

Advanced Materials & Devices

(**S**emiconductor **D**evice **R**esearch **L**aboratory: SDRL)

TOPICS: synthesis, fabrication, and application of
advanced semiconductor materials and devices

MAR-2023

Overview

This presentation briefly describes the main activities of the AMD cluster with focus on semiconductors and nanoelectronics/photonics. The *Material* aspect is described on page 3, *Devices* on p.4, and *Advanced* on p.5. Key technology used in our research is molecular beam epitaxy, see p.6. Current research topics are detailed on pp.7-??. Faculty members and their research topics are shown on p.?.

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The “material” aspect involves the synthesis of novel compound semiconductors based on the III-V system

- electronics: IV (Si)
- optoelectronics: III-V compounds (GaAs, InP,...)

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After material synthesis, the semiconductor is fabricated into “devices”.

2-Terminal = junctions/diodes: solar cells, LED, lasers...

3-Terminal = transistors (FET, BJT), ...

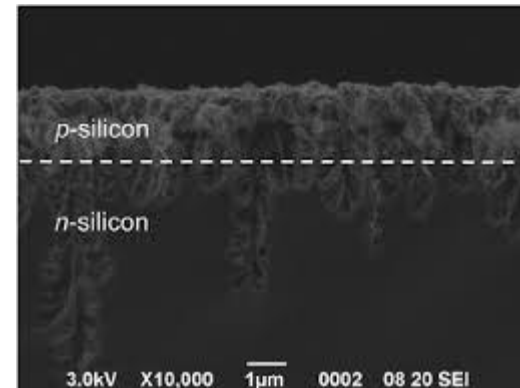
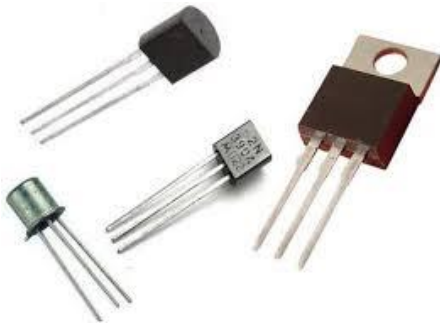
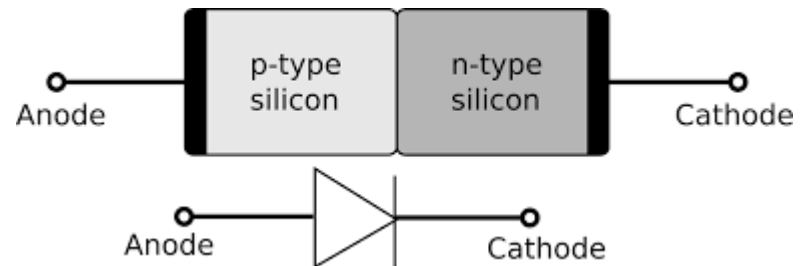


Image From: https://www.researchgate.net/publication/250308373_Fabrication_electrical_characterization_and_modeling_of_fully-porous_pn_junctions

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Quantum nanostructures with tuneable properties especially energy gap (E_G) rely not only on chemical composition but also on size.

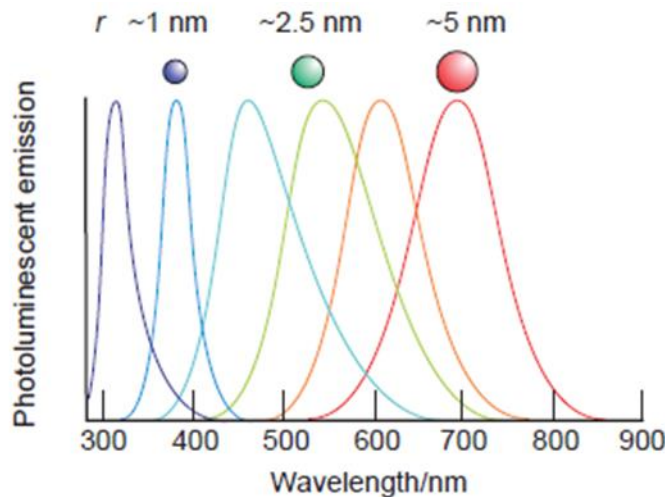


Figure 14.40 Photoluminescent colours emitted by CdS quantum dots.

