Characterization of intermediate band materials and solar cells

POLITÉCNICA

Instituto de Energía Solar

C. del Cañizo

CHEETA Workshop:
Advanced characterization methods for PV

Freiburg, January 14th 2016

Overview

- Brief overview of the IB concept
- Two-photon below bandgap absorption characterization
- Voltage preservation
- Characterization of some IB properties

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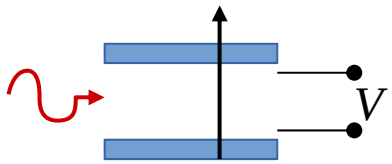
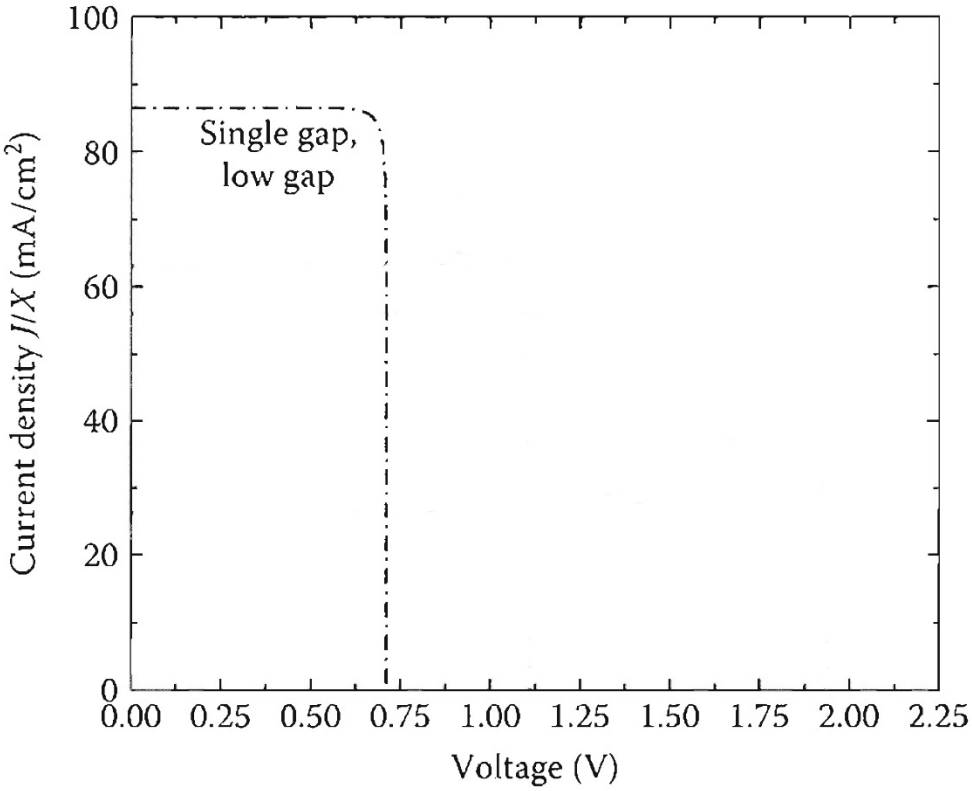
IBSC concept



Low bandgap



E. Antolín, A. Martí, and A. Luque, "High effciency intermediate band solar cells implemented with quantum dots," in VLSI Micro- and Nanophotonics: Science, Technology, and Applications, ed Boca Raton: CRC, 2010.

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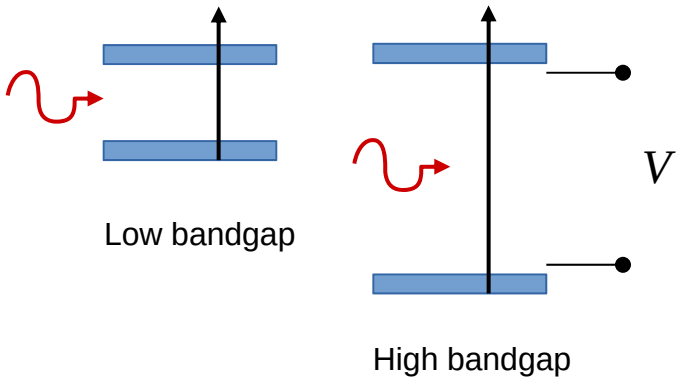

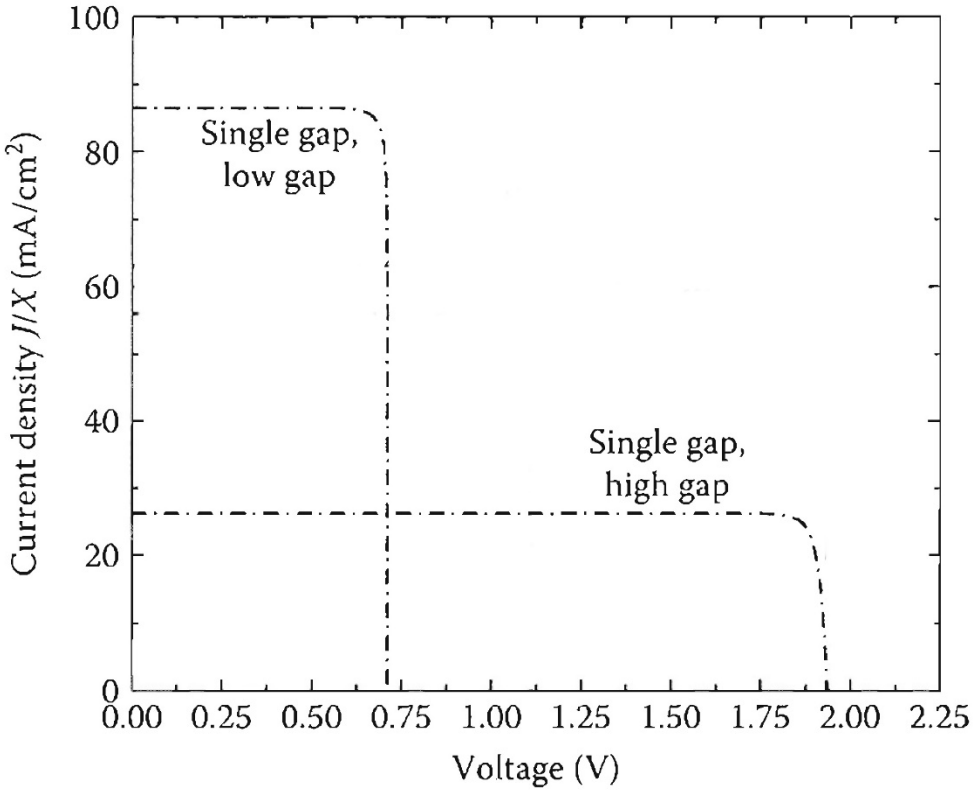

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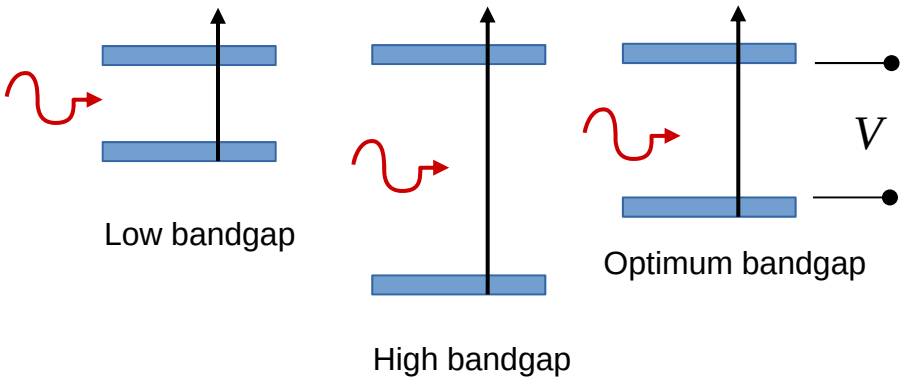

