Novel Ultra-miniature Technology for Earth Observation and Sensing

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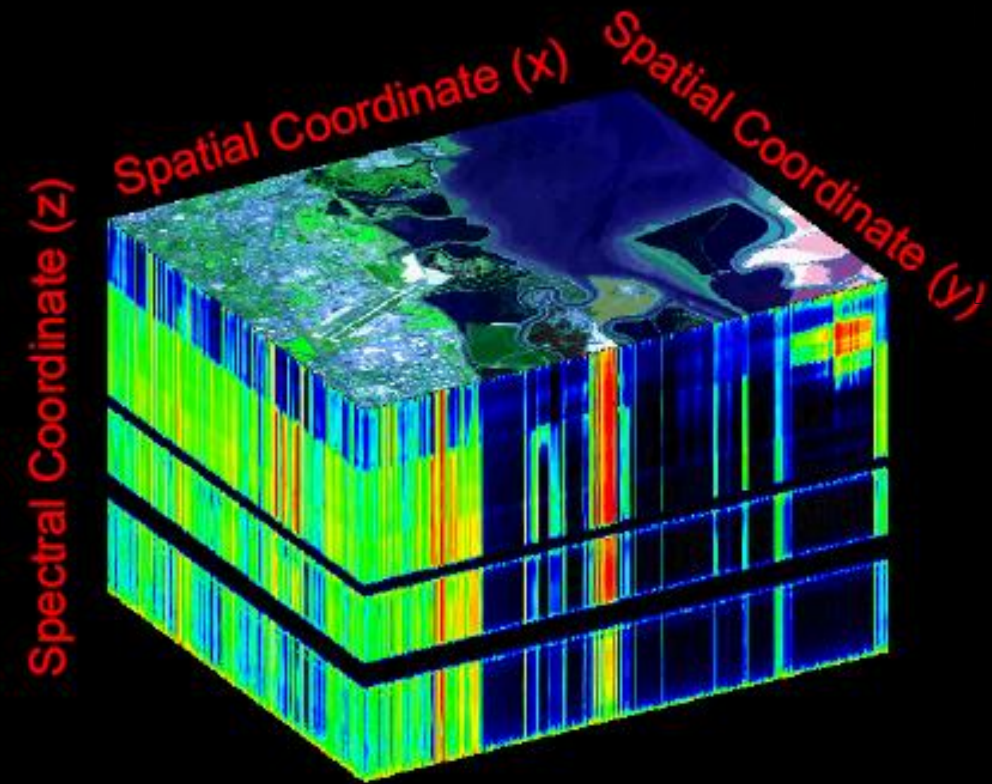
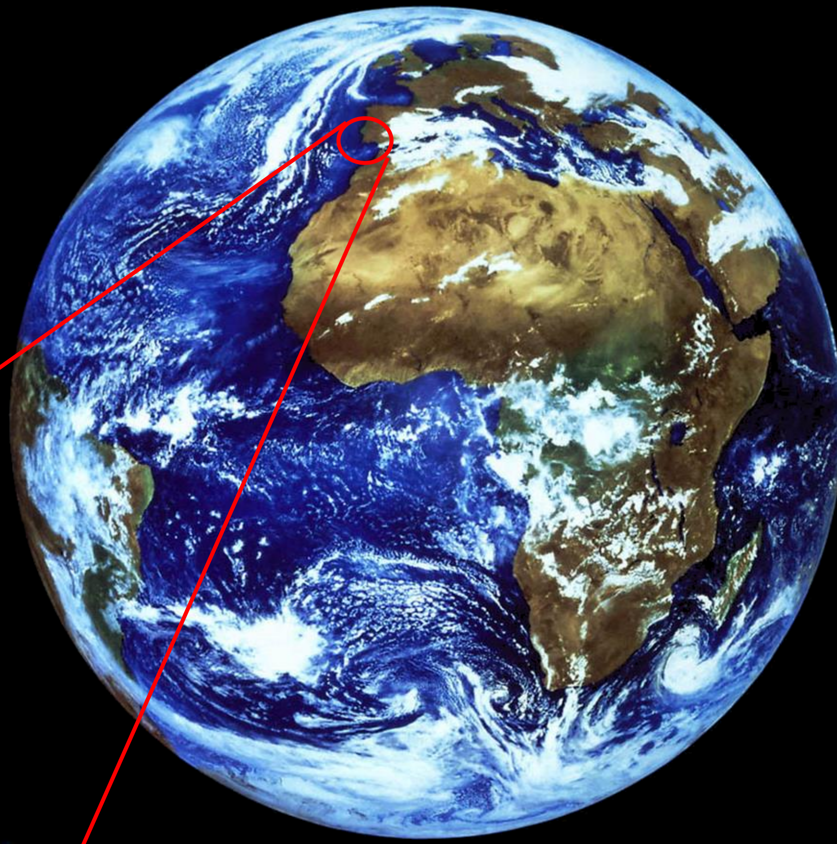
Introduction