$$E_\gamma = h\nu = \frac{hc}{\lambda}$$

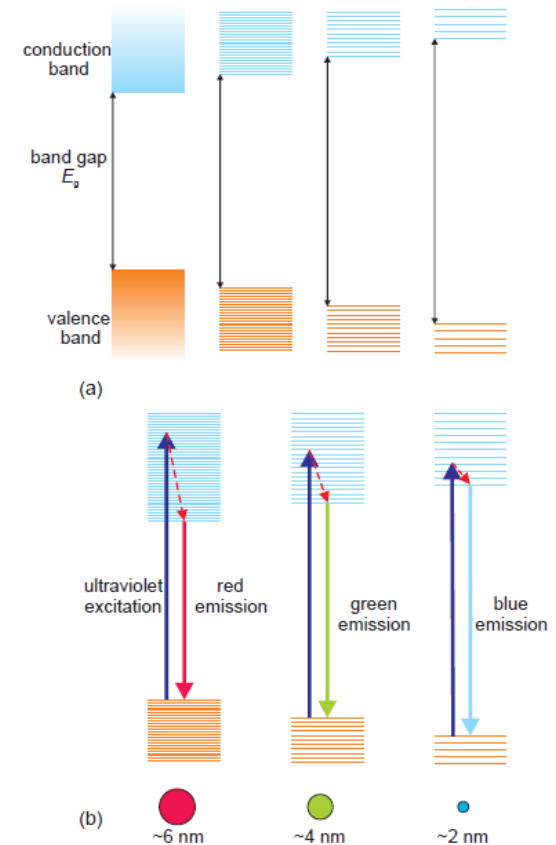
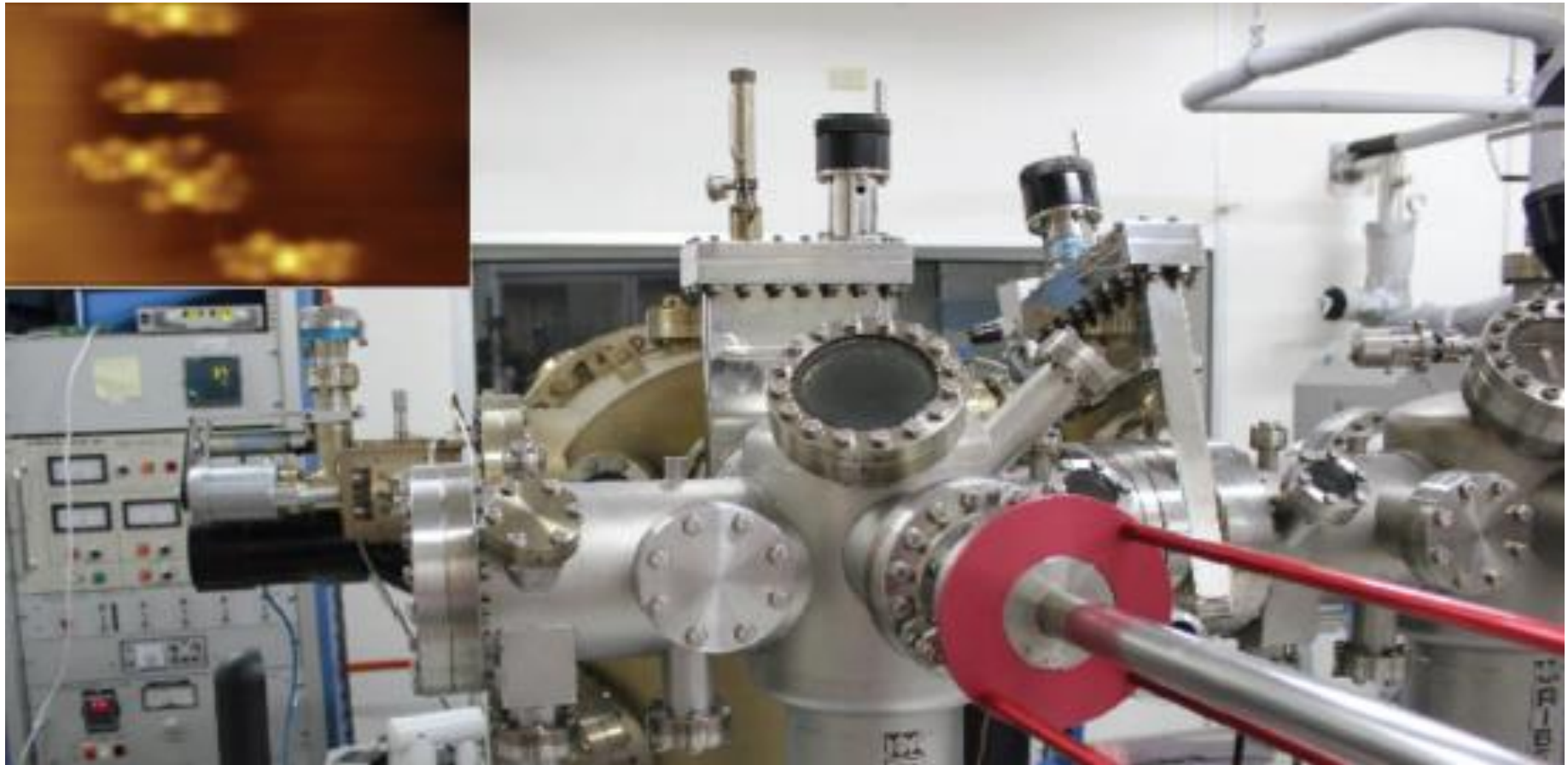


