NRC·CNRC

NRC.CANADA.CA

Advanced Electronics and Photonics Research Centre Overview

June 2023

AEP: developing semiconductor components

Vision

We develop game changing sensing and communications technologies that collect and move data, enabling Canada's infrastructure and services to become smarter and accessible; and creating sustainable prosperity.

Mission

Through world class researchers and facilities, we work with academia, other research organizations, and industry to discover, de-risk, develop and commercialize technologies that address economical and social challenges critical to Canada and the world. We focus on semiconductor-based photonics and next-generation electronics.

AEP Research priorities

NRC challenge programs

- High Throughput and Secure Networks for Rural and Remote Communities Program: 1GB everywhere
- Leading Semi-conductor based quantum sensing systems Theme in Quantum Sensors Program (QSP)
- Leading Printable/wearable sensors theme for health and safety in Ageing in Place Program (AiP)
- Participating in AI 4 design projects on photonic devices and novel materials developments

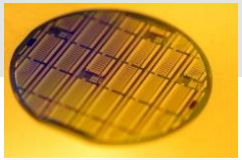
Other collaborative R&D

- III-V sensors for astrophotonics, environmental monitoring, metrology
- Novel materials and processes

Client projects:

- Joint technology development with SMEs and CPFC
- Technology transfer and Small scale production at the CPFC

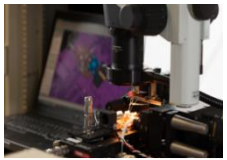
A tight innovation cycle leading to manufacturing and productization



Manufacturing

New product introduction

Fab process development

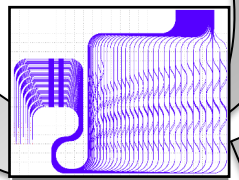


Packaging Integration

Product Integration

Device testing

Material growth and analysis



Device simulation and design

Novel materials

Novel concepts Client/Societal needs

AEP has strategic alliance with CPFC

CPFC is the only InP pure play foundry in North America

- Joint value proposition of concept to market
- AEP and CPFC collaborating on internal technology developments
- Common business development and joint revenue projects
- Shared fabrication processes and common $100M fab capability refurbishment project

TRL 1:	Basic principles observed and reported	MRL 1:	Manufacturing feasibility assessed
TRL 2:	Technology concept and/or application formulated	MRL 2:	Manufacturing concepts defined
TRL 3:	Analytical and experimental critical function and/or characteristic proof of concept	MRL 3:	Manufacturing concepts developed
TRL 4:	Component and/or breadboard validation in a laboratory environment	MRL 4:	Capability to produce the technology in a laboratory environment
TRL 5:	Component or breadboard validation in a relevant environment	MRL 5:	Capability to produce prototype components in a production relevant environment
TRL 6:	System/subsystem model or prototype demonstration in a relevant environment	MRL 6:	Capability to produce prototype system or subsystem in a production relevant environment
TRL 7:	System prototype demonstration in an operational environment	MRL 7:	Capability to produce systems, subsystems or components in a production relevant environment
TRL 8:	Actual system completed and qualified through test and demonstrated	MRL 8:	Pilot line capability demonstrated; Ready to begin Low Rate Initial Production
TRL 9:	Actual system proven through successful mission operations	MRL 9:	Low rate production demonstrated; Capability in place to begin Full Rate Production

Technology Platforms

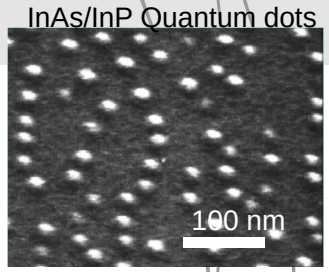
in blue, co-developed with CPFC

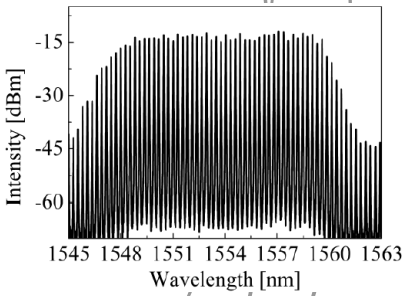
- Quantum dot lasers for multiwavelength applications in telecom
- BHET DFB narrow-linewidth lasers for sensing
- Mid-IR lasers for spectroscopic sensing
- Nanostructures for quantum
- Silicon and silicon nitride integrated photonics applied to communications and sensing
- Short wavelength infra-red sensors for imaging and detectors
- Optical thin films for filters and facet coatings
- GaN for RF electronics and harsh environment sensing
- Printable electronics for autonomous distributed and wearable sensors

