EXPERIMENTAL INVESTIGATION OF PHOTOCONDUCTIVITY IN N-TYPE PBTE QUANTUM WELLS

F. S. Pena[1], M. J. P. Pirralho[1], M. L. Peres[1], D. A. W. Soares[1], P. C. O. Braga[1], A. K. Okazaki[2], C. I. Fornari[2], P. H. O. Rappl[2], E. Abramof[2]

[1]*Instituto de Física e Química, Universidade Federal de Itajubá, Itajubá, MG CEP 37500-903, Brazil*
[2]*Laboratório Associado de Sensores e Materiais, Instituto Nacional de Pesquisas Espaciais, São José dos Campos, PB 515, SP CEP 12201-970, Brazil*

1. INTRODUCTION

PbTe is a narrow gap semiconductor which exhibits interesting properties that differentiate it from other semiconductors [1]. PbTe based materials have being widely used in the fabrication of infrared devices [2] and its electrical properties are well investigated in literature. Concerning to photoconductivity effect, very few information have being reported in structures base in this compound..

2. STATEMENT OF WORK

In this work, we present photoconductivity measurements performed in *n*-type PbTe quantum wells (QW) under infrared (IR) illumination and the results presented anomalous behavior at different temperature regions. The effect of persistent photoconductivity was also observed .

3. EXPERIMENTAL

The PbTe/$Pb_{1-x}Eu_xTe$ QW samples investigated in this work were grown by molecular beam epitaxy on (111) cleaved BaF_2 substrates. The sample structure consisted PbTe well embedded between two $Pb_{1-x}Eu_xTe$ buffer of a 20 to 30 nm thick layer as illustrate in figure **1a**. These barriers are doped with bismuth, which guarantee an n -type character for these samples. The 6072 sample have 12% of Eu and the width of the QW is 10nm and 7111 sample have 10% of Eu and the width of the QW is 14.5nm.

For photoconductivity experiments, these samples with Indium contacts in Van der Pauw geometry are connected in the sample port with gold thin wires and a near IR commercial *LED* as illustrate in figure **1b**. The samples are cooled with a liquid nitrogen in a cold finger system in temperatures between 80k e 300K and electrical characterized with and without *LED* radiation.

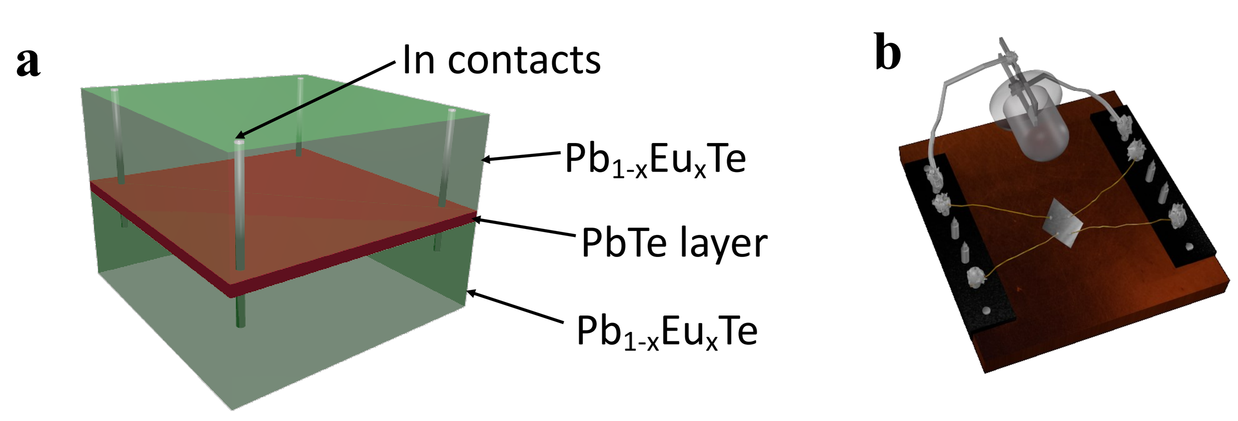

Figure 1. a) Illustration of PbTe/$Pb_{1-x}Eu_xTe$ QW with In contacts. b) illustration of sample port with a sample connected with gold thin wires and a *LED*.

