AC ELECTRICAL BEHAVIOUR OF MERCURIC IODIDE UNDER DIFFERENT LIGHT INTENSITIES

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Abstract

The impedance, Z, and phase angle, Φ, of HgI_2 crystal were measured at room temperature as a function of frequency, f, in the range 1 Hz - 20 KHz under different intensities of green light. No appreciable change in Z and Φ light intensity, I, is observed at frequencies higher than 3 KHz suggesting that the effect of light is masked by the frequency-dependent conduction through the capacitance of the crystal bulk. In the low frequency region, however, the effect of light intensity on Z and Φ is relatively large. For $f < 100$ Hz, the real part, Z_R, and imaginary part, Z_I, of the impedance almost follow a power-law dependance on I of the form Z_R or $Z_I \propto I^{-m}$ with m is slightly dependent on frequency and ranging from 0.4-0.6 for Z_R and 0.7-0.9 for Z_I. This variation of Z_R and/or Z_I is understood in the light of the network proposed by others.

Introduction

Considerable interest has been arose up during recent years in the use of mercuric iodide (HgI_2) as a low-energy gamma and/or x-ray detector material at room temperature (1-10). The actual physical properties of this material are yet not fully understood due to several undesirable processes occuring in the crystal that deteriorate the performance of the material as a radiation detector (9-17). Several methods have been used to study a variety of physical properties of HgI_2 crystals under the effect of different experimental parameters in attempt to accomplish a better understanding of the electrical behaviour of radiation detectors made of this material (9,10,14,15,17-23). One of these methods is the AC impedance technique (15,16) used by Bitar and co-workers to measure directly the complex impedance, Z, and the phase angle, Φ, of the HgI_2 cell being investigated.

The aim of this paper is to describe measurements of Z and Φ, using our previous impedance technique (15,16), of HgI_2 crystals at room temperature under

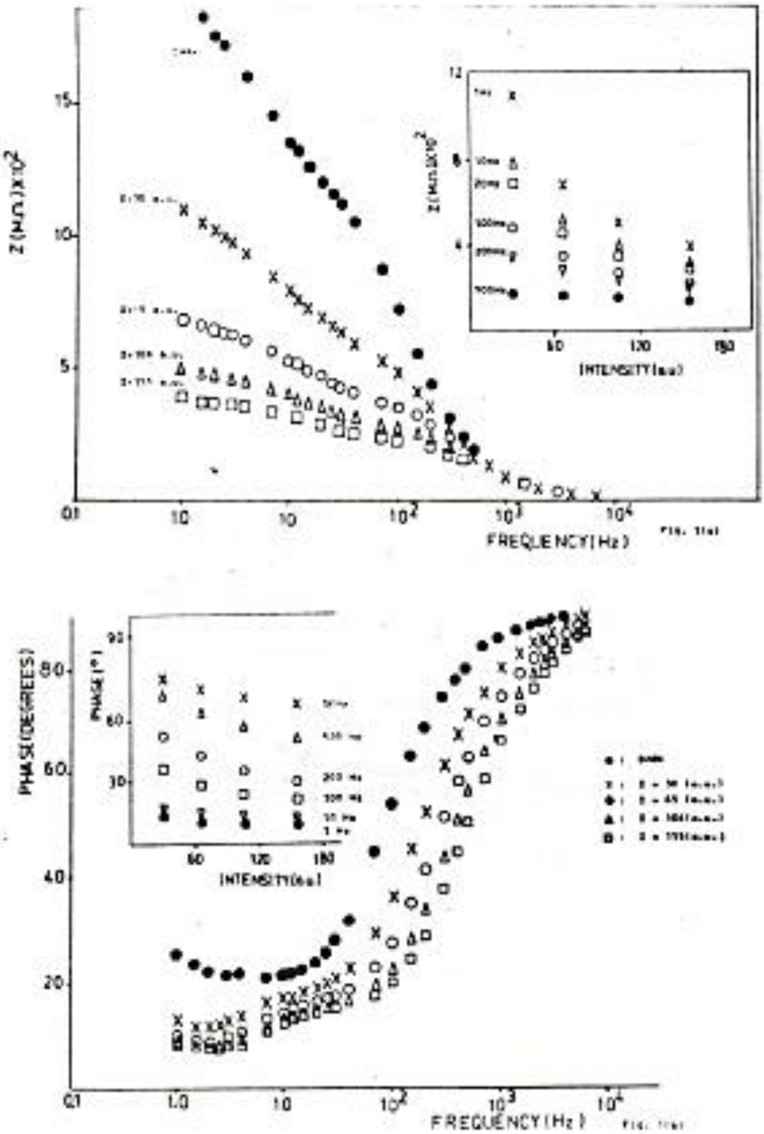

Figure 1: Impedance, Z, (1a) and phase angle, Φ, (1b) behaviours as a function of frequency under different light intensities (arbitrary units). The inserts show the variation of Z and Φ with light intensity, I, at various frequencies.

The response of HgI_2 crystal to the green LED can be attributed to an excition formation (15,21,26-28). The observed decrease in Z with increasing intensity of light may be attributed to the increase in the number of conduction electrons excited from the valence band via an exciton. Consequently, this increases the electrical and photo-conductivity of the crystal (14,21,23,26-28). Since Z is a complex quantity, it may be preferable to study the variation of its real, Z_R, and imaginary, Z_I, parts with light intensity. It has been found that Z_R follows a power law-dependence on light intensity of the form $Z_R \propto I^{-m}$, with m = 0.4-0.6. Similar dependence of Z_I is found with m ranges from 0.7-0.9. In both cases m is generally dependent on frequency. These variations of Z_R and Z_I with light intensity is not easy to interpret, since they are functions of several crystal parameters. These parameters depend on frequency, light intensity, peak-to-peak voltage of the applied ac signal, DC bias etc.. (9,10,14-17, 23). However, detailed analysis of the networks proposed by Bitar et al. (15) and Regolini and Saura (9) confirms this behaviour of Z_R and Z_I with I. The observed variation of R_b and R_a, the activation resistance of the low frequency network, with I as C_g and C_d, the effective double layer capacitance (15), are found to be independent of light intensity.

Conclusion

In this high frequency region (f > 3 KHz), the variation of the bulk resistance of the crystal with light intensity is masked by the frequency-dependent conduction through the bulk capacitance C_g which is independent of frequency and light intensity. On the other hand, the relatively large variation of both Z_R and Z_I with light intensity observed at lower frequencies may be understood from a detailed analysis of the equivalent network representing the HgI_2 cell.

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