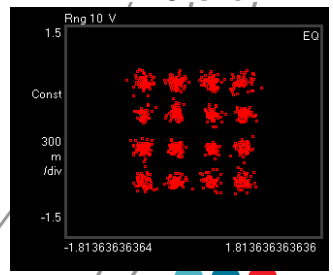
Quantum dot lasers

First InP-based quantum dot materials and laser devices designed and demonstrated at NRC

- Single photon guns for quantum encryption, now part of QSP program: application to Qeysat
- Multi-wavelength lasers transferred to Ranovus in 2015 for optical transceiver application in data center interconnect market at lower cost and power consumption than state of the art
- 12 TB coherent communication demonstrated in both PAM and QAM modulation
- Application to mmW generation for cell towers in 5G and beyond





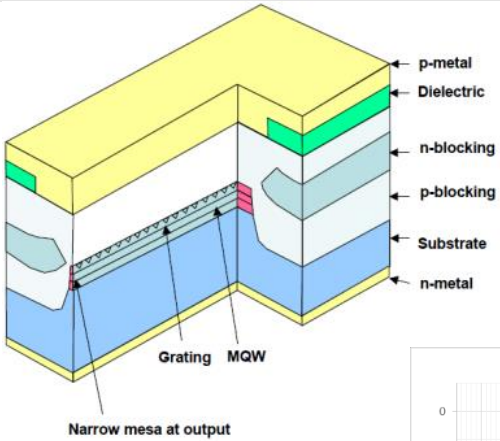


Buried Heterostructure DFB lasers

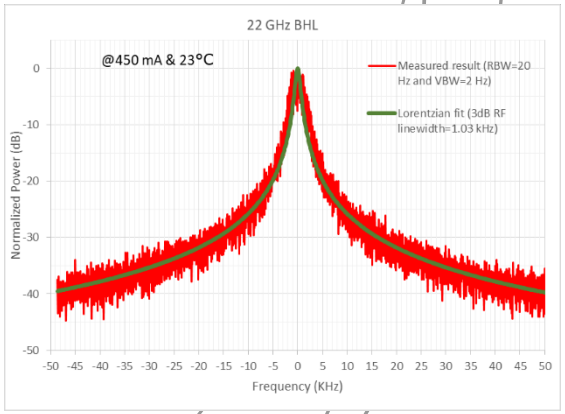
Advantages:

- Low threshold and low power consumption
- Nearly symmetrical profile
- Low noise characteristics
- Well adapted to multiple applications in sensing and telecom ie spectroscopy, fast data transfer and medical applications

Commercialized by TeraXion for gyroscope and Lidar applications



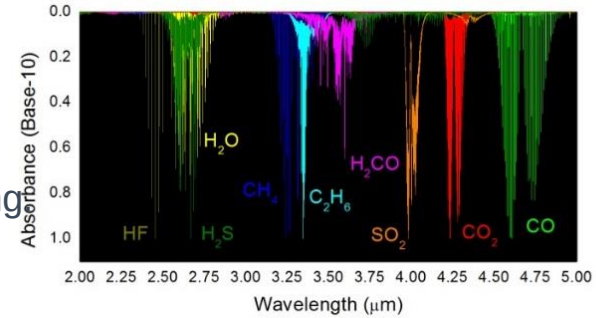
InGaAsP/InP and AlInGaAs/InP Laser structure



Example of BH QD measured spectrum

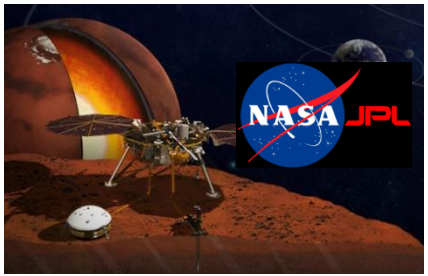
Mid-IR lasers for spectroscopic sensing

Wavelength-tunable single-mode mid-IR lasers enable trace gas sensing with ultrahigh sensitivity and selectivity.



- TDLAS spectroscopy for industrial sensing and environmental monitoring
- Light Detection and Ranging (LIDAR) and TDLAS instruments with JPL/NASA, qualified for space.