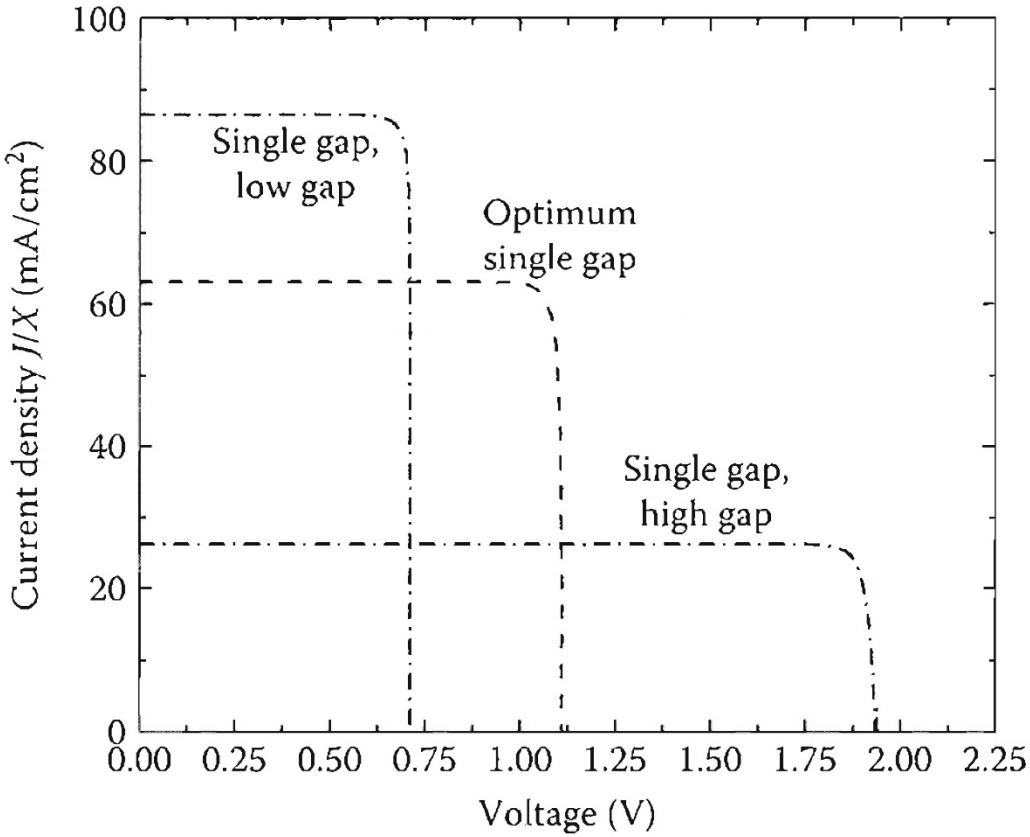

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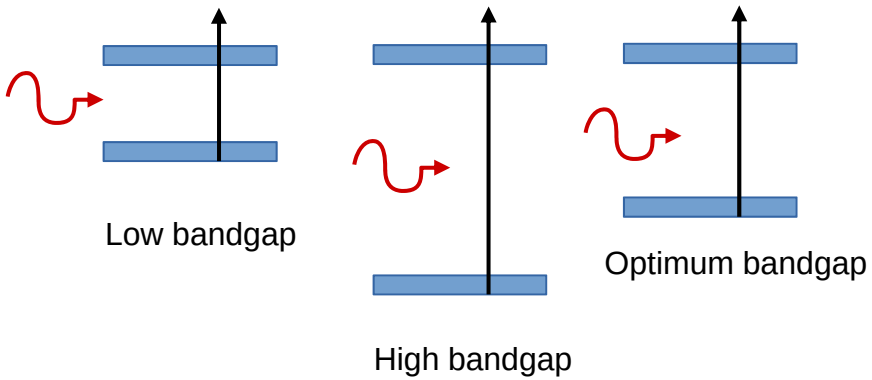

