Short-wave Infrared PbS Colloidal Quantum Dot Photodetectors with AlOx Atomic Layer Deposition Passivation

*Chen Hu[1,2,3], Alban Gassenq[1,2], Yolanda Justo[2,3], Kilian Devloo-Casier[4], Hongtao Chen[1,2,5], Haolan Zhao[1,2], Christophe Detavernier[4], Zeger Hens[2,3] and Günther Roelkens[1,2]**

[1]Photonics Research Group-INTEC, Ghent University-imec, Sint-Pietersnieuwstraat 41, 9000 Ghent, Belgium
[2]Center for Nano- and Biophotonics, Ghent University, Belgium
[3]Physics and Chemistry of Nanostructures Group, Ghent University, Krijgslaan 281-S3, B-9000 Gent, Belgium
[4]Department of Solid State Sciences, CoCooN, Ghent University, Krijgslaan 281-S1, 9000 Gent, Belgium
[5]IMEC, Kapeldreef 75, 3001 Leuven, Belgium
*corresponding author: gunther.roelkens@intec.UGent.be

Short-wave infrared (SWIR) detectors are typically based on III-V epitaxial materials, resulting in expensive devices, especially when used in a linear on two-dimensional focal plane array. Colloidal quantum dots (QDs) as a new optoelectronic material, provides an alternative way to achieve SWIR photodetectors, either as discrete components or being integrated on photonic integrated circuits. The colloidal QDs are prepared by simple hot injection chemical synthesis, which provides a significant cost reduction. Due to the quantum size effect, the electrical and chemical properties of QDs can be easily modified. Moreover, the fact that the suspension of QDs is in solution allows straightforward integration on large area substrates.

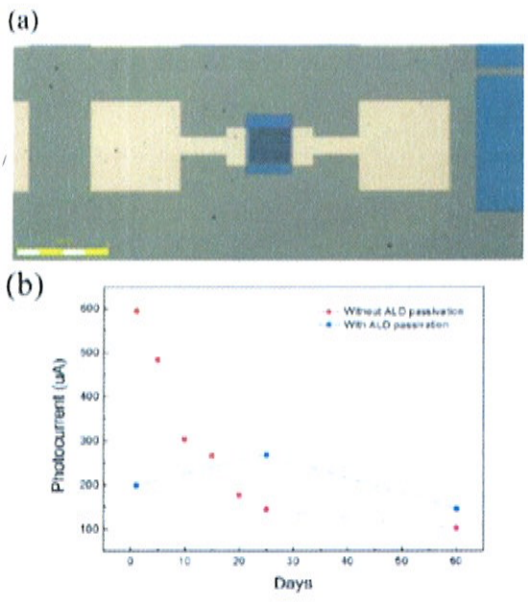

Fig.1. a) Top view of PbS QD photodetector; b) Photocurrent of S^{2-} terminated PbS photodetectors with 1 mW incident power at different time intervals. The bias voltage is 2V.

In this study, PbS colloidal QDs were investigated for SWIR photodetector applications. Starting from colloidal QDs with their as-synthesized organic ligands, a layer-by-layer approach is used to fabricate uniform, ultra smooth and crack-free QD films. Each cycle involves a deposition of a QD layer by dip coating, the replacement of native organic ligands by inorganic moieties (S^{2-} and OH^-), followed by a thorough cleaning of the film afterwards. Here the short inorganic ligands are used to facilitate the charge carrier transport. The PbS QD films are fabricated on a pair of interdigitated gold electrodes. Afterwards a selective wet-etching approach is used to achieve micropatterned QD film and the resulting films are then passivated with aluminum oxide film through atomic layer deposition (ALD) to realize air stable devices.

