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OPERATION TEMPERATURE BEHAVIOR OF PbSnTe DETECTORS MADE BY LPE AND HWE

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12. Revised by

Paulo Nubile

13. Authorized by

Marco Antônio Raupp
General Director

9. Authorship: Sukarno Olavo Ferreira
Eduardo Abramof
Irajá Newton Bandeira

Responsible author

14. Abstract/Notes

Lead-tin-telluride infrared photovoltaic detectors have been widely used in detection of the 3-14 μm wavelength radiation for several applications. The more promising techniques used to make the p-n junctions are Liquid Phase Epitaxy and Hot Wall Epitaxy. In this work a characterization of detectors as a function of temperature and a comparison of the two growth techniques based on it have been carried out.

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OPERATION TEMPERATURE BEHAVIOR OF PbSnTe DETECTORS MADE BY LPE AND HWE

S.O. Ferreira, E. Abramof, I.N. Bandeira - MCT/Instituto de Pesquisas Espaciais - INPE, Laboratório Associado de Sensores e Materiais - LAS, Caixa Postal 515, 12201 - São José dos Campos, SP, Brasil

ABSTRACT - Lead-tin-telluride infrared photovoltaic detectors have been widely used in detection of the 3-14 μm wavelength radiation for several applications. The more promising techniques used to make the p-n junctions are Liquid Phase Epitaxy and Hot Wall Epitaxy. In this work a characterization of detectors as a function of temperature and a comparison of the two growth techniques based on it have been carried out.

Lead-tin-telluride photovoltaic detectors are successfully used for thermal imaging in the 3-5 and 8-14 μm atmospheric windows besides pollution control, remote sensing of temperature, tracking systems, etc. We have employed Liquid Phase Expitaxy (LPE) and Hot Wall Epitaxy (HWE) to make the homo and heterostructures devices shown in Fig. [1].

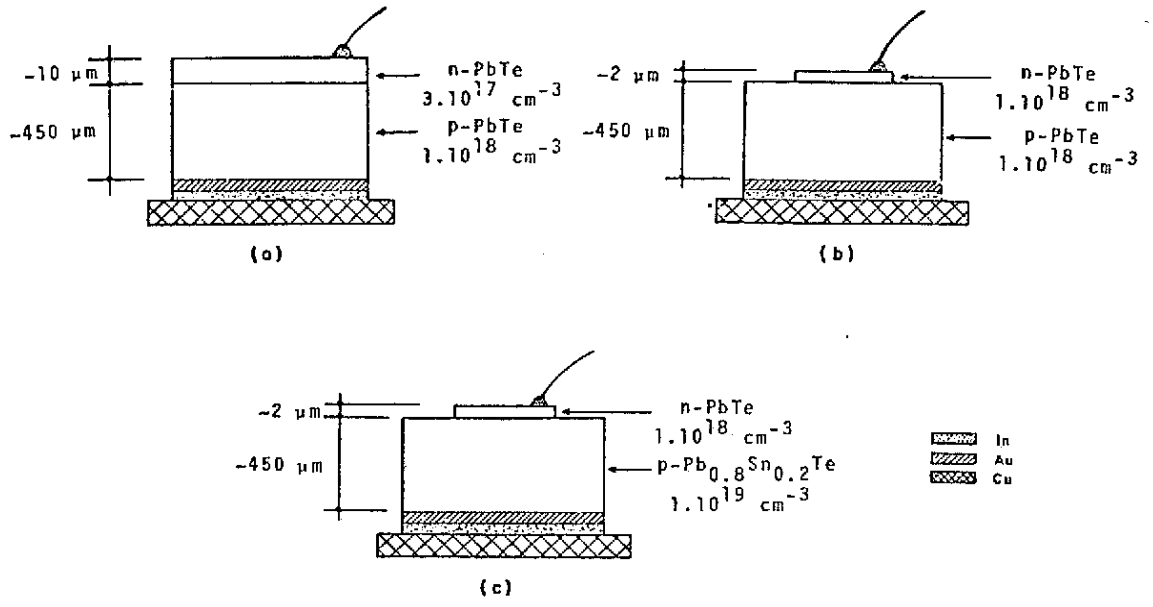

Fig. [1] - Structures tested.