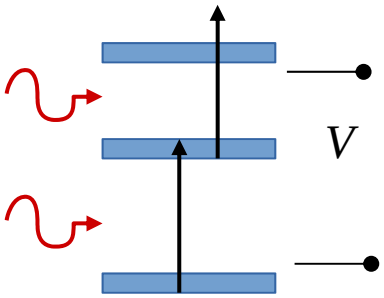

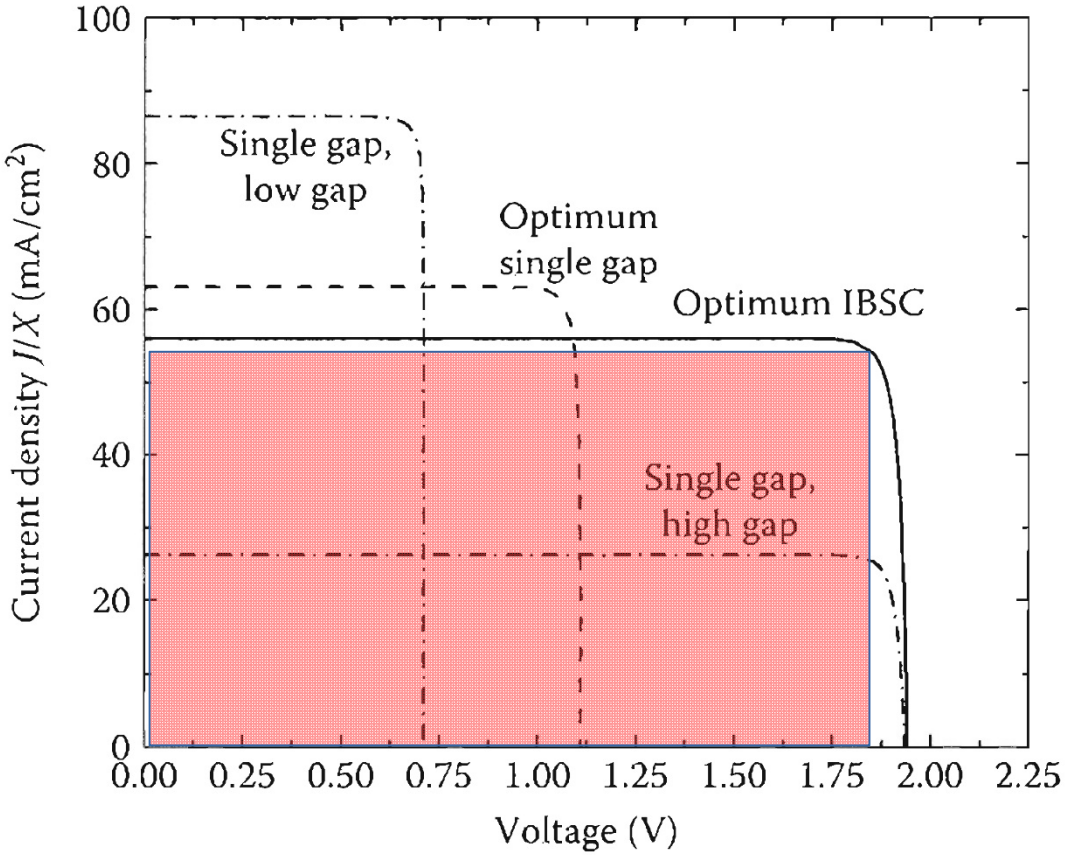

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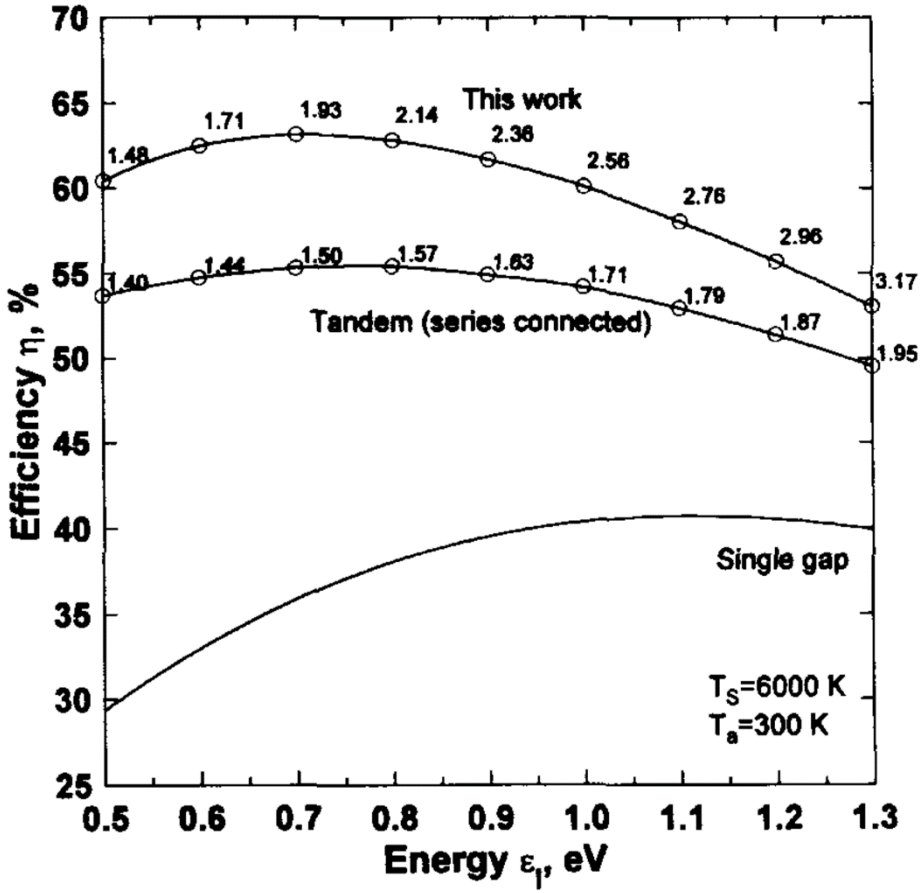
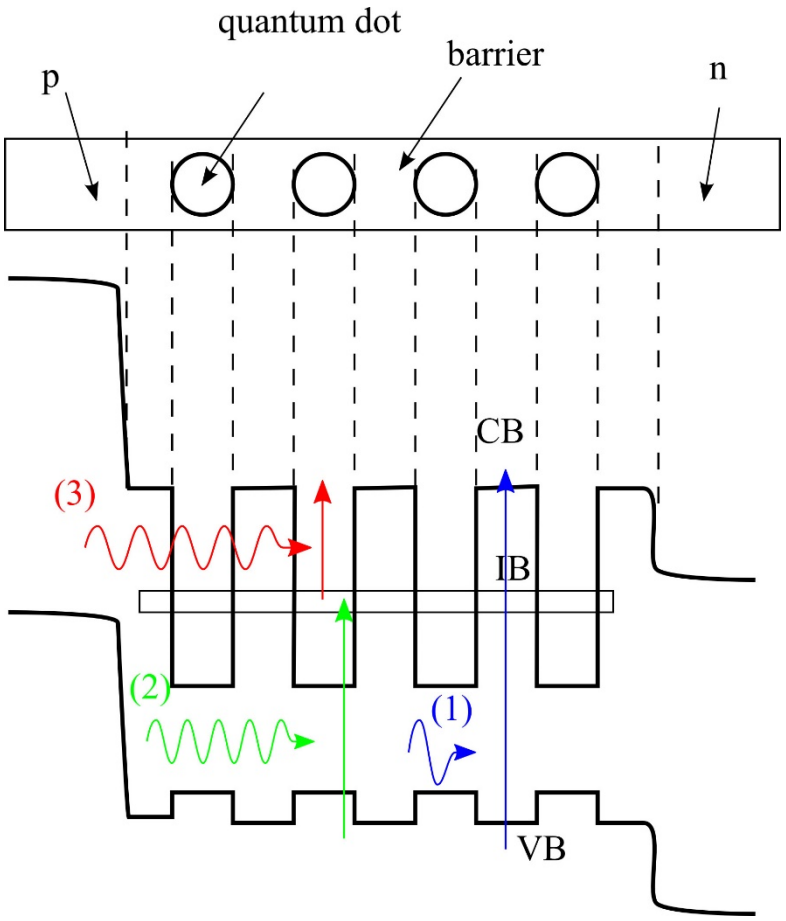
Limiting efficiency



