

permitted to flow, the injected minority carriers drift back to the junction where their concentration becomes depleted with time, since more carriers drift away on the side of the junction where they are the majority carriers. Thus in time the flow of injected carriers back to the junction will be enhanced by diffusion. Experiments were made on a sample with constant cross section, the p and n regions being long compared to the injection distance. It was observed that the back current remains essentially constant over a considerable time T_1 . Consequently, the calculated voltage drop across the junction and therefore the injected carrier concentration at the junction must have been roughly constant during this time.¹⁰ With a small series resistance the trailing edge of the pulse is sharp and a definite value of T_1 can be assigned. With T_1 and the forward rectangular pulse length T_0 , small compared to the carrier lifetime we should have, approximately,

$$T_0/T_1 = i_b/i_f, \quad (4)$$

where i_f and i_b refer to injection and collection current, respectively. Figure 2 is an experimental plot of T_0/T_1 vs i_b/i_f , indicating that about half the injected carriers were returned during T_1 .

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¹⁰ The calculated emf's are in the neighborhood of 0.2 volt at room temperature and 0.65 volt at liquid nitrogen temperature for the sample used to obtain data for Fig. 2.

Thermoluminescence of Quartz and Fused Quartz Colored by X-Ray Irradiation

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THE study of color centers in quartz and fused quartz induced by x-ray irradiation has been studied by the writer.¹ When x-rayed quartz and fused quartz are heated, luminescence is observed and the absorption bands are bleached.

We prepare fused quartz by two methods, in one of which fused quartz is produced in a strongly reducing condition and in the other in a mildly oxidizing condition.

The samples of quartz and fused quartz ($10 \times 10 \times 0.3$ mm) were exposed to x-rays (100-kv, 3-ma, tungsten target) at room temperature for 56 hours. Saturation of coloration takes place approximately after exposure for 56 hours.

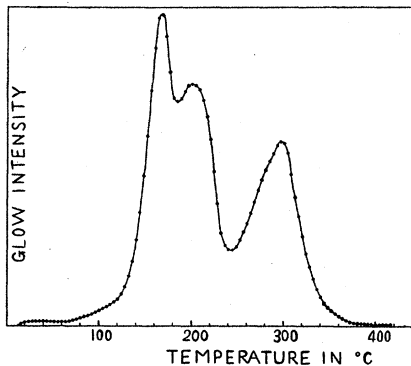


FIG. 1. Glow curve of quartz.

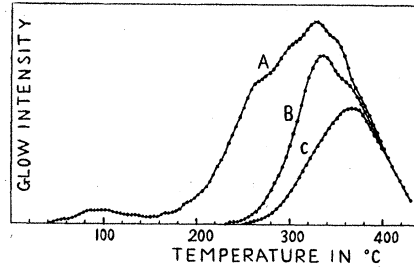


FIG. 2. Glow curves of fused quartz prepared in a reducing condition. (A): no decay; (B): 15-min decay at 276°C; (C): 5-min decay at 312°C.

The emitted light was observed with a multiplier phototube of RCA 1P28 type connected to a string electrometer. Glow curves were obtained at a linear heating rate of 0.033°C/sec, which is so slow that a good resolution in glow curves is obtained.

Figures 1, 2(A), and 3(A) give examples of glow curves for quartz and fused quartz. These curves are reproducible in general shape.

A comparison of the glow curves for quartz and fused quartz shows that in quartz crystal there exist trapping centers having

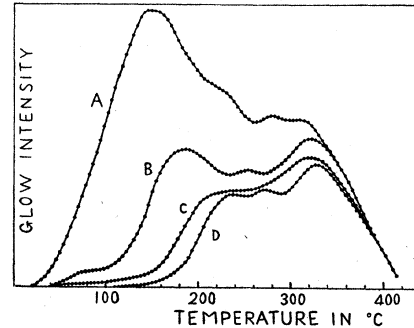


FIG. 3. Glow curves of fused quartz prepared in a mildly oxidizing condition. (A): no decay; (B): 10-min decay at 150°C; (C): after B decay, a further 5-min decay at 196°C; (D): after B decay, a further 10-min decay at 196°C.

several discrete trapping levels, but in fused quartz there exist some groups of trapping levels.

To verify the above, the following experiment was performed. A glow curve for traps of one depth has the same shape and peak temperature regardless of the number of electrons trapped. Figures 2 and 3 show glow curves of fused quartz prepared in a reducing condition and in a mildly oxidizing condition, respectively, after various periods of decay at different temperatures. Fused quartz was x-rayed and then allowed to decay for the designated

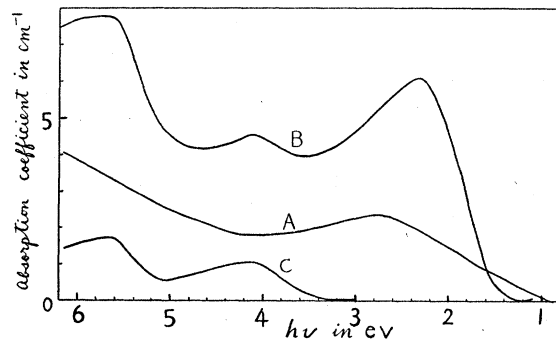


FIG. 4. Induced absorption bands of quartz and fused quartz (A): quartz; (B) and (C): fused quartz prepared in the reducing and mildly oxidizing conditions, respectively.

period. Then it was rapidly cooled to room temperature, and the glow curve was measured.

The peak of the glow curve shifts continuously to higher temperatures with increasing period of decay and with higher decay temperatures. Therefore it is concluded that there exist in glass some unresolved groups of trapping centers, each group of which has its distribution around its center.