Figure 14.41 Quantum dot colours: (a) the change in band structure of a quantum dot as the diameter falls; (b) fluorescence colours of different diameter dots

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Molecular Beam Epitaxy (MBE) enables crystal growth with subatomic layer precision, enabling size, shape, and density control



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Current research topics

TOPIC 1 (III-V)

Infrared materials & devices (solar cells, photodetectors, lasers...)

using MBE, we grow GaAs(P,Bi,Sb) compounds on binary substrates such as GaAs, InAs, CdTe, and study their structures using XRD, AFM, and their optical properties using photoluminescence

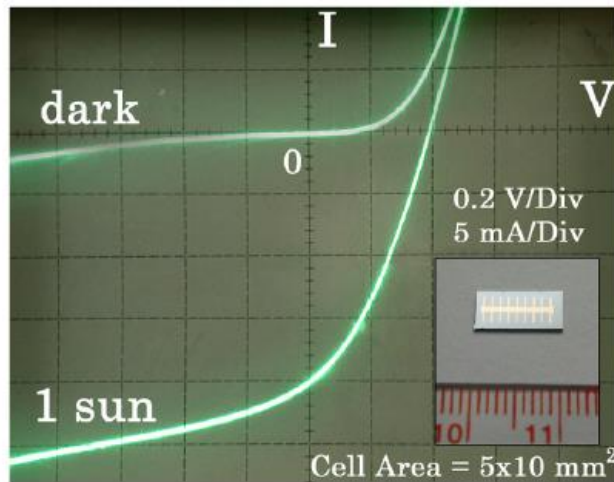
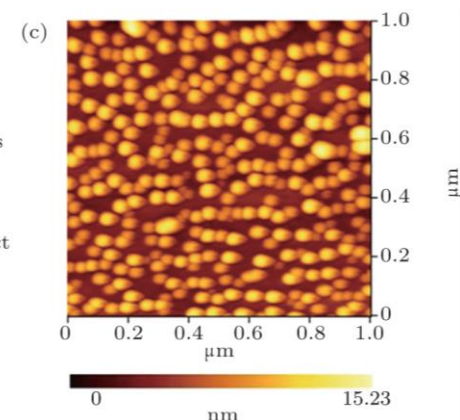
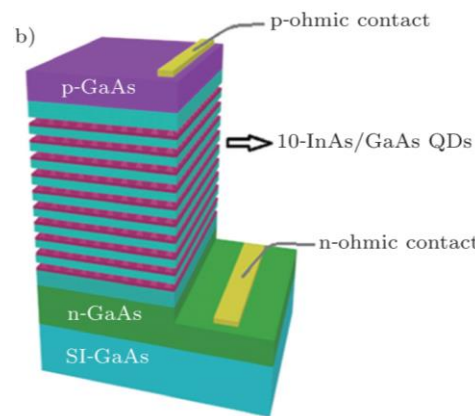