The two basic behaviors of the signal-to-noise ratio (S/N) presented in Fig. [3] were observed independently of the structure and fabrication technique (two devices of the same array showed different behaviors). In curve (a) the S/N for a HWE-PbTe/PbTe detector oscillates between 75 and 100% of its maximum for temperatures up to 80 K, decreasing for higher temperatures. Curve (b), for aHWE-PbTe/$Pb_{0.8}Sn_{0.2}Te$, shows that the S/N increases from low temperatures to reach a maximum between 60 and 80 K and then decreases abruptly. Curve (c) presents the theoretical S/N for the HWE-PbTe/$Pb_{0.8}Sn_{0.2}Te$ detector if the Johnson noise was considered to be the dominant noise mechanism. The points were calculated from the R_o values given by the I x V curve (Fig. [2]).

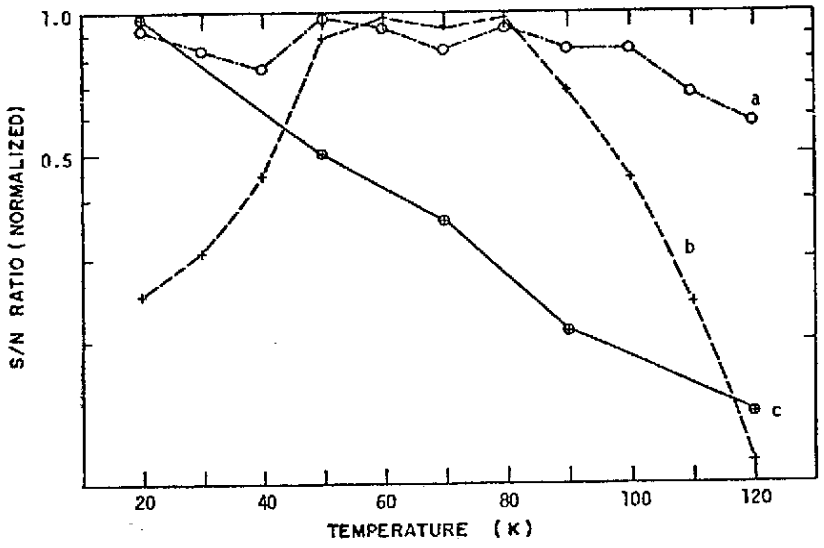

Fig. [3] - S/N ratio versus temperature, (a) HWE-PbTe/PbTe; (b) HWE - PbTe/$Pb_{0.8}Sn_{0.2}Te$; (c) Theoretical.

Differently from the similar I x V characteristics and the sort of randomly behavior for the S/N of the detectors made by LPE or HWE, the spectral response shows a strong de-

pendence on the p-n junction growth technique. Fig. [4] shows that a HWE detector (curve b) has an almost ideal spectral response except for the peak shift to shorter wavelength, that is explained by the Burstein-Moss effect due to the high carrier concentration in the upper layer[4]. In the LPE diode (curve c) this effect is not observed since the upper layer has a lower concentration. In this case, however, there is a decrease in the spectral response for lower wavelengths which may be due to a high surface recombination rate and a large layer thickness.

