Chinese Physics B Template

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Carrier behavior in CuInS2 thin films on the and microsecond time scales is discussed in detail. The transient absorption data shows that the photo-generated carriers rapidly relax accompanied by energy change. The photo-generated charge carriers are extracted by a bias electric field (E) in the nanosecond transient system; moreover, E would improve the efficiency of photon conversion to charge carriers and enhance the velocity of extracted charge carriers. In addition, there is a threshold of illumination intensity in the extraction process of charge carriers in the CuInS2 thin film. There is carrier recombination if the illumination is higher than the threshold. The corresponding loss further increases with illumination intensity, and the recombination percentage is almost independent of E. The results are useful to further understand the characteristics of carriers in the CuInS2 thin film and are important for the operation of the corresponding devices.

# Introduction

Metal sulfide thin films are bulk semiconductor films that have attracted much attention recently because of their many excellent advantages. Examples include CuS$, Cu2S$, ZnS$, CdS$, SnS$, FeS2$, Sb2S3$, CuAlS2$, Cu2BaS2$, CuInS2$, and Cu2ZnSnS4$. The synthesis process is easy to control and tune$ $, and the performance of the film is better than nanocrystal films. This is influenced by the surface ligands of the nanocrystal$. Therefore, metal sulfide thin films have huge potential in the fields of optoelectronic devices, including photo-voltage and photoconductive devices.

CuInS2 is a representative metal sulfide thin film with many superior characteristics, such as optimal bandgaps$, a large absorption coefficient$, and low toxicity$ . To further develop optoelectronic devices based on the CuInS2 thin films, studies of charge carrier behavior are important, including charge carrier generation, mobility, and recombination mechanisms. However, understanding of the carrier dynamics in the CuInS2 thin films remains limited and requires further study. These materials have an amorphous structure$ $, and the corresponding photo-physical properties have some difference with the nanocrystals. In addition, the carrier behavior in the inorganic semiconductor film is complicated and is affected by many factors. A single test method is not sufficient to analyze this process.

Here, we simultaneously applied femtosecond transient absorption and nanosecond transient photocurrent to test the carrier behavior in the CuInS2 thin films. Finally, we hope to further understand the carrier behavior occurring in the CuInS2 film and find intrinsic physical characteristics that are independent of the external condition.

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# Acknowledgements

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# References

Zinszer K, Morrison K, Verma A and Brownstein J S 2017 Spatial Determinants of Ebola Virus Disease Risk for the West African Epidemic. *PLoS Curr* **9**

[2] Zhou J, Xue Z, Du Z, Melese T and Boyer P D 1988 Relationship of tightly bound ADP and ATP to control and catalysis by chloroplast ATP synthase *Biochemistry* **27** 5129–35

[3] Boyer P D 1998 Energy Life, and ATP (Nobel Lecture) *Angewandte Chemie International Edition* **37** 2296–307