

I. Introduction

For PbTe based materials, it is well known that trap states are located inside the band gap and are originated from the intrinsic disorder introduced during the sample growth [1] and when illuminated these materials present positive photoconductivity [2]. The introduction of Sn atoms changes the position of the trap level in relation to the maximum of the valence band and alters the generation and recombination rates when the sample is illuminated [3].

In this work, we present the results of photoconductivity measurements performed in a p -type $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$ film, grown on (111) cleaved BaF_2 substrate, for $x=0.44$. We observed the NPC effect at room temperature and also that its amplitude increases as temperature decreases. We show that the NPC effect is a consequence of the reduction of electrons and holes in the conduction and valence bands, respectively, due to the influence of the trap level in the dynamics of the generation and recombination rates when the sample is illuminated.

We investigated the negative photoconductivity (NPC) effect that was observed in a p -type $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$ film for temperatures varying from 300 K down to 85 K. We found that this effect is a consequence of defect states located in the band gap that act as a trapping level changing the relation between the generation and recombination rates. Theoretical calculations predict contributions to the NPC from both conduction and valence bands which is in accordance to the experimental observations.

III. Experimental Results

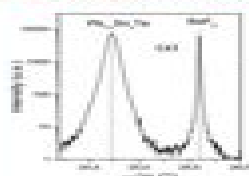


Figure 1. Atomic force microscopy image of (111) $\text{Pb}_{0.56}\text{Sn}_{0.44}\text{Te}$, 7 μm thick epitaxial film. This image of (70x70) μm^2 shows that voids still present in the sample surface morphology.

Figure 2. Photoconductivity curves for an undoped PbTe film, under blue and IR light illumination. The amplitude is positive, presenting the expected behavior for semiconductors.

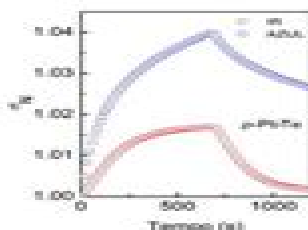


Figure 3. Time dependence of the normalized photoconductivity ($\sigma/\sigma_0 = \Delta\sigma/\sigma_0$) for $\text{Pb}_{0.56}\text{Sn}_{0.44}\text{Te}$ film in the temperature range of 85 - 300K under illumination. The inset exhibits the buildup and decay at 300K and 100K, under illumination and dark conditions [see the arrows for LED on/off]. (a) The values of $\mu_{ph} = 1/\sigma_{ph}$ for the temperatures presented in (a) when the illumination is removed revealing the effect of persistent photoconductivity.



Figure 4. (a) Plot of $\ln(\tau)$ as a function of $1/(k_B T)$. Inset: Thermal energy $k_B T$ vs. the energy gap E_g . (b) and (c): schematic representation of the transitions taking in account the trap level (τ_0).

IV. Analysis

$$\begin{aligned} \Delta\sigma &= \Delta n + \Delta p \mu_{ph} \\ \Delta n &= \mu_{ph} (G_{ph} - R_{ph}) \\ R_{ph} &= R_{ph0} + R_{ph1} \\ R_{ph0} &= R_{ph0} - R_{ph0} \mu_{ph} \\ R_{ph1} &= R_{ph1} - R_{ph1} \mu_{ph} \end{aligned}$$

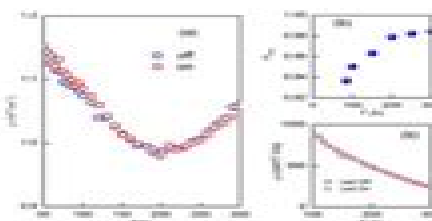
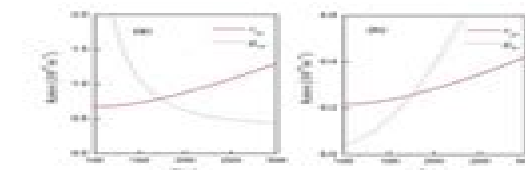


Figure 5. (a) Hole concentration in dark conditions and under illumination. (b) Values for which the NPC amplitude, $\Delta\sigma_{max}$, saturates. (c) Experimental hole mobility measured under light and dark conditions for $T=100 - 300$ K.

