 3.1-eV light. This measurement located the dipole layer and indicated that the charge carriers were negative, i.e., electrons. If the carriers had been positive holes, an analysis similar to that above shows that the dipole layer would have been located at the left-hand edge of the region which had been illuminated with 3.1-eV light.[16] The experiment was repeated with the initial externally applied electric field in the opposite direction, in order to determine whether any geometrical effects in the apparatus were affecting the result. The sign of the carriers was again determined to be negative.

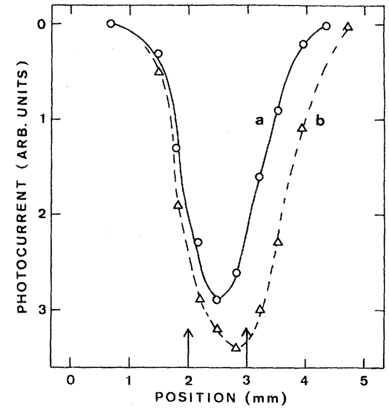

FIG. 5. Electric field distribution obtained in the determination of the sign of the charge carriers excited by 3.1-eV light in electron irradiated SrO. The measurements were made with both electrodes held at the same potential after illumination with an externally applied electric field going from right to left, curve a, and after subsequent illumination with no applied electric field, curve b. Curve a has been reduced by a factor of 10 to accommodate it on the figure. The vertical arrows indicate the region of the crystal which was illuminated.

The performance and interpretation of the type of experiments described above are somewhat difficult, and more direct confirmation of the result will be required, such as would come, for example, from Hall-effect measurements. It is worth noting, however, that similar experiments performed on the 400-nm F band in CaO indicated that the charge carriers were electrons in this case too, as expected.

The photocurrent originating from F^+ centers in SrO was found to go to zero within a fraction of a second of the incident light being removed. There was no evidence of the long-lived dark current found by Roberts and Crawford[8] after illuminating the 5.0-eV band in MgO. We also found that the

F^+ absorption band in proton-irradiated SrO could not be optically bleached at 120 K, although from the temperature dependence of the photoresponse, Fig. 4, F^+ centers which have absorbed a photon are expected to be thermally ionized with almost unity probability at this temperature. If we assume that F^+ centers produced in proton-irradiated SrO are mutually independent, these results suggest that in high concentrations the oxygen vacancy is an efficient trap in SrO. However, the fact that there is no sign of F centers being formed in SrO which has been heavily irradiated and which contains a comparatively large concentration of F^+ centers, Fig. 1, suggests that F^+ centers on the other hand are not effective electron traps in our material.

When an electron-irradiated sample was subsequently γ irradiated for 30 min at room temperature just prior to being mounted in the cryostat, the photoresponse was found to have increased uniformly by a factor of about 2 across the spectral range from 2 to 4 eV. A ^{60}Co γ source was used with a strength of about 5×10^4 R h^{-1}. The F^+ photoresponse was unchanged relative to the background and no band was introduced in the region of 2.5 eV, where the F absorption has been reported.[7] This result again suggests that the F^+ center is not an efficient electron trap compared to other traps in the crystal.

We show in Fig. 6(a) the photoresponse at 77 K of a crystal which was γ irradiated at room temperature for about 30 min and measured with no further treatment. γ irradiation increased the photoresponse generally between 2 and 5 eV, and introduced a band at 2.65 eV, which is also observed in electron-irradiated crystals. The inflexion in the photoresponse at about 4.8 eV, which is observed in unirradiated crystals, is further enhanced by the γ irradiation. γ irradiation alone did not produce any F^+ photoresponse.

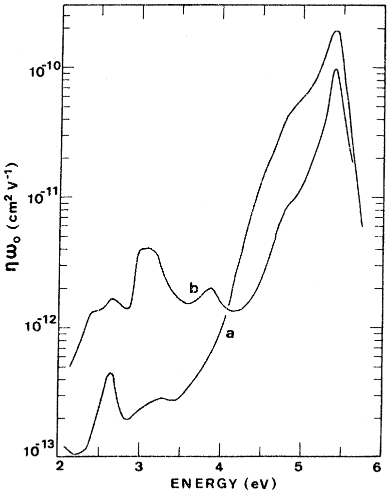

FIG. 6. Spectral dependence of the photoresponse $\eta\omega_0$ for SrO at 77 K after γ irradiation at room temperature, curve a; after irradiation with 1.5 MeV protons to a dose of approximately 2×10^{16} protons cm^{-2}, curve b.

Figure 6(b) shows the photoresponse at 77 K of a crystal which was proton irradiated at 77 K to a dose of about 2×10^{16} protons cm^{-2}. It can be seen that the most prominent feature introduced by the irradiation is again the asymmetric F^+ band located at 3.1 eV. The irradiation also introduced photoresponse bands centered at 2.65 and 3.9 eV as well as an inflexion at 2.5 eV. The 2.65-eV band was introduced by electron irradiation as well as by γ irradiation and is presumably due to an impurity in the crystal. The band at 3.9 eV, which was also produced by electron irradiation, may be associated with the same type of center which is produced when SrO is plastically deformed.[17]

V. DISCUSSION

Since photoconductivity originating from F^+ centers is unexpected, it is of interest to compare its magnitude to that measured from F centers in, for example, MgF_2.[13] For a useful comparison, it is necessary to compute the value of $\eta_T\omega_0$ for the two centers, where η_T is the free-electron yield per absorbed photon. If we estimate a maximum value of 0.002 for the optical density of the F^+ band for the sample used for Fig. 4, we obtain a lower limit of 4×10^{-10} cm^{2}V^{-1} for $\eta_T\omega_0$ at 120 K. For low-concentration F centers in MgF_2, $\eta_T\omega_0$ is about 4×10^{-10} cm^{2}V^{-1} at room temperature. It is worth recalling, however, that the magnitude of the photoresponse depends on ω_0 which is closely dependent on the purity of the crystals.