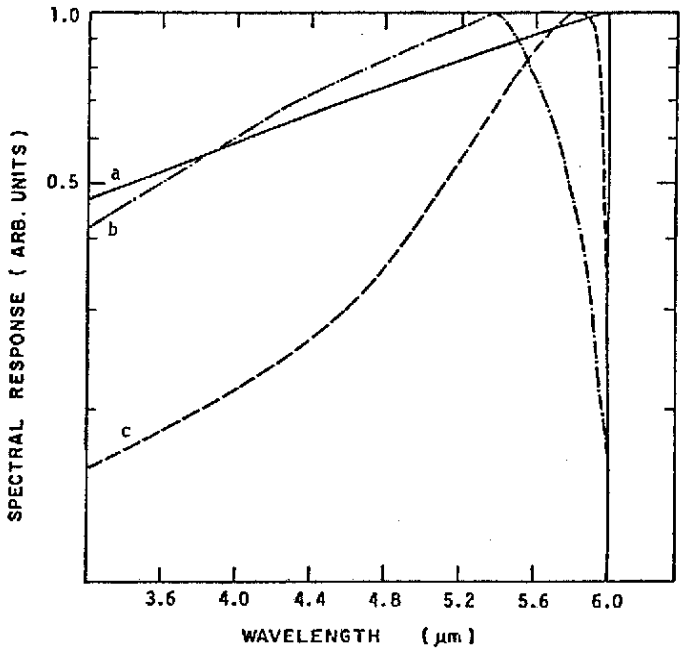

Fig. [4] - Spectral response of some structures: (a) ideal detector; (b) HWE-PbTe/PbTe; (c) LPE-PbTe/PbTe.

LPE layers have much more superfical defects than the HWE ones; beside that, the control over their thickness (for IV-VI compounds) had proven to be more difficult than for HWE layers. The ideal junction depth for the highest detectivity is 0.1Lp-2μm, which is the value for the HWE diodes.

Another possibility for this decrease at lower wavelengths is the In soldered ohmic contacts in the n-layer. Indium is known to be a lifetime "killer" in the PbSnTe alloys, hindering the carriers to reach the junction[5]. But, since the contacts are identical for all the diodes, the In diffusion should not be important.

From the cut-off wavelength of the spectral response, the PbTe gap dependence on temperature was calculated. The observed dependence, given by equations

$$Eg(T) = 176.4 + 0.526T; \quad T > 45K \qquad \text{and}$$

$$Eg(T) = 186.2 + 0.275T; \quad T < 45K$$

is shown in Fig. [5] (full line), together with the experimental points. This equation differs from others described in literature[6, 7, 8], one of them showed by the dashed line in Fig. [5].

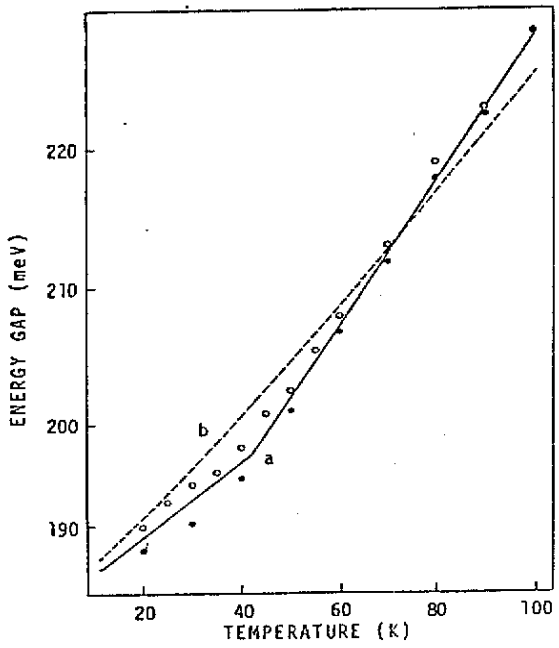

Fig. [5] - Energy gap dependence on temperature: o LPE-PbTe/PbTe; o HWE-PbTe/PbTe; (a) our equation, (b) Ref. 8.

The several characterizations made in this work leads to the conclusion that, while other merit figures seem to be

independent of construction technique, spectral response is the main difference regarding operation temperature, between LPE and HWE detectors. By reducing the layer thickness of LPE diodes, we have been able to obtain spectral responses close to ideal but still, due to superficial defects more or less inherent in the technique, HWE seem to be a more promising method for making high quality PbSnTe devices if the carrier concentration would be optimized.

It is important to mention that further work should be done to completely understand the temperature dependence of PbSnTe detectors characteristics, mainly the signal-to-noise ratio.

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AUTOR(ES)

S.O. Ferreira - (376)
E. Abramof
I. N. Bandeira

ORIENTADOR

CO-ORIENTADOR

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