- Motivation
- Spectrometer chip concept
- Design process
- Future work and prospects

Satellite Earth Observations



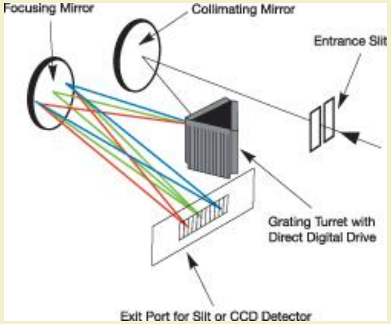


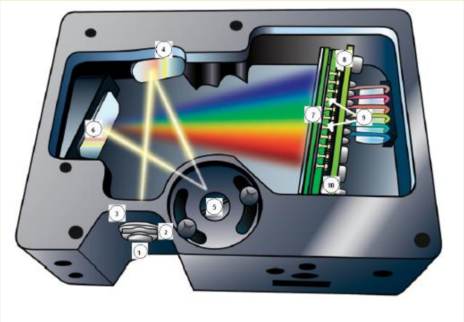
“Ground Truth”:
Satellite data need to be calibrated and validated with ground-based measurements

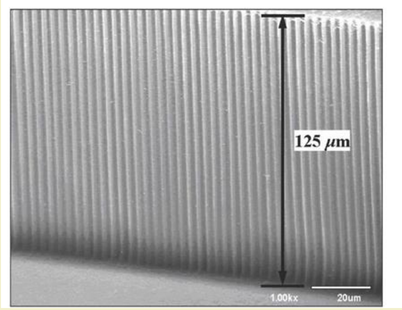
Ground-based measurements

Issues with conventional spectroscopy systems

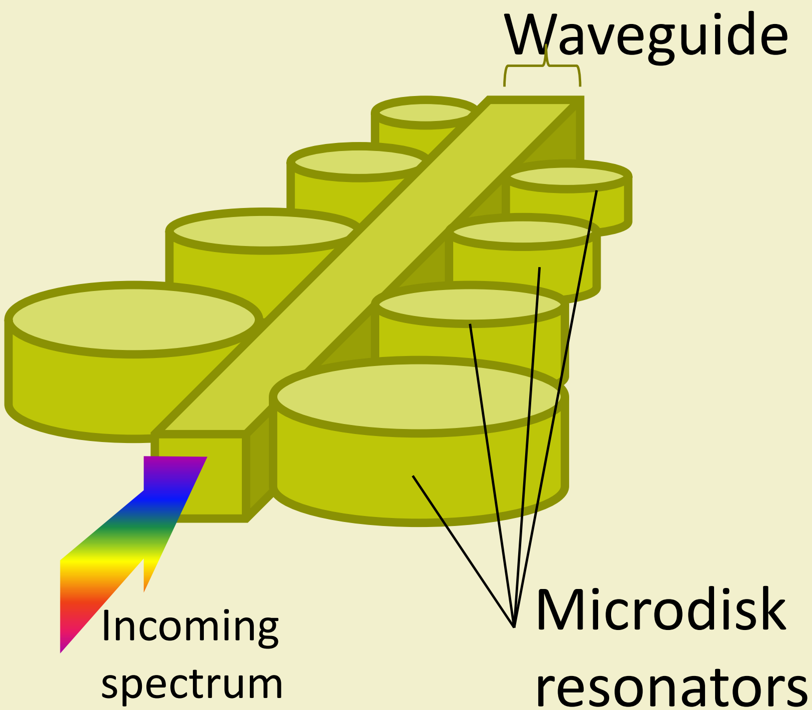
- Current spectrometers have multiple components
  - Alignment issues
  - Expensive to manufacture
  - Optical effects – loss of photons / stray light
  - Miniaturisation difficult – spectral resolution suffers as size of spectrometer is decreased

