UNIVERSITA' DEGLI STUDI DI PAVIA

DOTTORATO DI RICERCA IN FISICA

COLLOQUIA 2014-2015

Giovedì 12 Marzo 2015
Aula 102 “L. Giulotto”, ore 16.00
Dipartimento di Fisica, via Bassi 6, Pavia

LEDs for lighting

Claude Weisbuch
Ecole Polytechnique, Palaiseau, France, and
University of California, Santa Barbara, CA, USA

The 2014 Nobel prize for Physics to Akasaki, Amano and Nakamura "*for the invention of efficient blue light-emitting diodes which has enabled bright and energy-saving white light sources*” illustrates the societal impact of nitrides.

We will first discuss light emission from semiconductors, which can in principle convert electrical power into light with a 100% efficiency.

For blue emission, nitrides semiconductors encountered major materials problems. It was later discovered that nitrides suffer large strains, and high spontaneous and piezo electric internal fields. The advances in materials quality and photon management strategies led to internal quantum efficiencies up to 90%, and light extraction also in the 90% range.

However, despite the remarkable present achievements, there are still scientific and technological roadblocks to reach the physical limits of nitride devices. At stake are major energy savings, and also an essential ingredient to quality of life.

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Claude Weisbuch
Laboratoire de la Physique de la Matière Condensée, CNRS, Ecole Polytechnique, Palaiseau, France, and Materials Department, UCSB, Santa Barbara, CA, USA

The award of the 2014 Nobel prize for Physics to Akasaki, Amano and Nakamura "for the invention of efficient blue light-emitting diodes which has enabled bright and energy-saving white light sources” illustrates the worldwide societal impact of nitrides. We will first discuss light emission from semiconductors, which can in principle *convert electrical power into light with a 100% efficiency*, a remarkable feat for such delocalized excitations as electrons and holes. I will describe semiconductor bands and excitations, pn junctions, electrical carrier injection, and the various materials structures double heterostructures (DHs), quantum wells (QWs) which lead to high efficiencies of IR or red light emitters.
For the blue and green spectral ranges, nitrides semiconductors were not an obvious materials candidate due to *major materials problems* such as lack of substrates and difficulty to obtain p-doping. Also, it was later discovered that nitrides suffered large strains and large thermal coefficient mismatch with substrates, and high spontaneous and piezo electric internal fields detrimental to radiative recombination. The major advances in materials quality lead to internal quantum efficiencies up to 90%, and photon management strategies leading to light extraction also in the 90% range.
However, despite the remarkable achievements of the pioneers and their followers, producing devices with unmatched performance, there are still scientific and technological roadblocks to reach the physical limits of nitride devices. At stake are major energy savings, and also an essential ingredient to quality of life.

2015 – The Year of Light

On 20 December 2013, the UN General Assembly 68th Session proclaimed 2015 as the **International Year of Light and Light-based Technologies** (IYL 2015).

INTERNATIONAL YEAR OF LIGHT 2015

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