The induced absorption bands at room temperature are shown in Fig. 4.

A comparison of glow and absorption curves shows that the resolution in glow curves is better than in absorption curves, although the resolution in absorption curves increases generally at low temperature.

The above results show clearly that fused quartz—the glassy state of quartz—has a disordered lattice but preserves to some extent the local order of the crystal.

A full account will appear in the *Journal of the Physical Society of Japan*.

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An Ultra-High-Frequency Rotational Line of HDO†

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AN asymmetric top molecule whose dipole moment is oblique to its axes of principal moments may be expected to have a rotational absorption spectrum extending to very low frequencies. Some of these low-frequency lines may be transitions between levels of low J and may have appreciable intensities. King, Hainer, and Cross¹ have predicted that the $3_2 \rightarrow 3_3$ transition of HDO would occur in the uhf region with remarkable intensity, $2 \times 10^{-7} \text{ cm}^{-1}$. Because of the possibility of observing deuteron quadrupole structure and of the novelty of working at such low frequencies, we have searched for this line.

Since the predicted frequency lay below the cutoff of our $1\frac{1}{2}$ -in. \times 3-in. \times 20-ft wave-guide absorption cell, it was necessary to devise a method whereby the cell could operate in its TEM mode. The rf power, supplied by a 6AF4 triode in a Mallory TV-101 television converter, and the 5000-cps square-wave generator were both connected to the Stark septum through a matching and decoupling network near one end of the cell. At the other end was connected a crystal detector with a special adapter which effected capacitive coupling to the Stark septum through the mica window. The crystal detector was connected to a tuned amplifier and phase-sensitive detector in the conventional manner. With this equipment the line was found.

The measured frequency is given in the first line of Table I. Also contained in Table I are revised values of the frequencies of the three Q -branch and one P -branch S -band lines which we have reported previously.²

The constants of the centrifugal distortion formula for Q -branch transitions due to Kivelson and Wilson³ were adjusted to obtain the best fit with the three S -band lines and six higher-frequency lines.⁴⁻⁷ The calculated frequencies using the parameters

TABLE I. Observed low-frequency lines of HDO.

Transition ($J_{\tau} \rightarrow J_{\tau'}$)	Measured frequency (Mc/sec)	Calculated frequency (Mc/sec)
$3_2 \rightarrow 3_3$	824.64 ± 0.05	824.61
$6_1 \rightarrow 6_2$	2394.56 ± 0.05	2394.5
$4_0 \rightarrow 5_{-5}$	2887.4 ± 0.1	
$12_{-1} \rightarrow 12_0$	2961 ± 1	2963
$9_0 \rightarrow 9_1$	3044.71 ± 0.10	3043.5

$(a-c)/2 = 8.4895 \text{ cm}^{-1}$ and $\kappa = -0.6830$ are given in the last column of Table I. It is to be noted that the agreement is excellent.

Satellite lines 30 kc/sec on either side of the main $3_2 \rightarrow 3_3$ line were partially resolved. The satellites are undoubtedly due to the deuteron quadrupole hyperfine structure. They will be studied for obtaining values of the coupling constants.

We wish to thank Dr. D. W. Posener and Professor M. W. P. Strandberg of M.I.T. for access to their unpublished results. Also thanks are due Professor C. H. Townes of Columbia University, who suggested that we look for the quadrupole splitting. We acknowledge the help of Mr. Gabriel Herrmann, who participated in the S -band work, and Mr. Leon Arnell, Mr. Leonard Yarnus, and Mr. Sol Krongelb for construction of some of the apparatus.

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Quadrupole Coupling of the Deuteron in DCCCl and DCN*

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THE $J=1 \rightarrow 2$ transition of deuterated chloroacetylene has been studied with a high-resolution bridge spectrometer.¹ DCCCl is a linear molecule containing two nuclei with quadrupole moments. The spectrum of this compound at lower resolution has been described in the literature,² as has the procedures for treating the two-quadrupole molecule.³ For the $F_1 = \frac{3}{2} \rightarrow \frac{1}{2}$ transition, where $F_1 = J + I_{Cl}$, it can be calculated that no splitting caused by the deuteron quadrupole moment would be expected, whereas for the $F_1 = \frac{3}{2} \rightarrow \frac{3}{2}$ transition the splitting should be most easily observed. Recorder traces of these lines were obtained, from which it was ascertained that $(eqQ)_D = +175 \pm 20 \text{ kc/sec}$. The pattern is not symmetric, so the sign of the coupling is unambiguously determined. A more detailed description of the experimental evidence and its interpretation will be published in the near future.

The investigation reported above was suggested by line broadening in DCN observed while studying asymmetries of the nitrogen quadrupole coupling in HCN and DCN. Line widths of 50 kc/sec could be obtained for HCN, while DCN produced lines of 70 kc/sec width under the same conditions of temperature, pressure, and power. From the line broadening a value $(eqQ)_D = 300 \text{ kc/sec} \pm 150$ was inferred. The large uncertainty is caused primarily by the circumstance that the transition involved, being $\Delta J = 0$, is most unfavorable for the quadrupole coupling investigation. Accordingly, the molecule DCCCl described above, with the same bond structure and a more favorable transition was examined.

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Measurement of Permeability Tensor in Ferrites*

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A NUMBER of investigators have measured the imaginary component of the magnetic permeability in ferromagnetic semiconductors.¹ The usual method has been to introduce a small ferrite sample into a microwave cavity and to note the resulting perturbing effect on the cavity Q upon application of a dc mag-