4. RESULTS

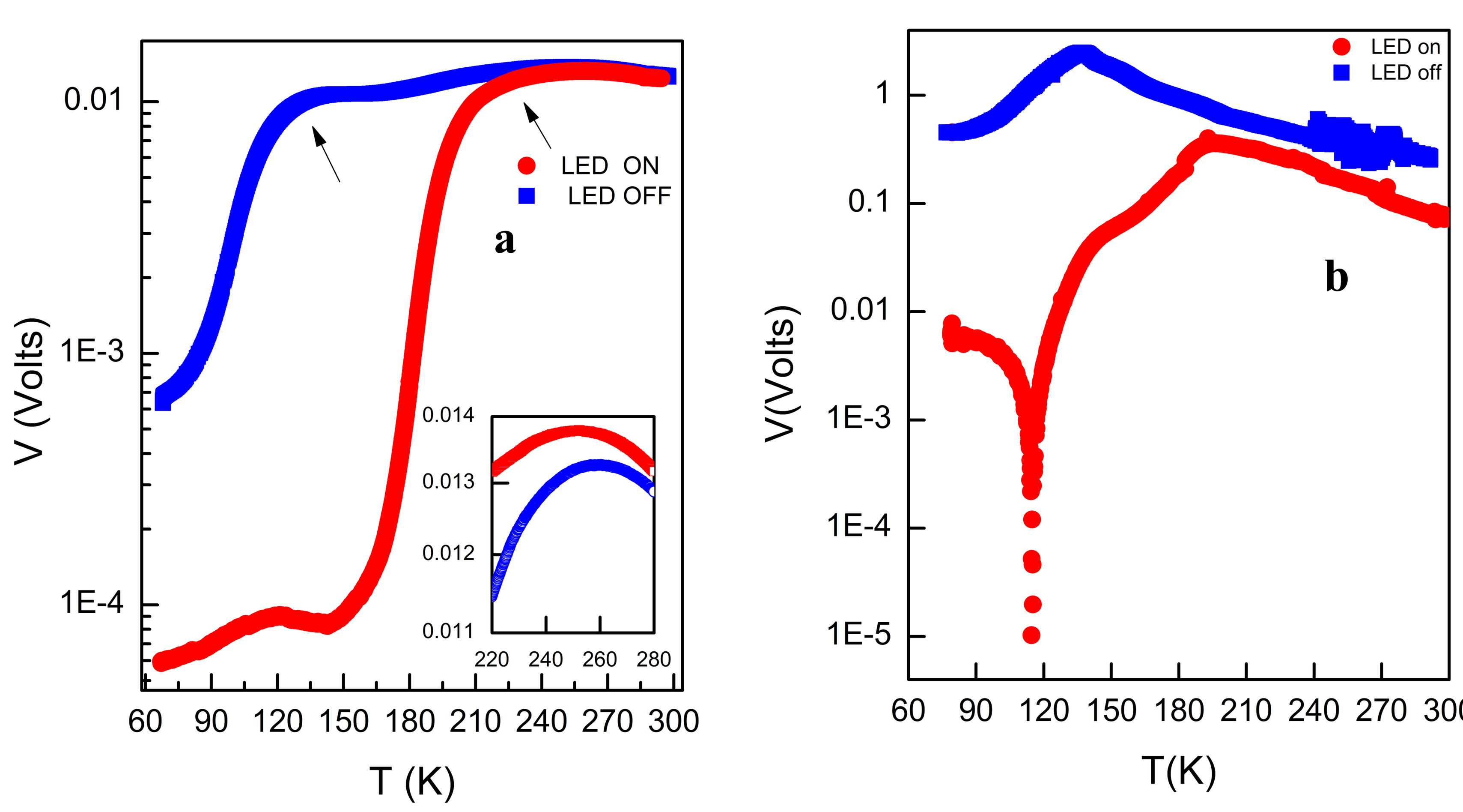

Figure 2. a) and b) Voltage in function of temperature with and without IR illumination in the 10nm and 14.5nm QW samples respectively.