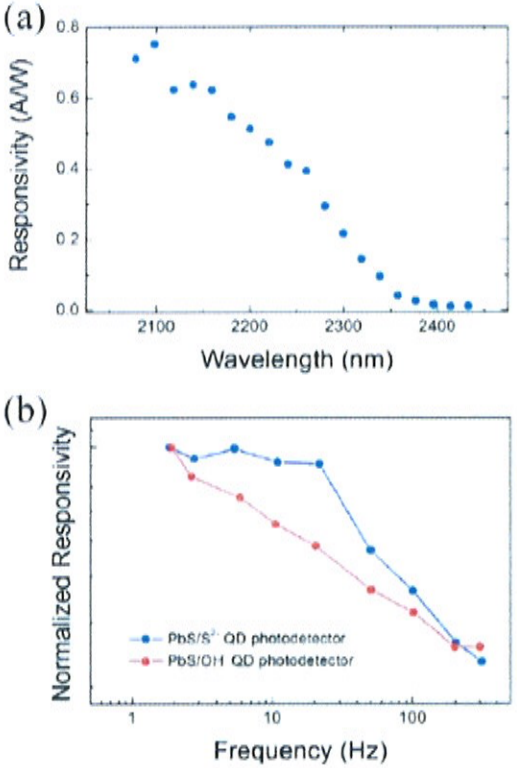

Fig.2. a) Detector responsivity as a function of wavelength for S^{2-} capped PbS QD photodetector with 276 µW incident power; b) Responsivity versus modulation frequency measured at a wavelength of 2250 nm with 5 mW incident power.

After passivation, the QD photodetectors exhibit improved stability and performance in air. A 2.4µm cut-off wavelength is obtained. The detector time response is suitable for imaging applications.

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[2] I. MOREELS, K. LAMBERT, D. SMEETS AT AL., ACS NANO 3(10), 3023–3030 (2009). [3] C. HU, T.AUBERT, Y. JUSTO AT AL., NANOTECHNOLOGY 25, 175302 (2014).

Foreword

Welcome to the 12th "Mid-Infrared Optoelectronics: Materials and Devices" (MIOMD-XII) conference in Montpellier, France!

The Mid-Infrared Optoelectronics Materials and Devices (MIOMD) conference series has been established in 1996 with a first conference organized in Lancaster. MIOMD is now held on a bi-annual basis and rotates between Europe, America and Asia. The last three conferences were held in Freiburg (2008), Shanghai (2010) and Chicago (2012).

The conference brings together researchers and scientists from all over the World working in the area of mid-infrared optoelectronics, from materials to applications. It covers all aspects of materials (theory, growth, property), optoelectronic devices (lasers, LEDs, photodetectors, modelling, fabrication, characterization) as well as practical applications (sensing, imaging, defense and security applications...). Last years the scope of the conference has been enlarged compared with its first editions and includes now all aspects of infrared technology from near-IR to THz.

This issue of MIOMD is a very special one. Indeed, exactly 20 years ago, in 1994, a new mid-infrared semiconductor laser, the quantum cascade laser (QCL), was invented in the group of F. Capasso at Bell labs. One of the co-inventors, **Prof. Jérôme Faist**, now with ETH Zurich, will open the scientific sessions of MIOMD-XII with a keynote presentation on "20 years of Quantum-Cascade Lasers".

In addition, a total of 16 invited talks, ~40 contributed oral papers and ~30 posters will be presented during the three days of the conference, from Monday 6th October to Wednesday 8th October. We are confident that you will find a lot of interesting papers and that active discussion will take place as usual. We wish to express our sincere gratitude to the members of Scientific Committee for their support. They invested an important amount of their time selecting invited speakers and reviewing abstracts.

Several social events have also been planned. A welcome reception will be offered on Sunday 5th October evening while the conference dinner will take place on Tuesday 7th October in a superb estate. In addition, guided visits of Montpellier or of a vineyard will be possible on Wednesday 8th October afternoon. Finally, a special full-day excursion will be proposed on Thursday 9th October. It will take you to the Pont du Gard, a stunning Roman aqueduct, and to Nîmes, a rich heritage city.

We want to particularly thank the *Agglomération de Montpellier, Région Languedoc-Roussillon, the OPTITEC cluster, the French National Research Agency* and the European Union for their support, as well as our sponsors and exhibitors. Last but not least, we also wish to thank our colleagues of the local-arrangement committee who made it possible to practically happen.

We hope you have a very rewarding and enjoyable conference in the shiny city of Montpellier!

Alexei N. Baranov
Conference Chair

Eric Tournié
Conference Chair

Thierry Taliercio
Program Chair

Aurore Vicet
Local Committee Chair

5-9 October 2014