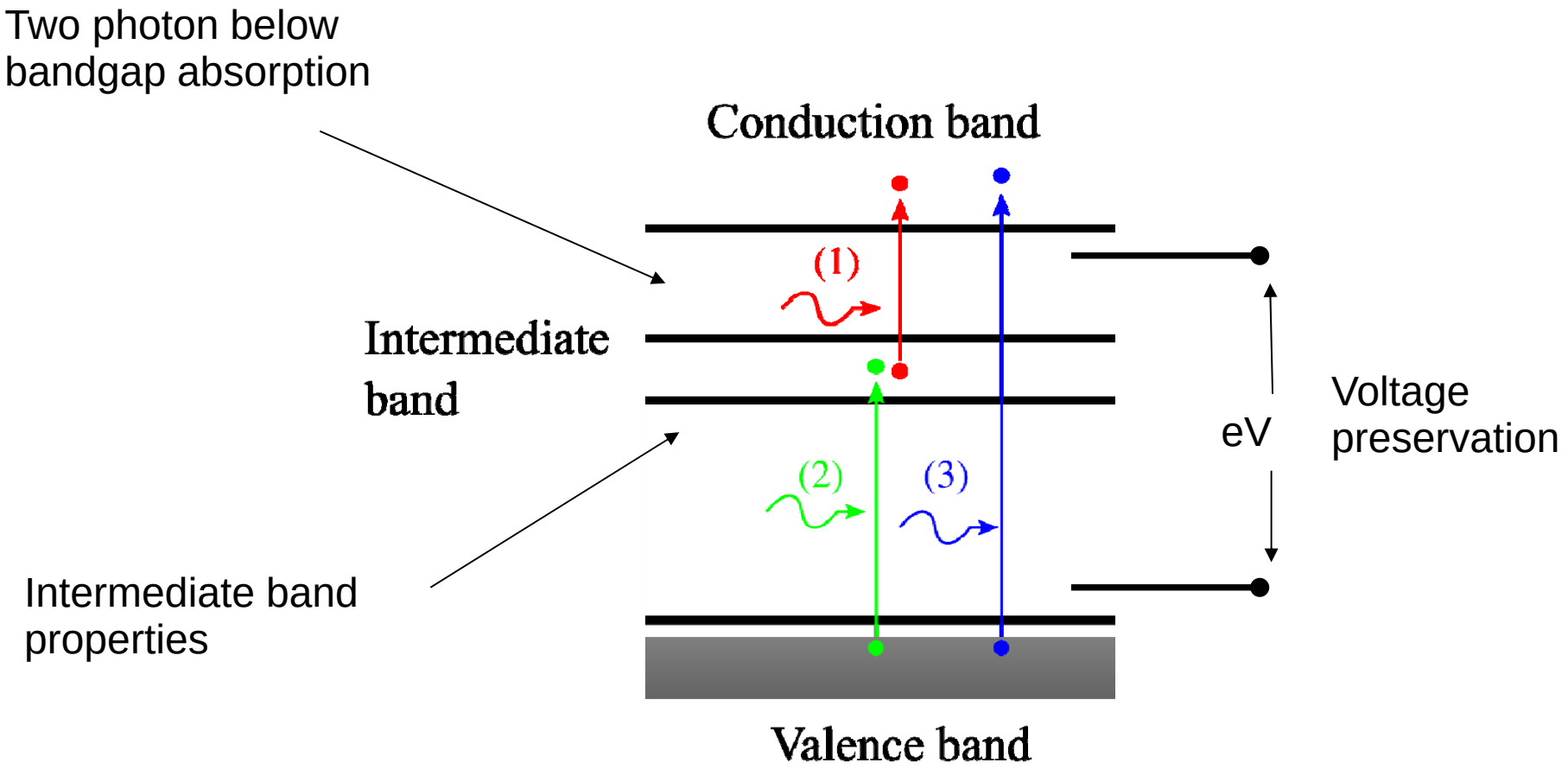
A. Luque and A. Martí, "Increasing the efficiency of ideal solar cells by photon induced transitions at intermediate levels," Physical Review Letters 78 (26), 5014–5017 (1997).

One approach for implementing the concept: QDs



A. Martí, L. Cuadra, and A. Luque, "Quantum dot intermediate band solar cell," Conference Record of the Twenty-Eighth IEEE Photovoltaic Specialists Conference, 2000., pp. 940-943, 2000.

Key aspects related to characterization



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Two-photon characterization set-up