NORCADA

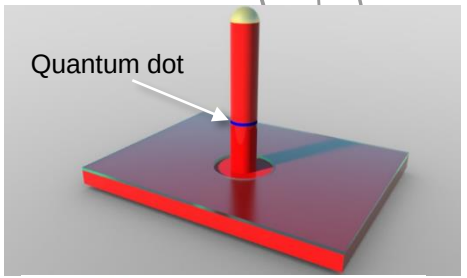


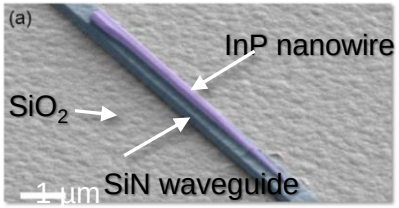
Nanostructures for quantum

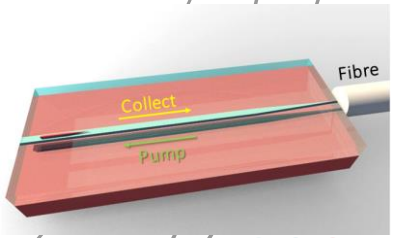
Hybrid integration of InP nanostructures on SiN waveguide

Delivering Qbits for communications (HTSN), sensing (QSP) and computing (QCP) challenge programs

- Quantum key distribution: application to QeySat, encrypted satellite communication to the North
- Exploration of single photon sources, moving from 850nm to 1550nm with QSP program
- Quantum repeaters supported by Small Teams in collaboration with Nanophotonics platform

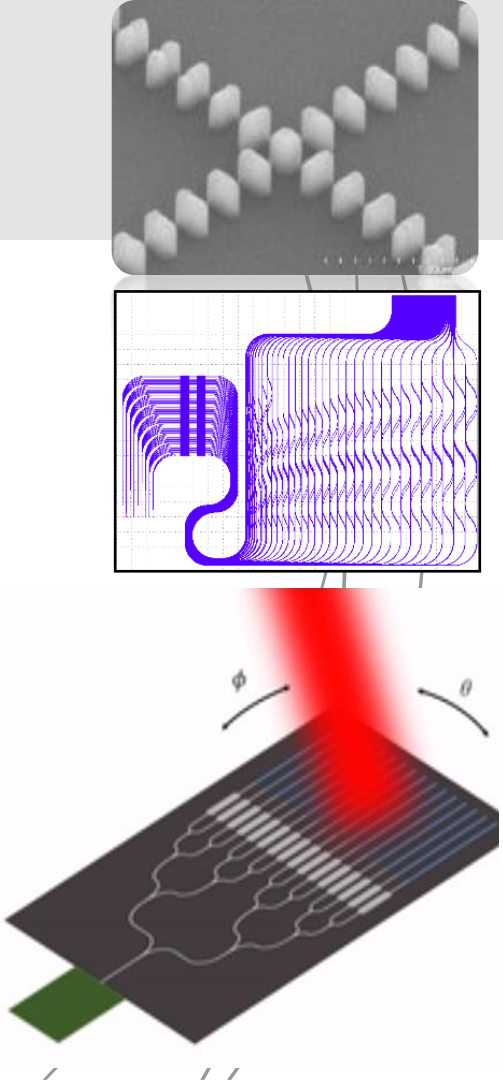






Silicon integrated photonics

- Sub-wavelength metamaterials for integrated photonics and silicon nanophotonics
- Working with Si and SiN foundries to incorporate designs into technological offering
- High efficiency meta-structure fiber-chip coupler for telecom
- Fourier spectrometer-on-chip for gas sensing
- High sensitivity photonic wire sensor array
- Optical Phase Array design for Optical SatCom consortium, applicable t solid-state Lidars



Short Wavelength Infra Red sensors

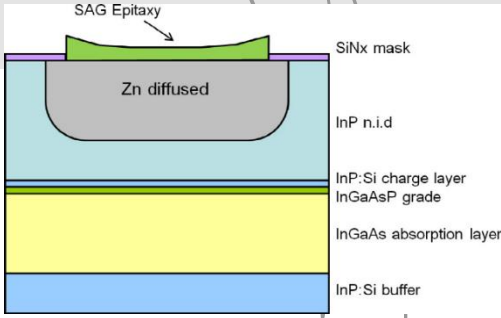
Avalanche Photodiodes and arrays

- Selective area growth and diffusion for edge beakdown suppression; high uniformity, low-noise and high sensitivity
- Application to core photonic networks, Satcom (Geiger-mode arrays for wavefront sensing), Lidar

Focal Plane arrays

- From design and modeling to fab, hybridization of packaging
- Application in night vision, machine vision, food or IC device inspection, autonomous cars, biomedical imaging