Fig. 5. *I-V* characteristics of 3-stack, high-density QDM solar cell showing a possibility to deliver short-circuit current density as high as 40 mA/cm² (the inset shows the photo of the cell with area of 5 × 10 mm²).

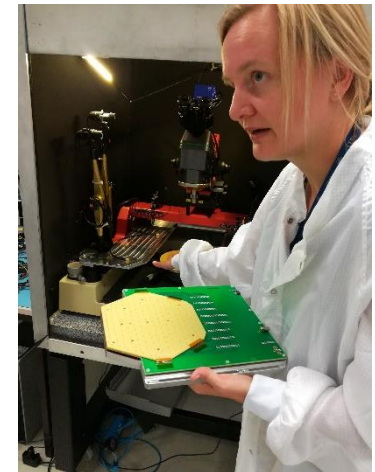
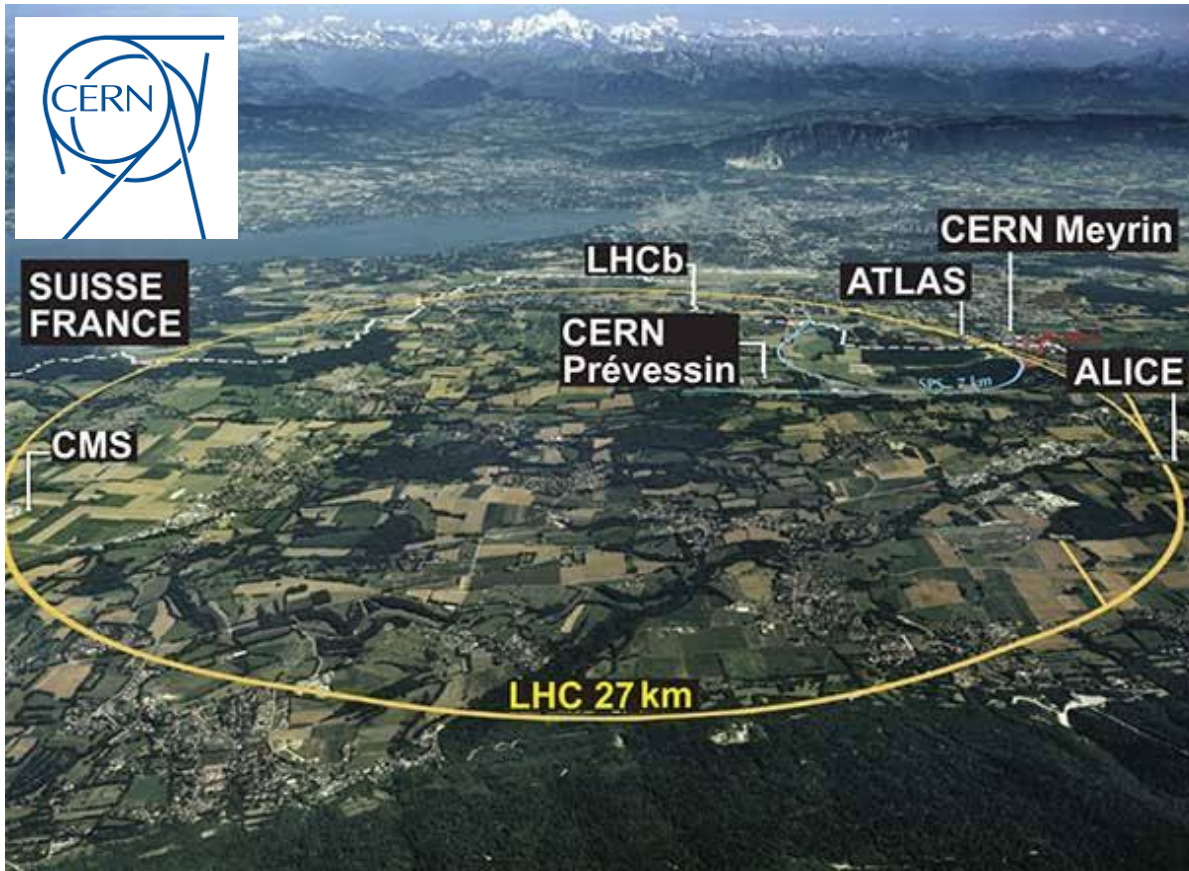