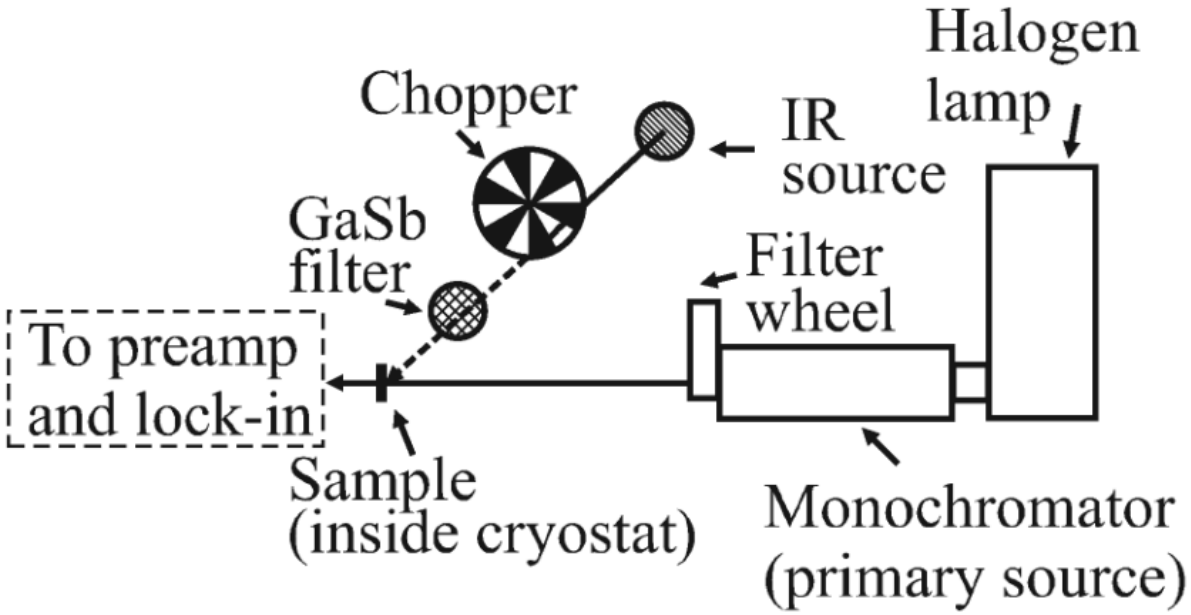
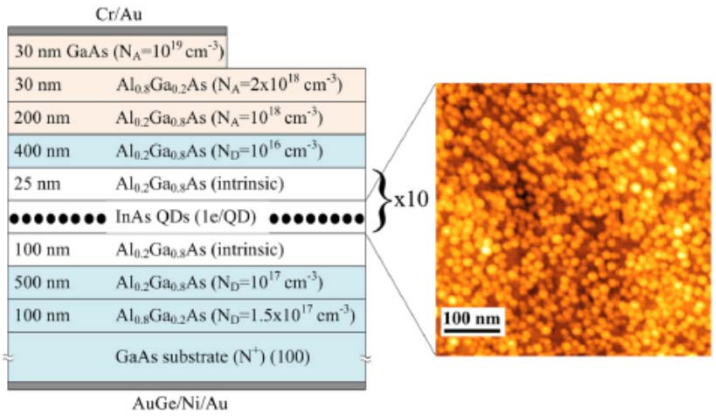
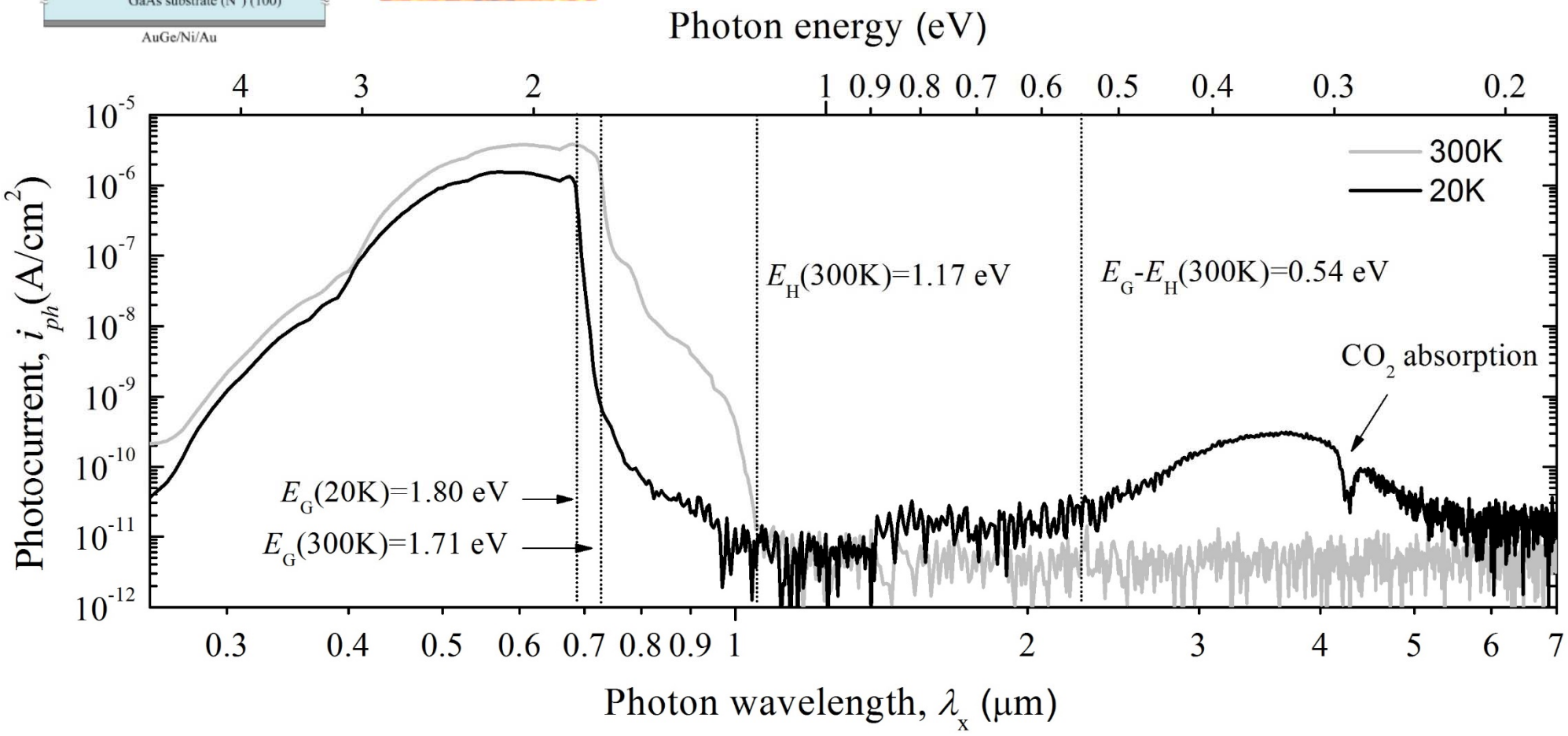


FIG. 4. Description of the experimental setup.

A. Martí, E. Antolin, C. R. Stanley, C. D. Farmer, N. Lopez, P. Diaz*, et al., "Production of Photocurrent due to Intermediate-to-Conduction-Band Transitions: A Demonstration of a Key Operating Principle of the Intermediate-Band Solar Cell," Physical Review Letters, vol. 97, pp. 247701-4, 2006.*

Some results (obtained with InAs/AlGaAs QDs)





A. Datas, E. López, I. Ramiro, E. Antolín, A. Martí, A. Luque, et al., "Intermediate Band Solar Cell with Extreme Broadband Spectrum Quantum Efficiency," Physical Review Letters, vol. 114, p. 157701, 04/16/ 2015.