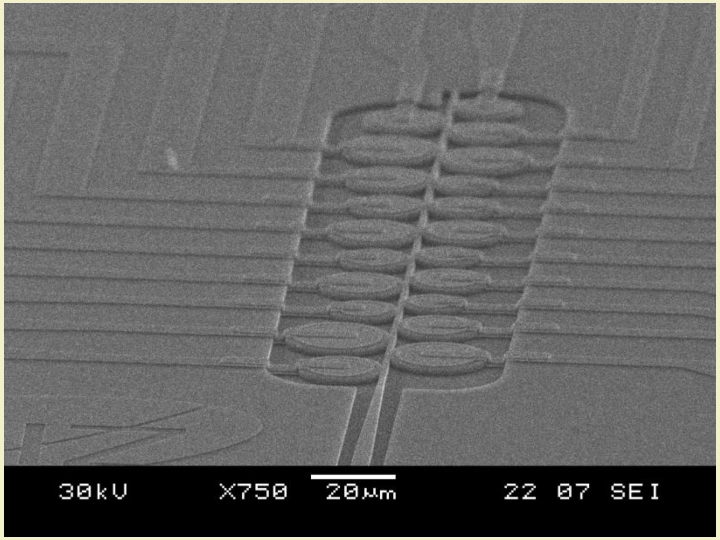




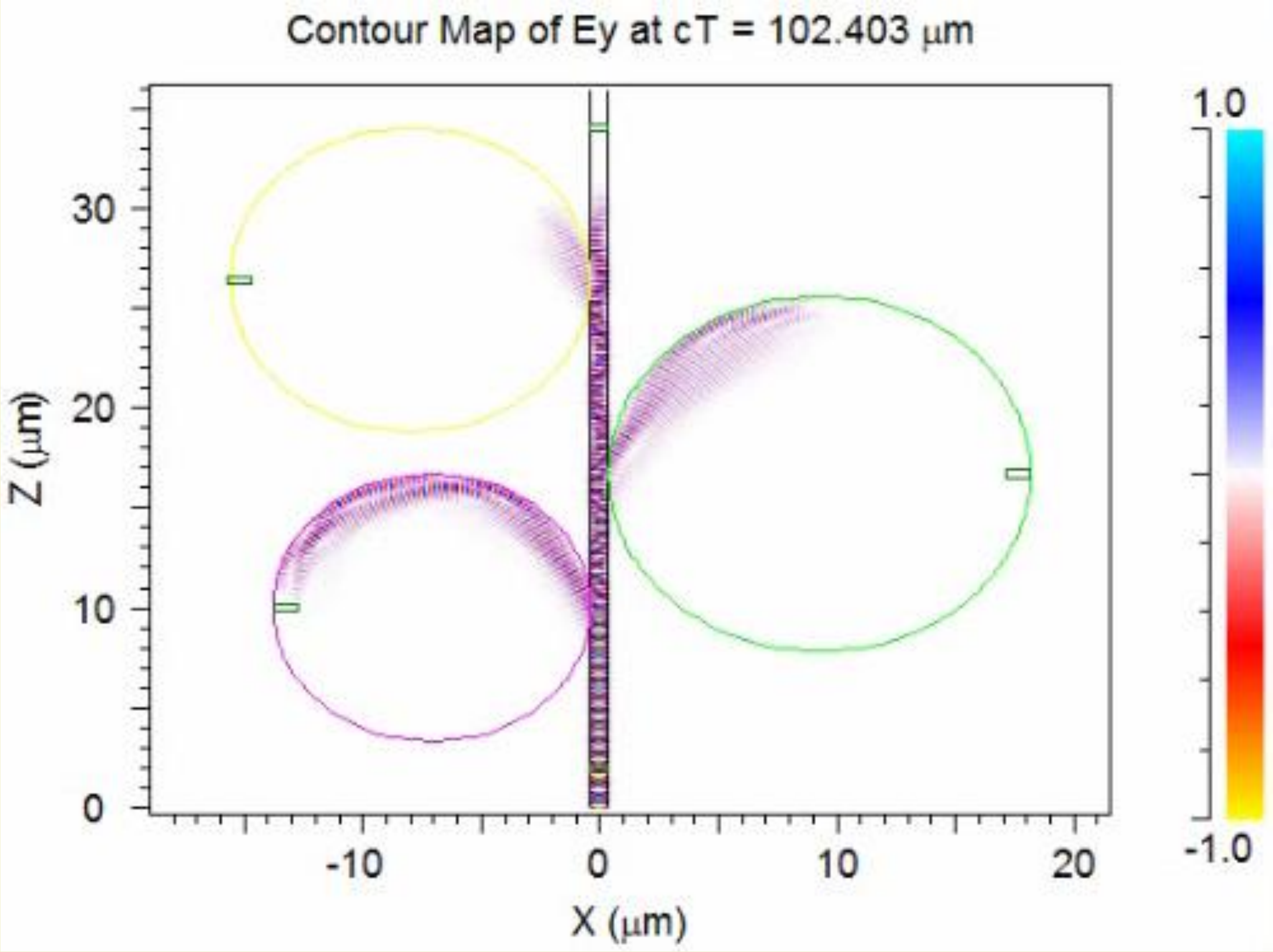