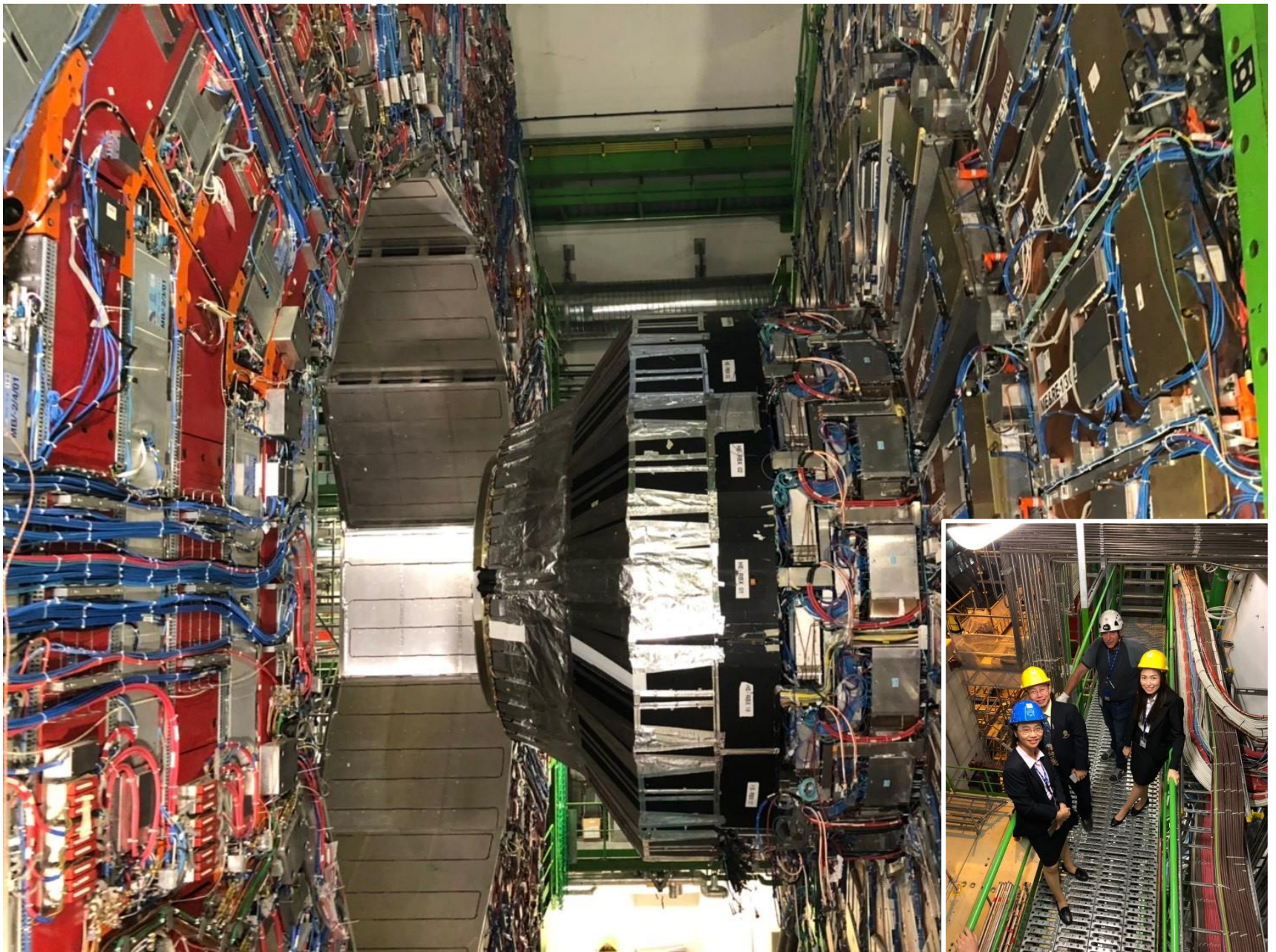
Images from <https://iopscience.iop.org/article/10.1088/1674-1056/25/9/097307>