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Set-ups

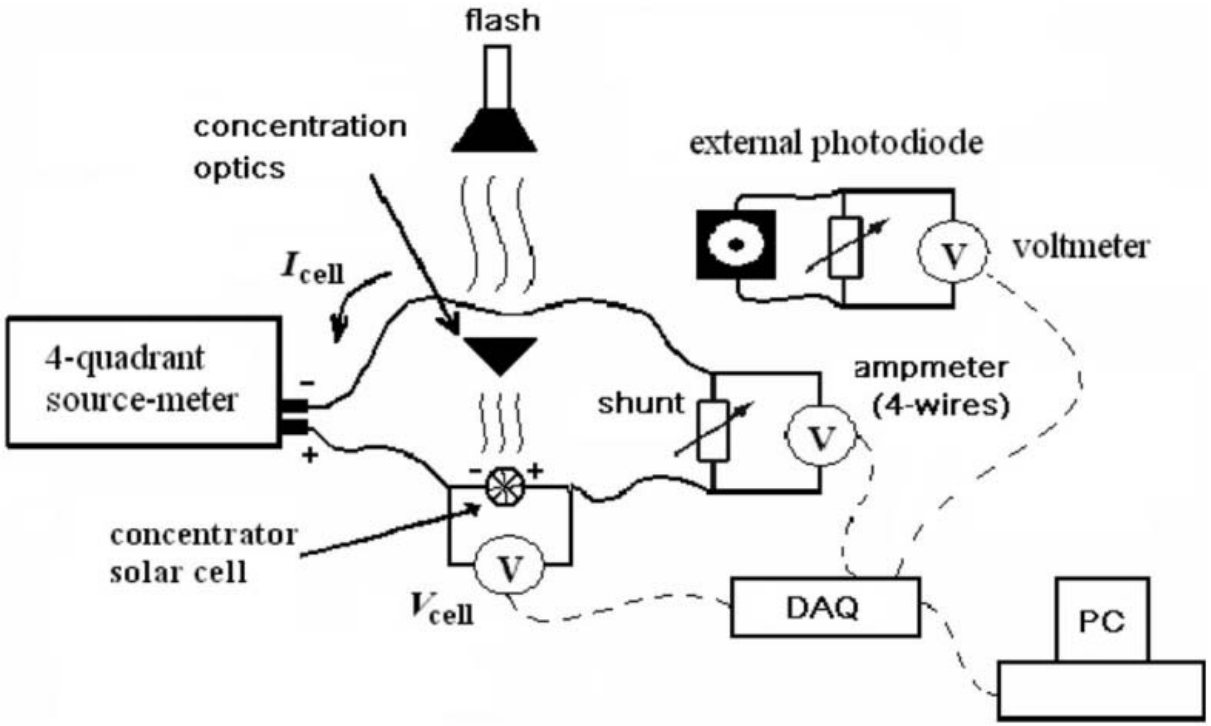
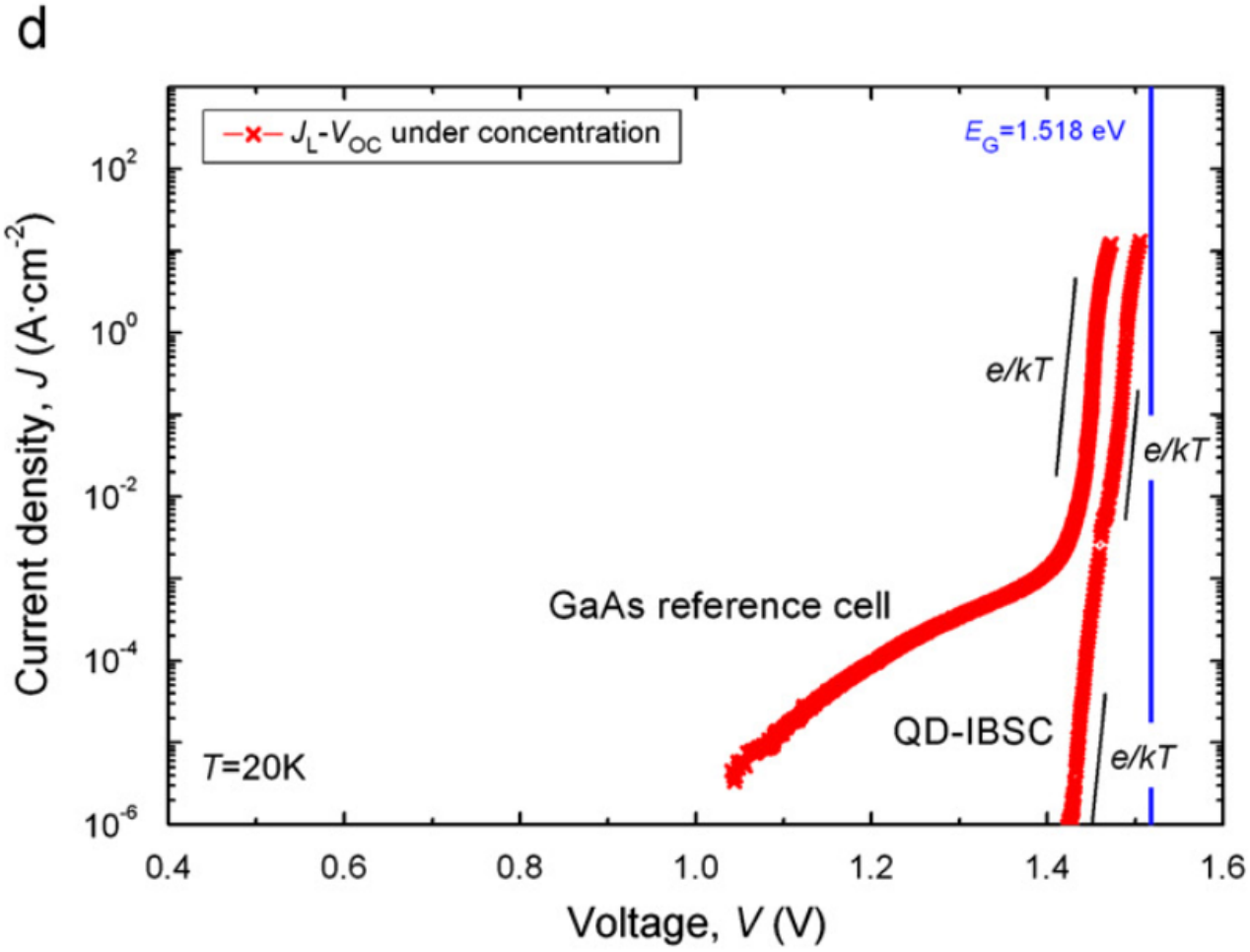


Fig. 4. Sketch of the $J_L - V_{OC}$ concentration setup.

Capability for measuring up to 5000 suns at 20 K

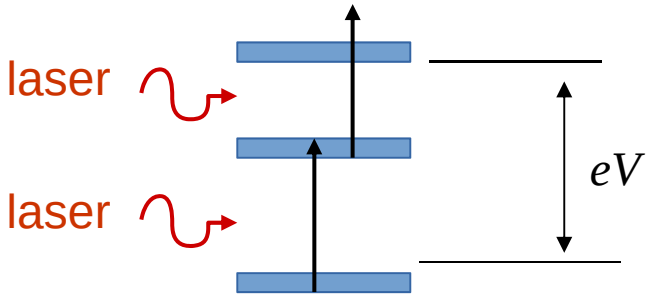
P. G. Linares, A. Marti, E. Antolin, I. Ramiro, E. Lopez, C. D. Farmer, *et al., "Low-Temperature Concentrated Light Characterization Applied to Intermediate Band Solar Cells," Photovoltaics, IEEE Journal of Photovoltaics, vol. 3, pp. 753-761, 2012.*