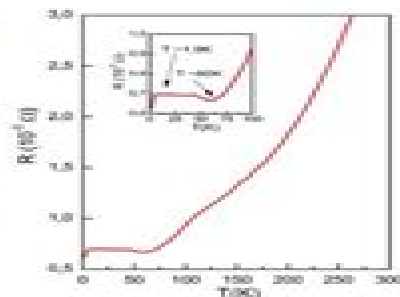


Figure 7. Temperature dependence of the electrical resistivity for a $\text{Pb}_{0.56}\text{Sn}_{0.44}\text{Te}$ film. At lower temperatures, $T < 85$ K, the drop indicate a possible superconductor effect.

V. Conclusions

- $\text{Pb}_{0.56}\text{Sn}_{0.44}\text{Te}$ samples present negative photoconductivity effect
- The NPC effect is caused due to the defect level present inside the band gap
- The sample also present the persistent photoconductivity effect also due to the defect level.

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- [2] S. de Castro, D. A. W. Soares, M. L. Pernes, P. H. O. Rapp, and E. Abramof, Appl. Phys. Lett. **99**, 142105 (2011).

V. Acknowledgements

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Anomalous Photoconductivity

M. I. Korsunskii



Anomalous Photoconductivity:

Anomalous Photoconductivity M. I. Korsunskii, 1973 *Photoconductivity and Photoconductive Materials, 2 Volume Set*
Safa O. Kasap, 2022-06-27 Dieses wichtige Referenzwerk behandelt die grundlegenden Konzepte der Photoleitfähigkeit und der photoleitenden Materialien Mit *Photoconductivity and Photoconductive Materials* präsentiert Professor Kasap eine maßgebliche Zusammenstellung der wesentlichen Grundsätze der Photoleitfähigkeit und stellt eine Auswahl aktueller photoleitfähiger Materialien vor Der erste Band des zweibändigen Werks beginnt mit einer Darstellung der grundlegenden Konzepte und Definitionen Es folgt eine Charakterisierung der verschiedenen Techniken auf Grundlage von stationärer transienter und modulierter Photoleitfähigkeit und der neuen Methode der Ladungsextraktion durch linear steigende Spannung CELIV Auch die Physik der Terahertz Photoleitfähigkeit sowie die Grundlagen der organischen Halbleiter LSoI werden behandelt Der zweite Band beginnt mit einem umfassenden Überblick über eine Vielzahl unterschiedlicher photoleitfähiger Materialien wobei der Schwerpunkt auf einige der wichtigsten Photoleiter gelegt wird darunter hydriertes amorphes Silizium Cadmium Quecksilber Tellurid verschiedene Röntgenphotoleiter Diamantfilme Metallhalogenidperowskite Nanodrähte und Quantenpunkte Auch die Anwendungen der photoleitenden Antenne werden erörtert Das Werk das zahlreiche Beiträge führender Autoren auf diesem Fachgebiet enthält bietet den Leserinnen und Lesern außerdem eine gründliche Einführung in die Charakterisierung von Halbleitern mit Hilfe von Techniken der Photoleitfähigkeit insbesondere gleichmäßiger Beleuchtung und Phototruer Gittertechniken Eine umfassende Darstellung organischer Photoleiter mitsamt Informationen zu Photoerzeugung Transport und Anwendungen im Druckbereich Praktische Erörterungen der transienten Lichtleitfähigkeit im Flugzeitverfahren inklusive Experimentiertechniken und Interpretationshinweisen Eine eingehende Betrachtung der transienten Photoleitfähigkeit organischer Halbleiterschichten und neuartiger Techniken der transienten Photoleitfähigkeit *Photoconductivity and Photoconductive Materials* ist nicht nur ein wichtiges Referenzwerk für Physiker in der Forschung Materialwissenschaftler und Elektroingenieure sondern auch ein unverzichtbares Nachschlagewerk für Doktoranden und Studierende höherer Semester die sich mit dem Bereich der optoelektronischen Materialien beschäftigen sowie für Forschende in der Industrie Ein umfassendes zweibändiges Werk mit Beiträgen führender Fachautoren herausgegeben von einem angesehenen Forscher auf dem Gebiet der Photoleitfähigkeit **Encyclopedic Dictionary of Condensed Matter Physics** Charles P. Poole Jr., 2004-03-11 This volume is a translation and revision of the Original Russian version by Baryahktar It covers all of the main fields involved in Condensed Matter Physics such as crystallography electrical properties fluids magnetism material properties optics radiation semiconductors and superconductivity as well as highlights of important related subjects such as quantum mechanics spectroscopy and statistical mechanics Both theoretical and experimental aspects of condensed matter are covered in detail The entries range from very short paragraphs on topics where definitions are needed such as Bloch's law clathrate compound donor domain Kondo lattice mean free path and

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