TOPIC 2

radiation-hard Si particle detectors, CU-TMEC-CERN

planar diodes are fabricated by Thai Microelectronic Center (TMEC) and irradiated by high energy neutrons at TINT after which the integrity of the p-n junctions is studied by electron microscopy at the Synchrotron Light Research Institute (SLRI) to establish the nature and limit of the device usefulness after exposure



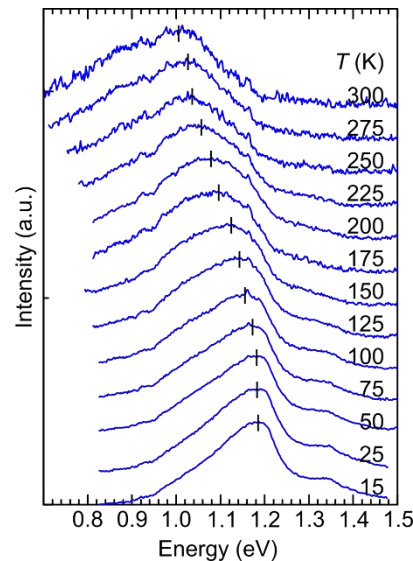
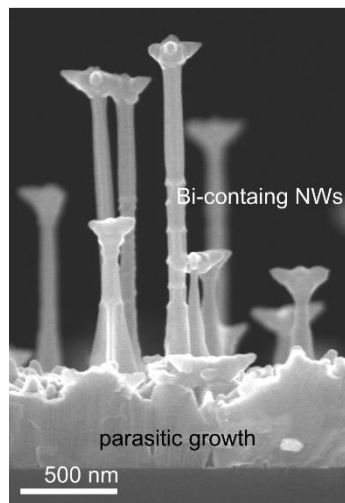


the heart of the CMS detector at CERN, taken during CU-CERN visit (pre-Covid)

TOPIC 3 Bismuth (Bi) containing (nano-) structures and their properties

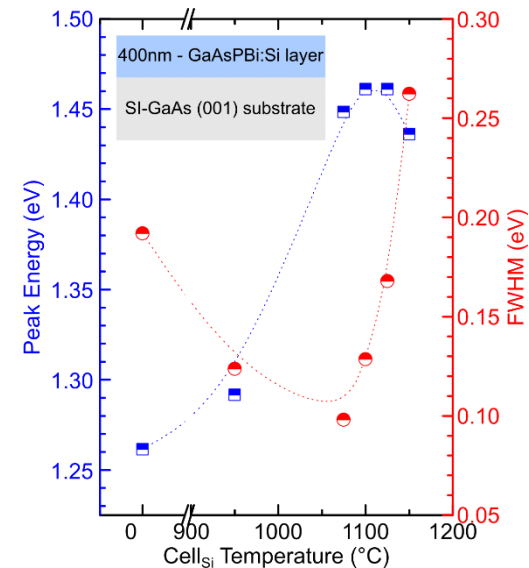
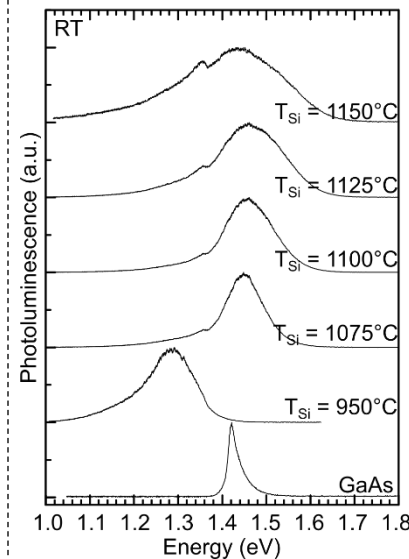
Current research topics