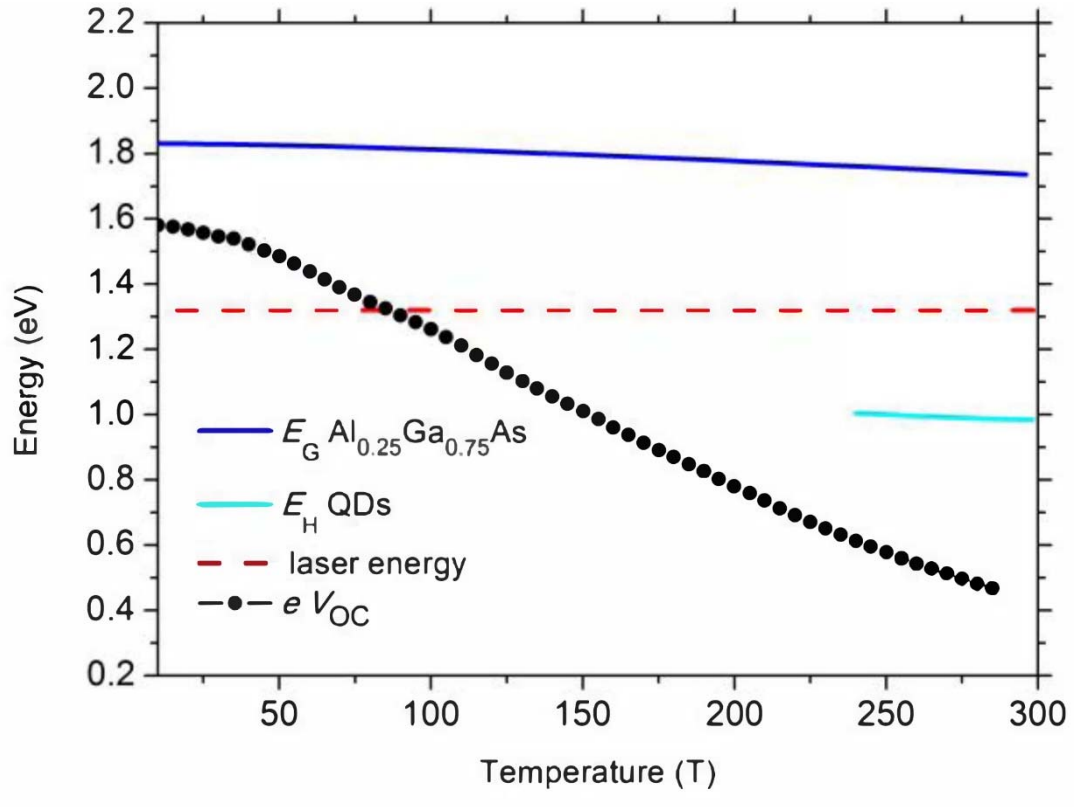
Some results (obtained in samples with quantum dots)



P. G. Linares, A. Martí, E. Antolín, C. D. Farmer, I. Ramiro, C. R. Stanley, *et al.*, *"Voltage recovery in intermediate band solar cells," Solar Energy Materials and Solar cells, vol. 98, pp. 240-244, 2012.*

Some results (obtained in samples with quantum dots)





I. Ramiro, E. Antolin, P. G. Linares, E. Lopez, I. Artacho, A. Datas, et al., "Two-photon photocurrent and voltage up-conversion in a quantum dot intermediate band solar cell," in Photovoltaic Specialist Conference (PVSC), 2014 IEEE 40th, 2014, pp. 3251-3253.

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Modulated photoreflectance

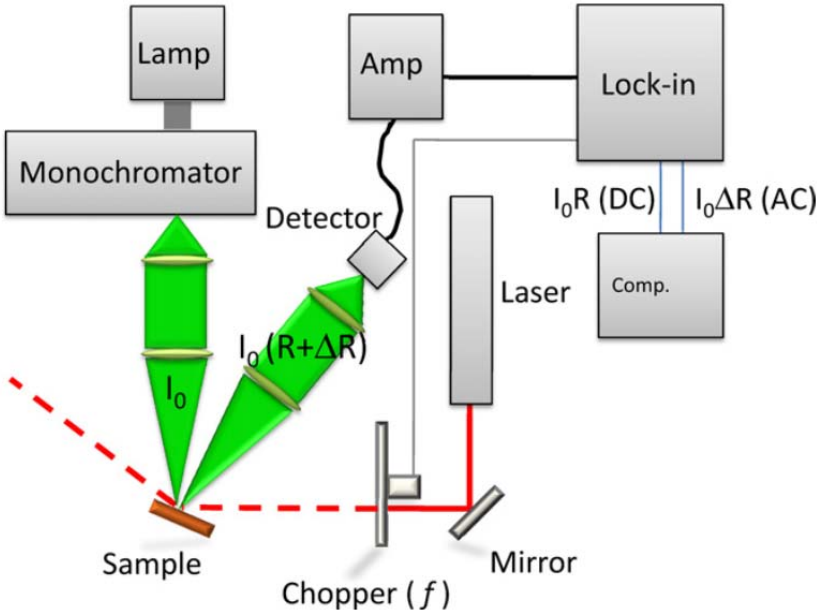
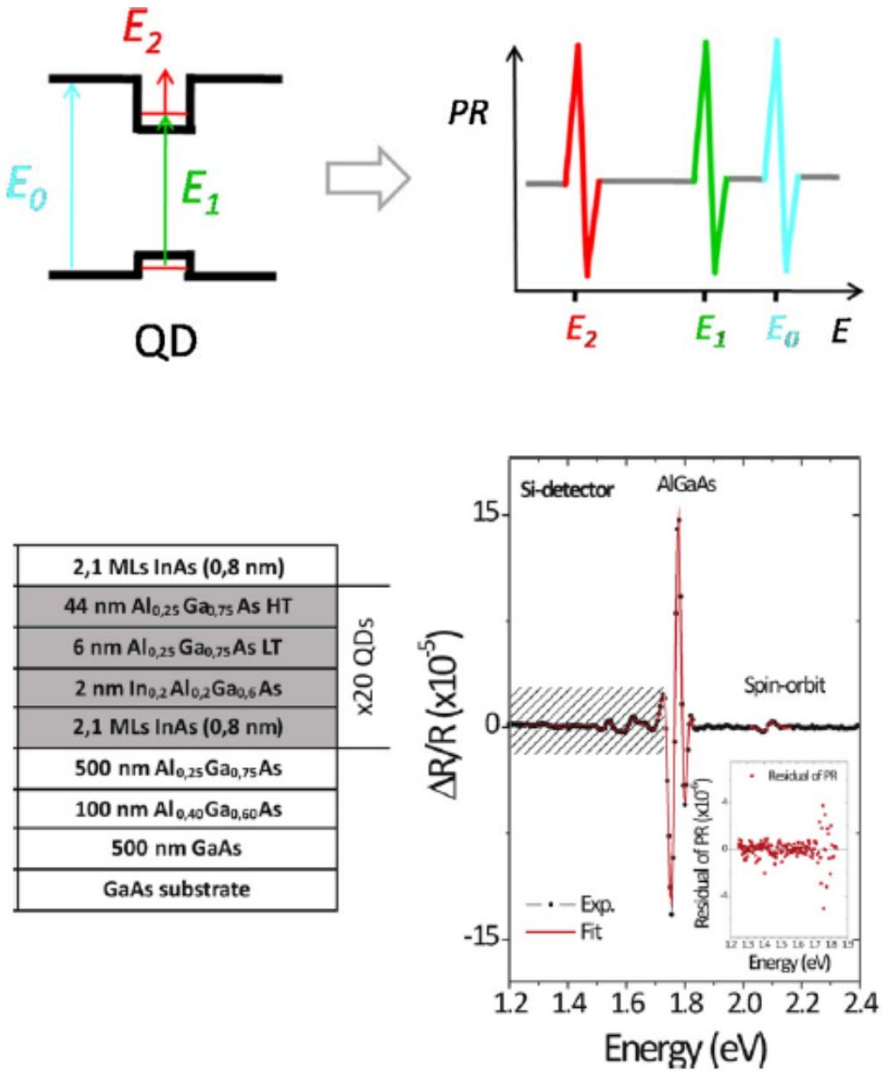
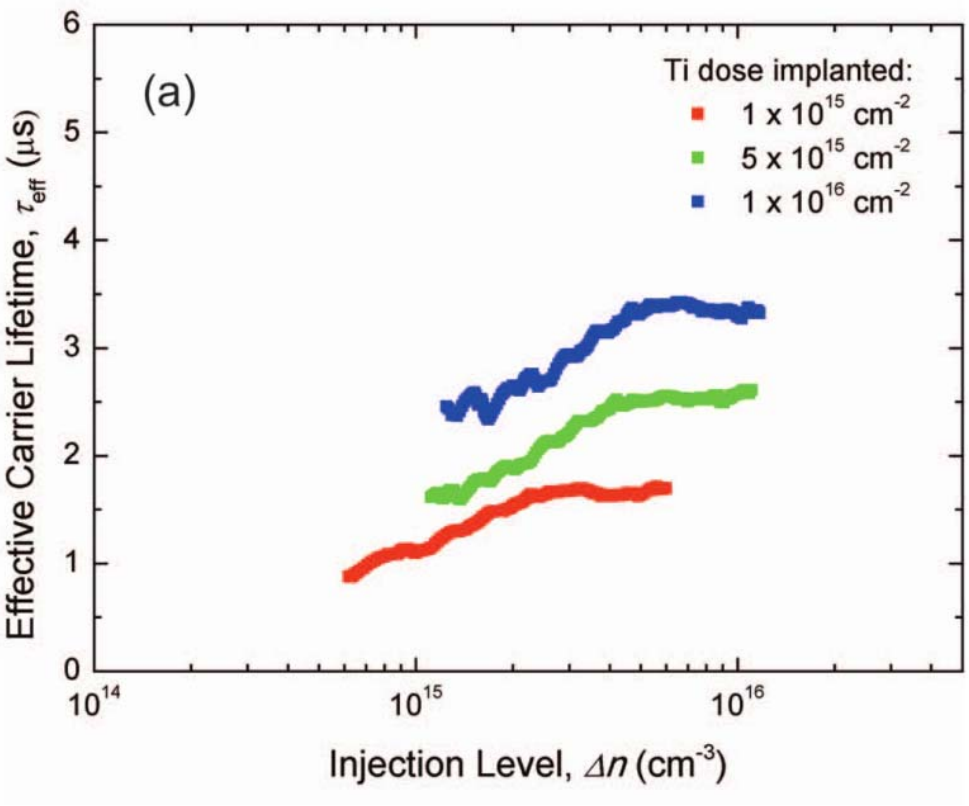