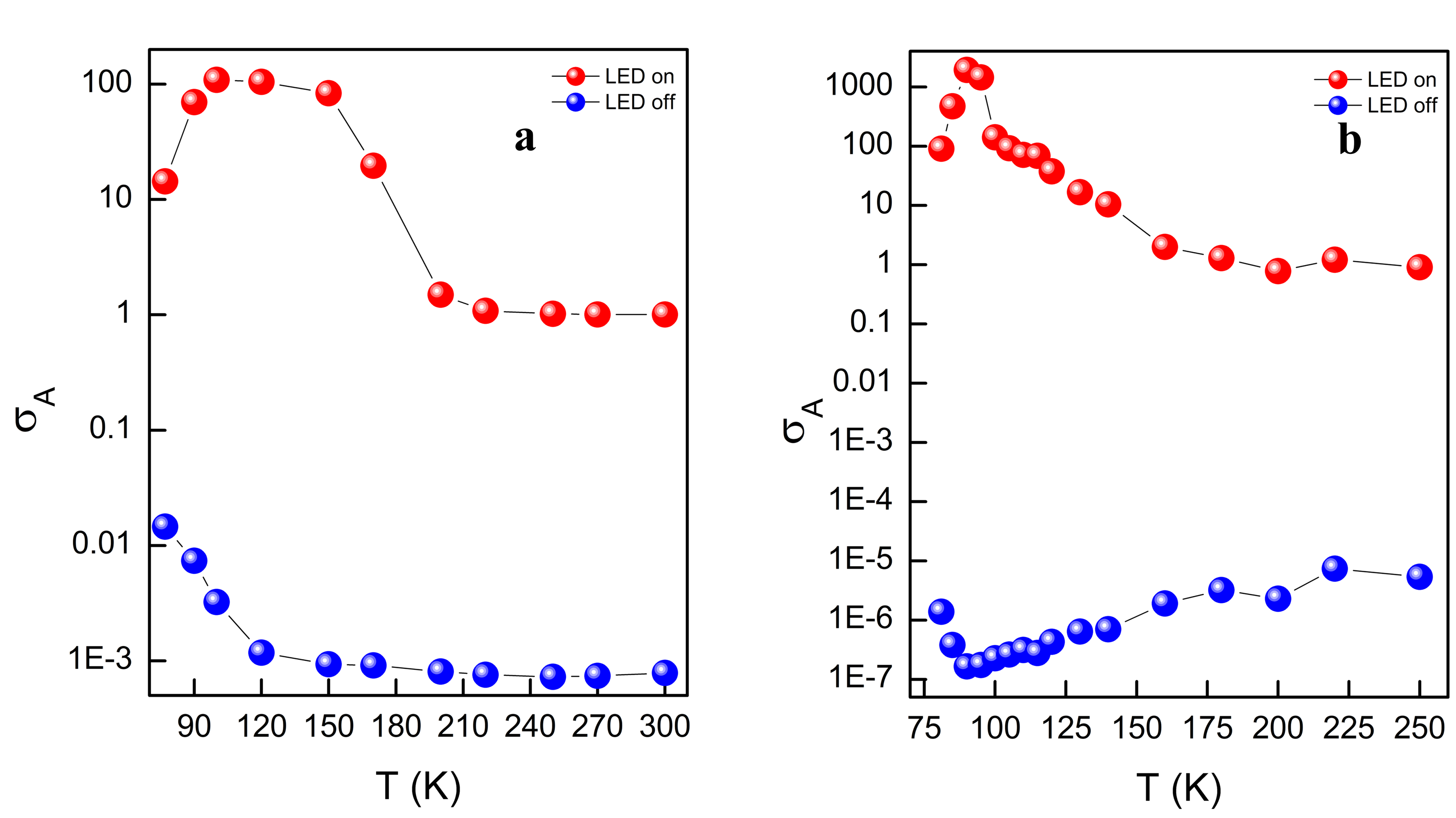

Figure 3. a) and d) normalized photoconductivity (red points) in comparison with dark conductivity (blue points) for 10nm and 14.5nm QW samples respectively.

The photovoltage and voltage in function of temperature as show in figures **2a** e **2b**, we can see a change of channel transport from the barrier to the well, beginning at 120K for 10nm and 130K for 14.5nm samples. With IR irradiation these temperatures suffer a dislocation for 205K in the 10nm and for 185K in the 14.5nm samples. But what happening with the photoconductivity in this QW?

The normalized photoconductivity in parallel with the dark conductivity is show in figures **3a** and **3b**. When the electrons are in the barrier the photoconductivity presents no relevant changes, but prisoned in the well the gain is very high. In figures **4a** and **4b** is show the normalized photoconductivity in some temperatures. When the *LED* is turned on the conductivity increase instantly reaching values 10000% and 100000% more than in the dark as can be clearly seem in figures **4**.