Serial imaging



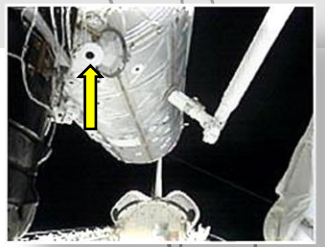
Optical Thin Films

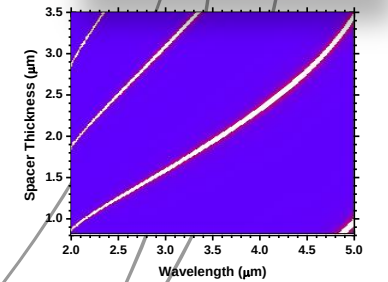
Design, fabrication and optical characterisation of optical filters in the visible and nIR

Facet Coatings for FB cavity lasers

Examples of coatings for space applications

- Broadly tunable narrow filter for Hyperspectral imaging
- Black coatings for high-resolution gratings fabrication (MAESTRO instrument, with Environ. Canada)
- Beam-splitter for Gemini North Telescope (ALTAIR instrument)
- Omnidirectional AR coatings on sensors protective dome with Lockheed Martin

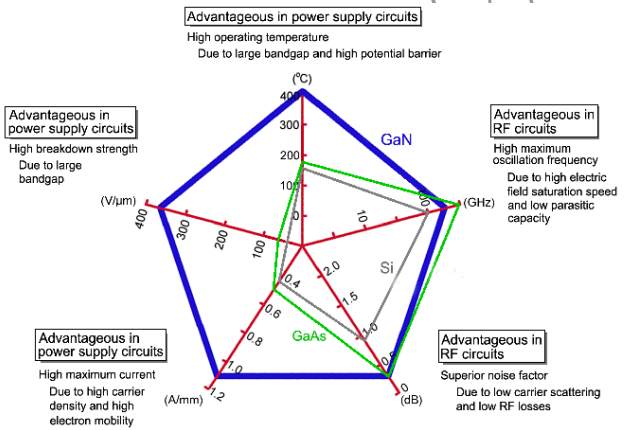




Gallium Nitride (GaN) Electronics for Harsh Environments

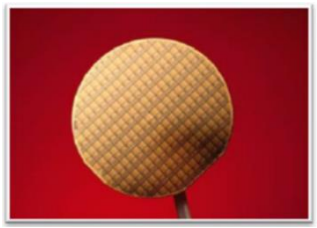
Technology advantages

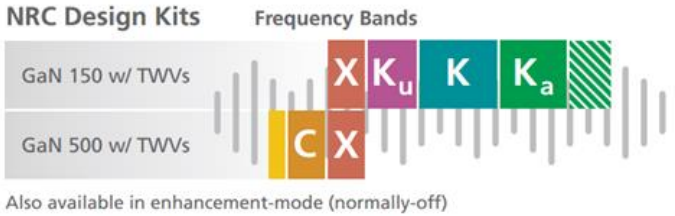
- RF operation into K band
- radiation hard
- high operating temperatures
- normally-on or normally-off options



NRC services

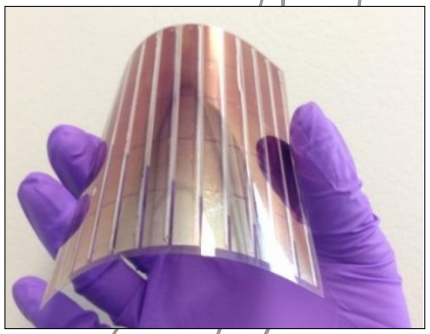
- Design kits (ADS): device libraries, automated layout, schematic, circuit simulation and design rule checking for circuit designers.
- Foundry fabrication (CPFC)
- RF testing





Printable electronics

From novel molecular materials, to inks, printing processes and optimization of device performance



Energy harvesting

- World-record in heterojunction polymer solar cells in 2009 within SDTC contract
- Efficient indoor light harvesting photovoltaic cells technology licensed
- Piezoelectric, triboelectric and thermoelectric schemes under development

Sensing technologies

- Chemical, environmental conditions for wearables, smart building, smart agriculture
- Smart drug monitoring packages, photo-detector array technologies transferred to members of Printable Electronics consortium

THANK YOU

Julie Lefebvre • **Director General** • julie.lefebvre2@nrc-cnrc.gc.ca

Christophe Py • **Director of R&D** • christophe.py@nrc-cnrc.gc.ca

www.nrc-cnrc.gc.ca