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STATUS REPORT

In the status report for March 1 through May 31, 1962, experiments with single CdS crystals activated with copper were reported, which showed that such single crystal can very successfully be used as elements for a memory device. The most interesting feature of these crystals were: The relatively large size of their polarization--up to 10^{-7} coul/cm² were observed--the long decay time of this polarization--half value decay time of 1000 sec were observed, and their very rapid rise and release times. In order to study how the polarizations of these crystals are affected by additional electric fields, the following experiments were carried out. They give very good insight into the processes leading to polarization of the crystal and into those causing the release of polarization.

The results are presented in Table 1. The procedure was similar to that previously described, but instead of applying a field of one polarity, fields of different polarities were applied subsequently. The reason for this procedure was to find out how the polarization produced by one polarity was influenced by a subsequently applied field of opposite polarity. It will be shown later that the procedure of reversed field can be successfully used to accelerate the readout time of the polarization.

The experiments with crystal X55 were carried out in the following way. The crystal was illuminated with white light, then kept in the dark for 30^s, then irradiated with I.R. for 30^s. One second thereafter, a voltage V_{1c} was applied at the conductive side for 30^s; 1 sec. after removal of V_{1c} , another voltage V_{2c} was applied for 30^s. 10 sec. thereafter the polarization release was carried out. The voltages were applied for 30 sec. in order to have identical conditions always. It was, however, observed that 80% of the

X-55 $1^m W_n, 30^S dQ, 30^S IRQ_n \xrightarrow{1 \text{ sec}}$ P (n = 0; $V_{1c}, 30^S$; dark) $\xrightarrow{10 \text{ sec.}}$ R(UV, + white, 15^S)

RELEASE

+ charge implies positive charge moves to conductive electrode
 Q(UV) - charge release upon radiation of UV
 Q(W) - charge release upon radiation of white
 charge in units of $10^{-11} \text{ col/cm}^2$

	V_{1c}	V_{2c}	QUV _c	QW _n	QUV _n	QW _c
1						
2	+200	0	+6	(-0.5) (+0.5)	(-0.3) 0	+4.8 +6.6
3	+400	0	+7			
4	0	-200	-12	-17	-38	(+1)
5	+200	-200	-17	-17	-39	(+1.5)
6	+400	-200	-15	-15	-42	+3
7	0	-400	-69	-108	-260	(-5)
8	+200	-400	-78	-102	-265	(-5)
9	+400	-400	-33	-78	-255	(-10)
10	0	+200	+25	0	0	+8.0
11	0	+400	+22	(-1)	0	+17
12	-200	0	-5	-13	-24	(+2)
13	-200	+200	+13	-8	-6.3	+8.1
14	-200	+400	+19	-4	-3	+14
15	-400	0	-45	-138	-210	0
16	-400	+200	-23	-132	-162	0
17	-400	+400	-37	-78	-156	(-6)

Parentheses indicate magnitude is of such small scale that it is doubtful.

Table 1

final polarization was already obtained in much less than 1 sec.

The releases were performed either with U.V. light which is completely absorbed in the crystal within a small fraction of its thickness or with white light (W) which excites the crystal almost uniformly. Illumination was carried out either from the conductive side U.V._c, W_c, or from the non-conductive side U.V._n, W_n. The charges measured on the electrometer upon illumination are given in the table as QUV and QW. Release with white light was always carried out immediately after the respective polarization with U.V.

The accompanying table gives a good survey about the results obtained when voltages of different polarities and strength are applied. Rows 2 and 3 present the released polarization for 200 and 400 volt positive polarity at the conductive electrode. Positive charges are collected at the barrier, and consequently the U.V. release is strongest when illuminated through the conductive side since then electrons, the more mobile charge, move across the sample to the barrier and discharge the accumulated positive charge there. U.V. illumination through the barrier side does not produce any appreciable discharge because positive charges have to move across the crystal which are, however, less mobile. White light, applied after the U.V._n illumination results in a released charge of the same order of magnitude as QUV_c. If these values are compared with those described in Rows 10 and 11 in which the polarization was carried out as V_{2c}, which is normally applied 30 seconds later than the V_{1c} polarization, one finds that the discharge values are larger in the latter case since the decay times are shorter. The difference between the QUV_c of Rows 10 and 11 and those of Rows 2 and 3 is a measure of the decay of the positive polarization

(V_c positive) within 30 seconds. It is also important to compare the 200 and 400 volt polarization values. It is seen that the increase from 200 to 400 positive voltage does not increase the release charges considerably.