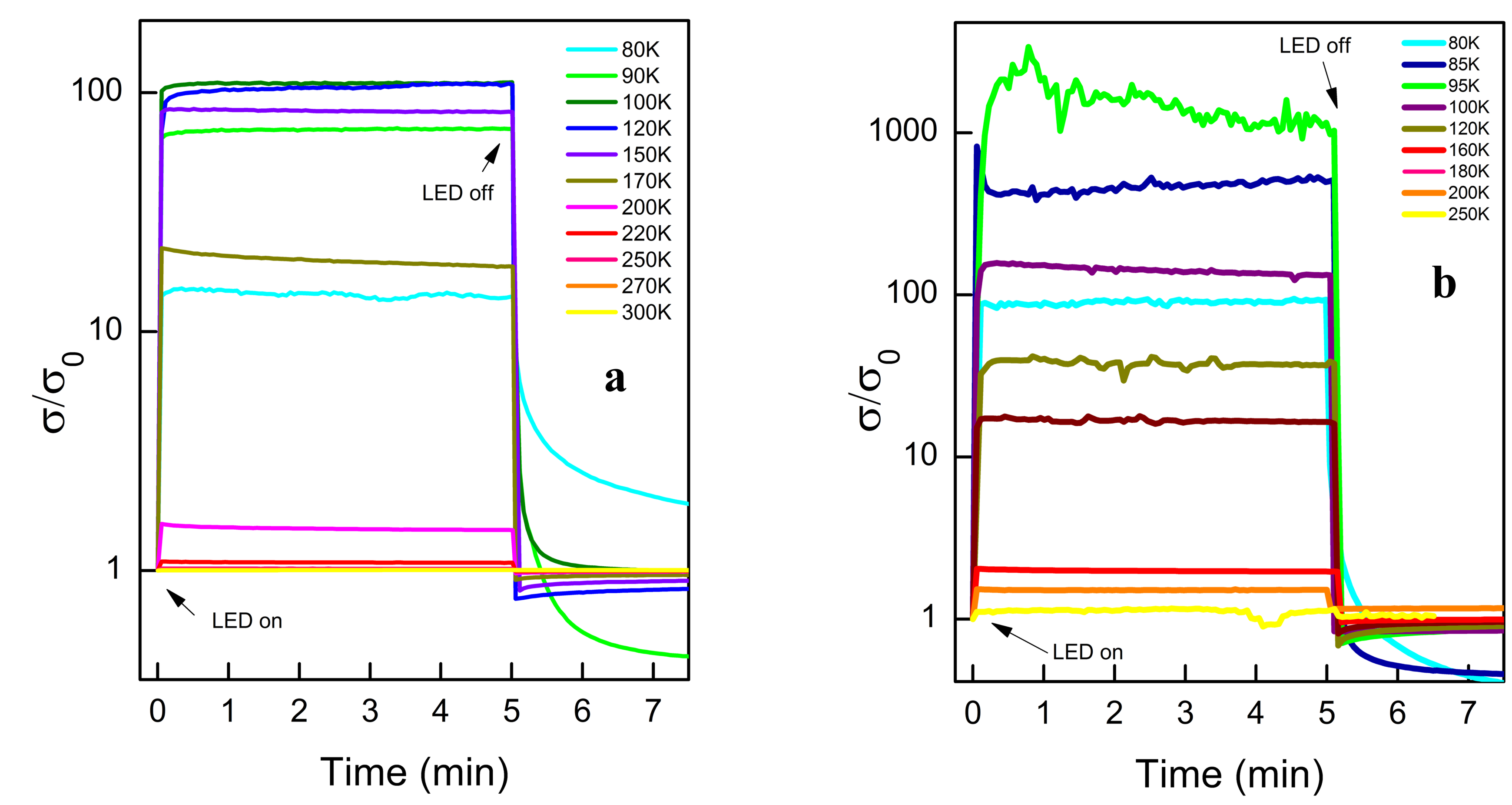

Figure 4. a) and b) Photoconductivity in several temperatures for 10nm and 14.5nm QW samples respectively.

When the *LED* is turned off, persistent photoconductivity appear in some temperatures as present in figure **5a** and **5b**. In order to find the decay time, a exponential fit was performed in the 14.5nm QW sample as show in figure **5c** for 120K. Applying the Arrhenius plot it is possible to find the value of activation energy related to this persistent photoconductivity as show in figure **5d**. The value founded is 695meV, its match with the 4f PbEuTe trap level if compared with the literature values [3], 601meV for 8% Eu and 641meV for 9% Eu.