3A) 1D-Bi containing structure



Optical characteristic of GaAs/GaAsPBi core-shell nanowires measured from 15 K to room temperature.

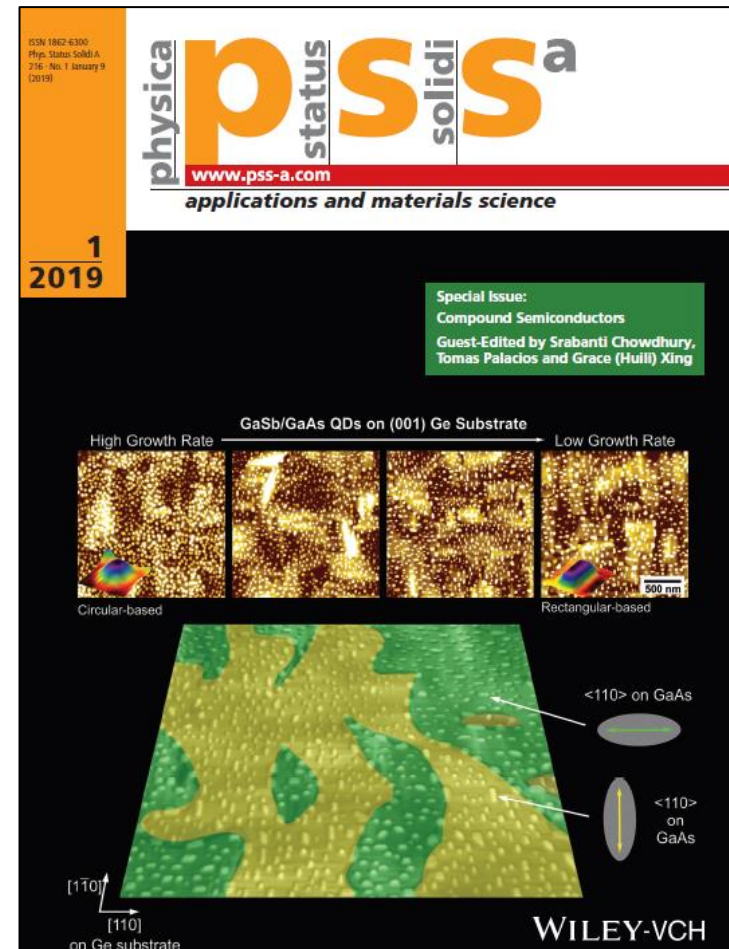
3B) Doped Bi-containing layers*



Doped Bi-containing layers are studied for the device integration.

Output

Some of our results are featured on the cover of academic journals related to the fields of semiconductor materials, properties and devices



AMD / SDRL Members



- III-V Infrared materials
- IV particle detectors (CU-CERN)
- cryogenic electronics



[Suwit Kiravittaya](#)

- Applied Photonics and Electronics in Various Systems
- Photonic Devices: Solar Cell, Photodetector, LED, and Laser
- Molecular Beam Epitaxy and Optical Properties of Semiconductor Nanostructures
- Quantum Technology: Sensing, Secure Communication, and Computing



- Bi-III-V nanostructures
- Bi containing devices
- Sb-Bi integration