No detailed calculation has been reported to date of the electronic structure of the relaxed F^+ center in SrO which can be compared with our photoconductivity measurements. However, the temperature dependence of the photoresponse between 70 and 110 K can be explained quite well by a two-level model.[3] In this model, an electron in the relaxed excited state of the center has a temperature-dependent probability $1/\tau_T=(1/\tau_0)\exp(-E_a/kT)$ of being thermally ionized across an energy gap E_a. $1/\tau_0$ is the preexponential frequency factor, k is Boltzmann's constant, and T is the temperature. There is also a temperature-independent probability $1/\tau_R$ of decay to a lower energy level. The yield of free carriers per absorbed photon η_T is then expected to follow

$$(1/\eta_T)-1=(\tau_0/\tau_R)\exp(E_a/kT)\,. \qquad (3)$$

In order to compare this equation with our experimental results, Fig. 4, which give directly the product $\eta\omega_0$ as a function of temperature, we make the approximation that ω_0 and the oscillator strength of the F^+ band remain independent of temperature between 70 and 110 K. The temperature dependence of $\eta\omega_0$ is thus assumed to be due entirely to the change in η_T over this range. Since it appears that F^+ centers are effectively fully ionized at 115 K, η_T is taken as unity at this temperature and we can then plot $\log_{10}[(1/\eta_T) - 1]$ against $1/T$ using the data of Fig. 4. The resulting curve is shown in Fig. 7, where it can be seen that over several orders of magnitude a straight line is obtained. From the data in Fig. 7, we obtain a value for E_a of 0.12 ± 0.01 eV and a value for τ_R/τ_0 of 5×10^6. It is interesting that these values are close to those found for F centers in alkali halides,[18] and estimating a reasonable value for τ_0, we obtain a value for τ_R of the order of 1 μsec.[19] If this were the radiative lifetime for an allowed decay from the $^2T_{1u}$ excited state to the $^2A_{1g}$ ground state, it would be surprisingly long for an F^+ center. However, without detailed knowledge about the electronic structure such as that obtained by Wood and Wilson[20] for F centers in alkaline-earth oxides, it is not possible to determine to which transition the parameter τ_R corresponds. Nevertheless, an increase in the free-electron yield with increasing temperature is expected to be accompanied by a decrease in the fluorescence yield, and Hughes and Webb[5] have found that the intensity of the F^+ luminescence decreases markedly between 77 K and room temperature.

The main feature of the photoresponse of SrO at high photon energies, Fig. 2, was the relatively abrupt increase in the vicinity of 5.3 eV. A steep rise in the photoresponse is expected when the incident photon energy approaches the band edge of the crystal.[21] A threshold for intrinsic photoconductivity can then occur. Photons of higher energy do not penetrate far into the surface because of the strong absorption of the crystal and the photoresponse usually decreases. However, photoconductivity can be found at energies close to the band edge due to an indirect process. Under these circumstances excitons, which are produced by the incident photons, give up their energy to ionizable centers, such as, for example, F centers, and photoconductivity can result.[22,23] This mechanism can be very efficient. Since there is an exciton band in SrO at 5.7 eV,[14] it is possible that a similar mechanism was occurring here. The same photoresponse peak occurred, however, in both irradiated and unirradiated samples, so that the photoconductivity would have to be produced mainly by impurity or defect centers other than F^+ centers, although a mechanism similar to that observed by Apker and Taft in KI cannot be ruled out. From the evidence available so far, we prefer to interpret the steep rise in photoresponse in SrO at high photon energies as due to the onset of band to band transitions. Our results, then, suggest that the photoconductivity band gap of SrO is about 5.3 eV, which is somewhat lower than has been given previously.[24] In addition, the exciton bands at 5.7 and[14] 5.8 eV would, then, be placed about 0.5 eV above the bottom of the conduction band.

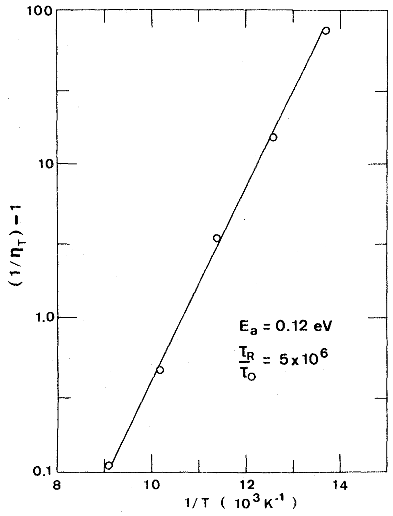

FIG. 7. Semilogarithmic plot of $(1/\eta_T) - 1$ vs inverse temperature $1/T$. Data points were obtained from the experimental results shown in Fig. 4 as described in the text.

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