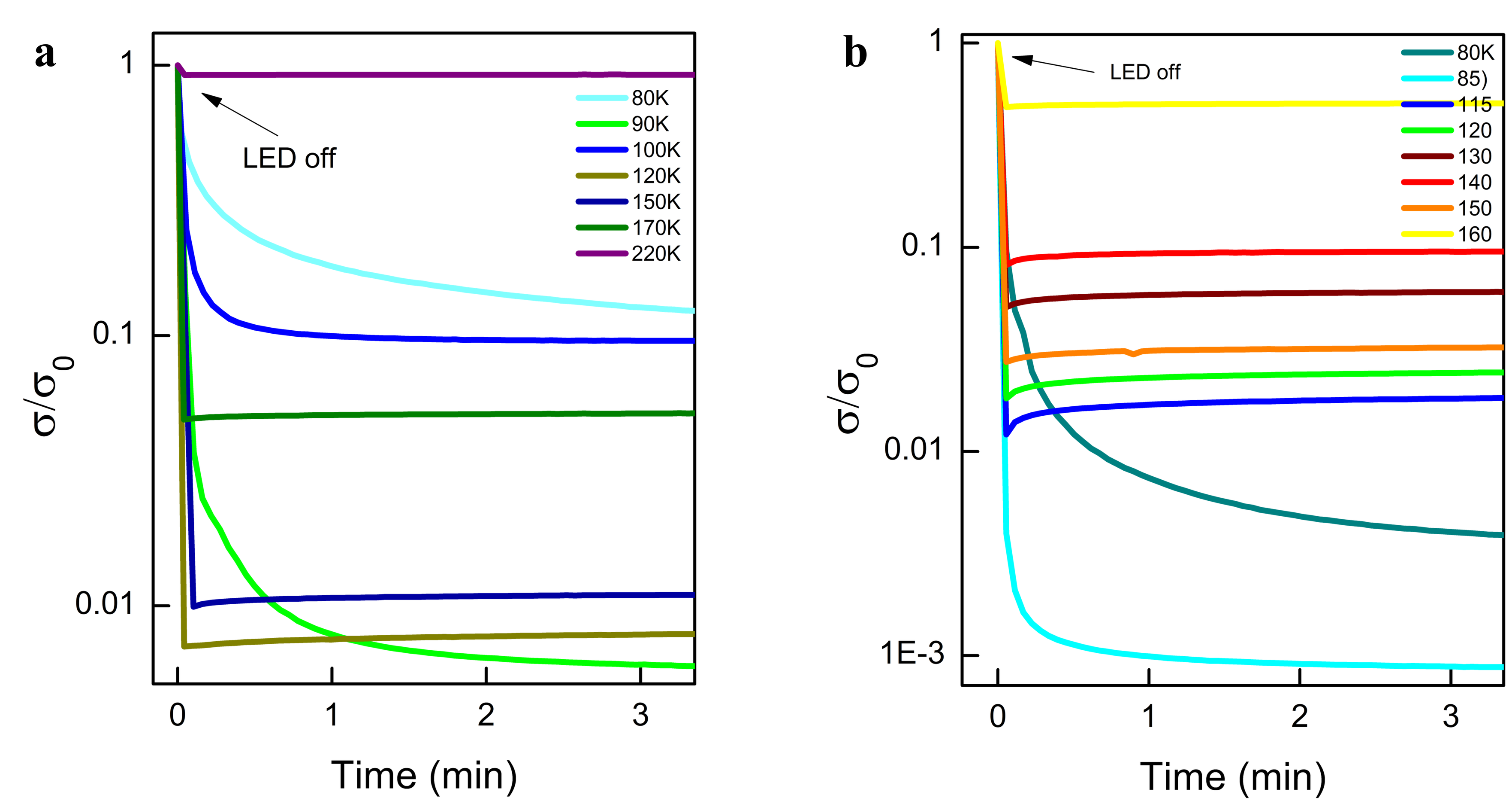

Figure 4. a) and b) Persistent photoconductivity in several temperatures for 10nm and 14.5nm QW samples respectively.