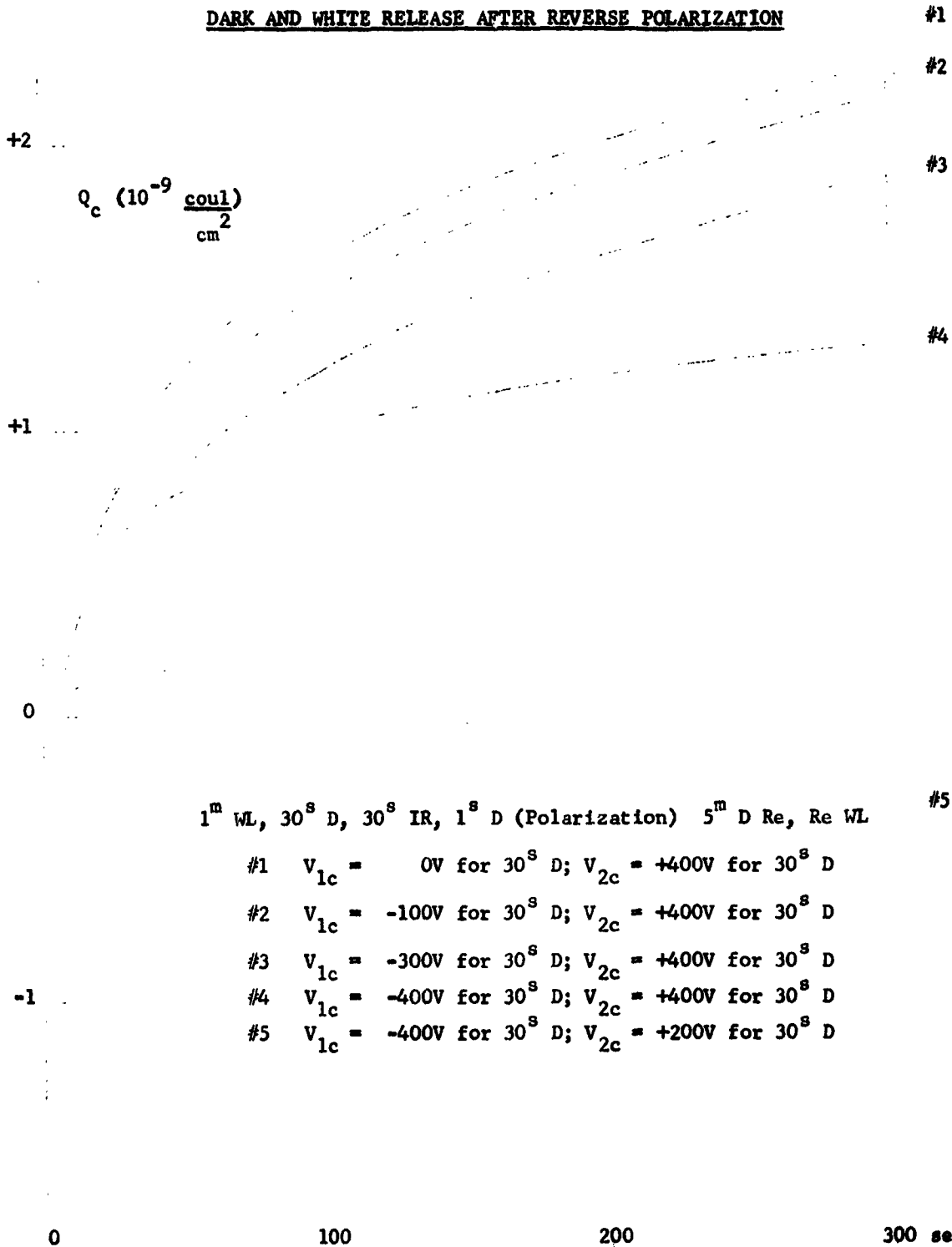
The results are quite different with negative polarity at the conductive side. Compare the results of Rows 12-15 with those of 2 and 3. In this case, the U.V. release on the conductive side is weak, and the U.V. release from the non-conductive side large. Note further the large increase between 200 and 400 volts which does not occur for positive voltages. Compare further with these values Rows 4 and 7 where the equivalent negative voltages are applied as V_{2c} . In this case, there is only a relatively slight decay with time. Especially compare QUV_n for Row 7 and Row 15. The decay for 200 volts is somewhat larger than for 400 volts. For negative voltages--this means for accumulation of negative charge at the barrier--also QUV_c has noticeable values, although when positive charges move from the conductive electrode through the sample to the barrier. This effect was already observed previously and has to be investigated further.

Now we consider the influence of reversed fields on a preceding polarization. First, consider Rows 6, 8 and 9, which present the results of positive polarization with 200 and 400 volt followed by negative polarization. It is seen that subsequent negative polarization reverses the released charge completely. The charge releases obtained under Column QUV_n are almost independent of the preceding polarization with positive voltages, but the QUV_c values are reversed compared with those obtained without reversed fields.

If one applies, however, a positive voltage after a preceding negative voltage at the conductive side, it is found that the influence of the reverse field is much less as shown by the results of Rows 13, 14, 16 and 17. With - 200 volt V_{1c} polarization, the subsequent polarization by + 200 and + 400 volts reduces the QUV_n values to some extent but does not reverse them; only the sign of the weaker QUV_c release is changed; but with - 400 volt V_{1c} polarization the subsequent polarization by + 200 and + 400 volts is still less effective as shown by the respective QUV_n and QUV_c . The releases with white light were only taken to see how much U.V. light had released the polarization. These results show that positive fields are much less effective in polarizing and depolarizing as negative fields.

These results are borne out by the curve of the accompanying figure which gives the release curves for negative polarization at the conductive side and subsequent positive polarization by 200 or 400 volts. First, the decay of polarization was observed in the dark for 300 seconds, and the curves given present this dark release. The dark release is positive for curves 1-4 and first positive and then negative for 5. This means that + 400 volts of the subsequent polarization produces some charge accumulation which decays in the dark rather fast. But even 300 seconds after this polarization, illumination with white light shows a very strong polarization in the direction expected from negative polarization. This means a transport of negative charge from the barrier to the conductive electrode. If these polarizations were released by white light or U.V. not after 300 seconds but after 30 seconds, the release in the negative direction would be much larger. Only for - 100 volts the subsequent

Figure 1



polarization by + 400 volts resulted in a small positive release. This shows quite obviously the considerable stability of negative polarization from the conductive side.

These results are important because they may enable us to accelerate the readout process by applying an opposite voltage during the release process. It is anticipated that this release will be much faster than the release without such a reverse field. Reverse field methods give further possibilities to erase the preceding polarization without light but with simple field application.

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