Fig. 1. Experimental setup for PR measurements.



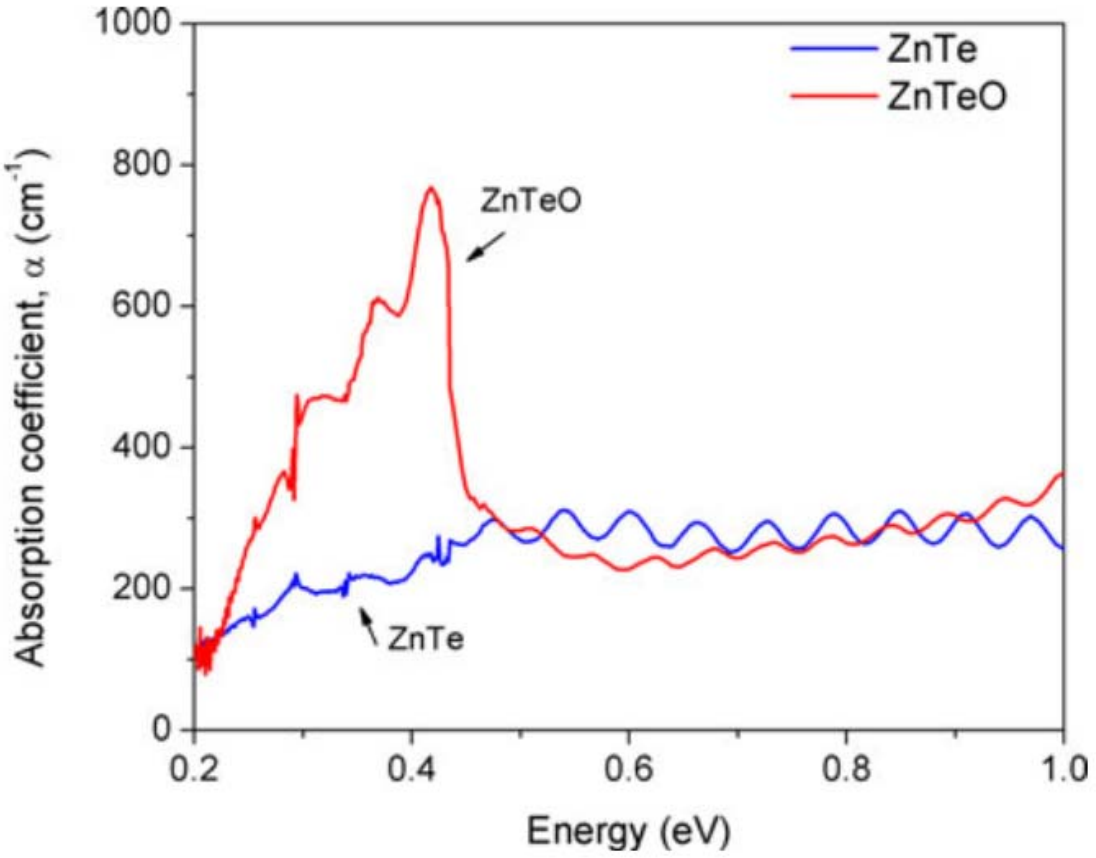
D. Fuertes Marrón, E. Cánovas, I. Artacho, C. R. Stanley, M. Steer, T. Kaizu, *et al., "Application of photoreflectance to advanced multilayer structures for photovoltaics," Materials Science and Engineering: B, 2012.*

Photocoductivity decay



E. Antolin, A. Marti, J. Olea, D. Pastor, G. Gonzalez-Diaz, I. Martil, *et al., "Lifetime recovery in ultrahighly titanium-doped silicon for the implementation of an intermediate band material," Applied Physics Letters, vol. 94, pp. 042115-3, 2009.*

FTIR



E. Antolin, C. Chen, I. Ramiro, J. Foley, E. Lopez, I. Artacho*, et al., "Intermediate Band to Conduction Band Optical Absorption in ZnTeO," Photovoltaics, IEEE Journal of, vol. 4, pp. 1091-1094, 2014.*

Summary

- Facilities to characterize below bandgap two-photon absorption (QE)
- Measurements under concentrated light up to 5000 suns and down to 20 K to check for voltage preservation
- Other techniques: PR, Photoconductivity decay, FTIR