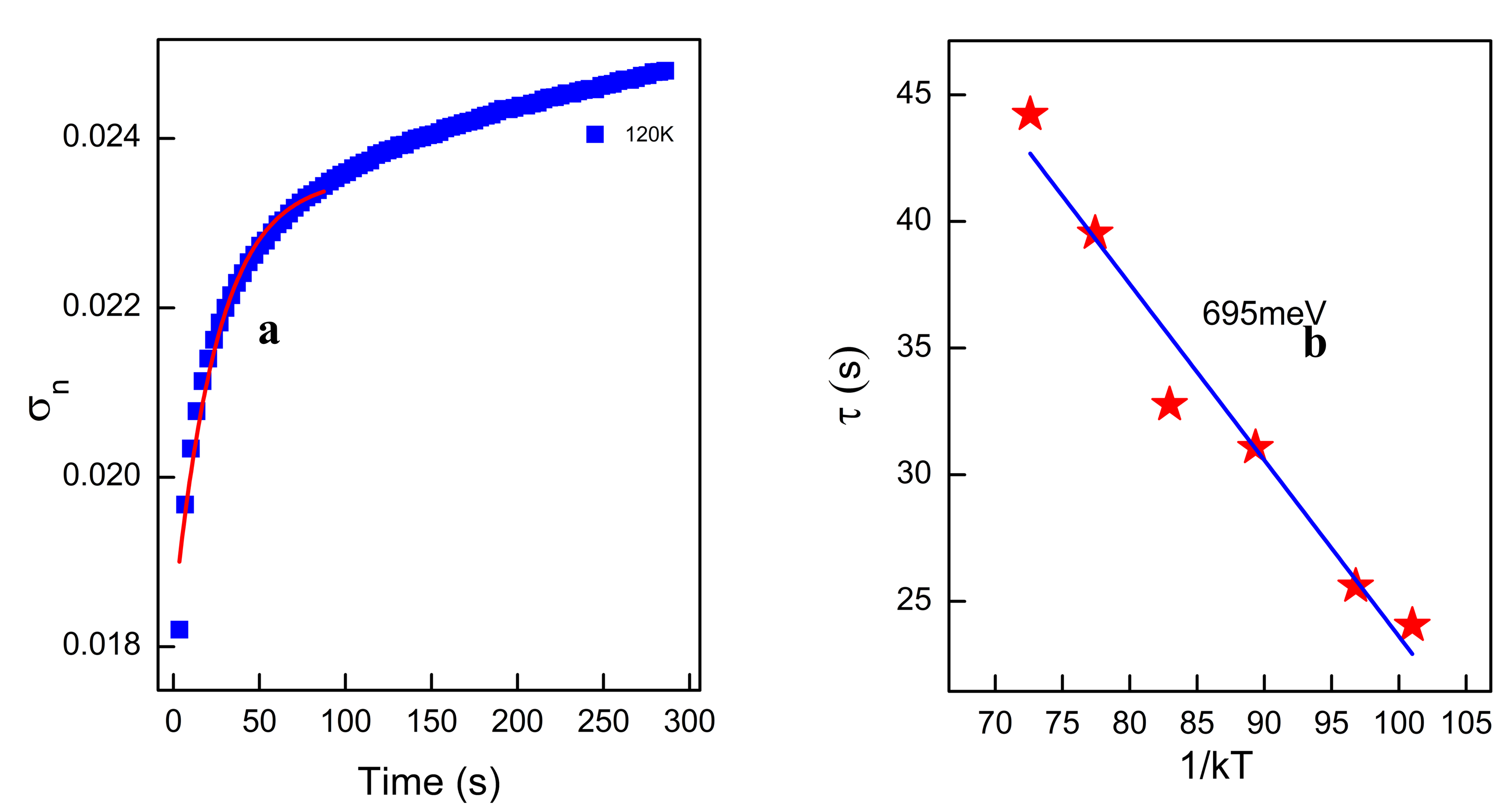

Figure 5. a) Exponential fit for 120K in the 10nm QW. b) Linear fit of the decay times for 10nm QW.

5. CONCLUSIONS

The data presented in this poster show a potential application for IR sensor since sample conductivity increases instantly when *LED* is on. This indicates that the QW is more effective to detect IR light rather than films based on PbTe. We also find persistent photoconductivity effect that appears probably due to 4f PbEuTe trap level that deeply influences the transport properties of this material.

6. REFERENCES

[1] V. A. Chitta *et al*, Phys. Rev. B **72**, 195326 (2005).
[2] A. S. Barros *et al*, Jour. of App. Phys. **99**, 024904 (2006) .
[3] M. L. Peres *et al,* Jour. of App. Phys, **111**, 123708 (2012).

FINANCIAL
FAPEMIG
CAPES