Our solution: Resonant Detector Array

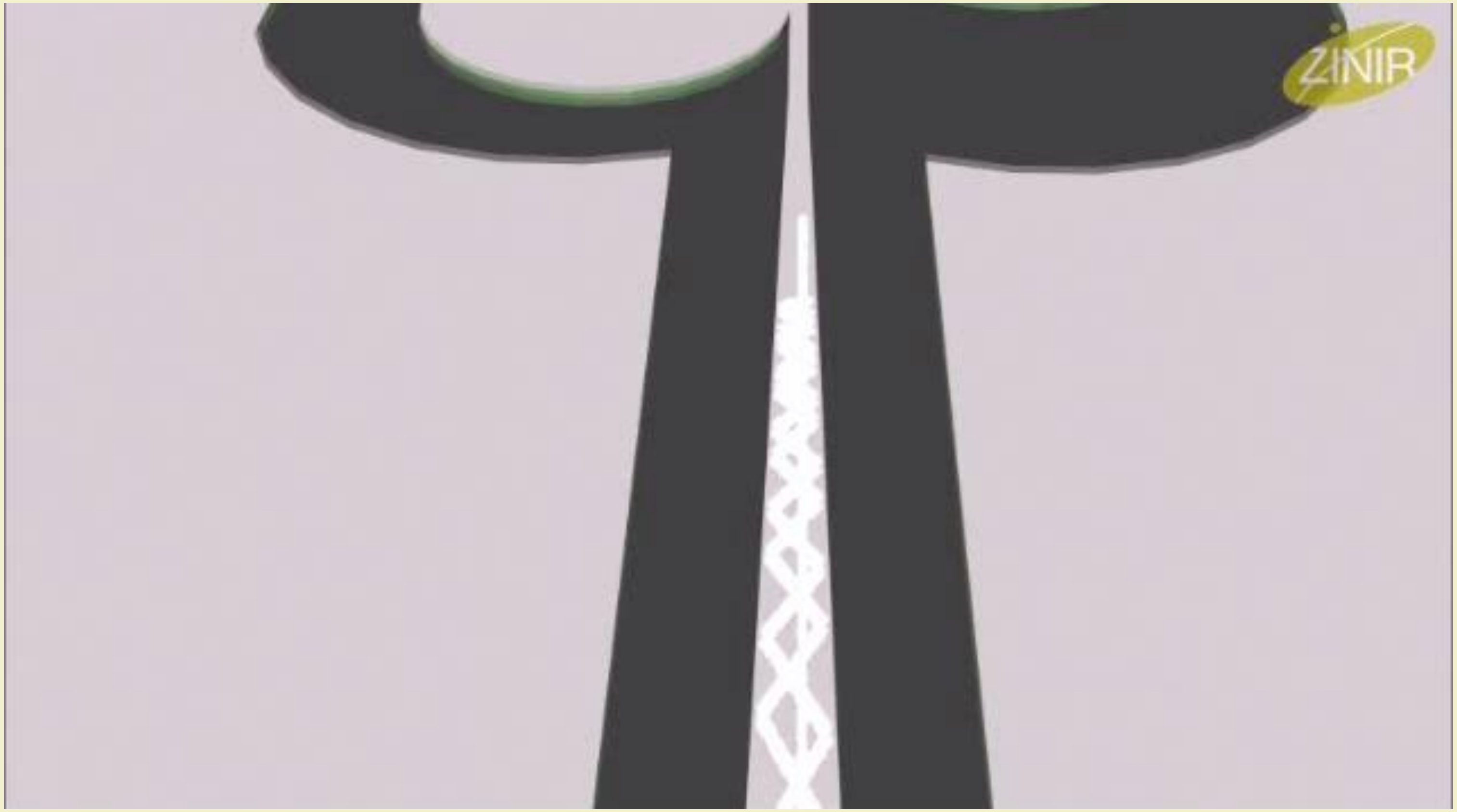




Microdisk resonance



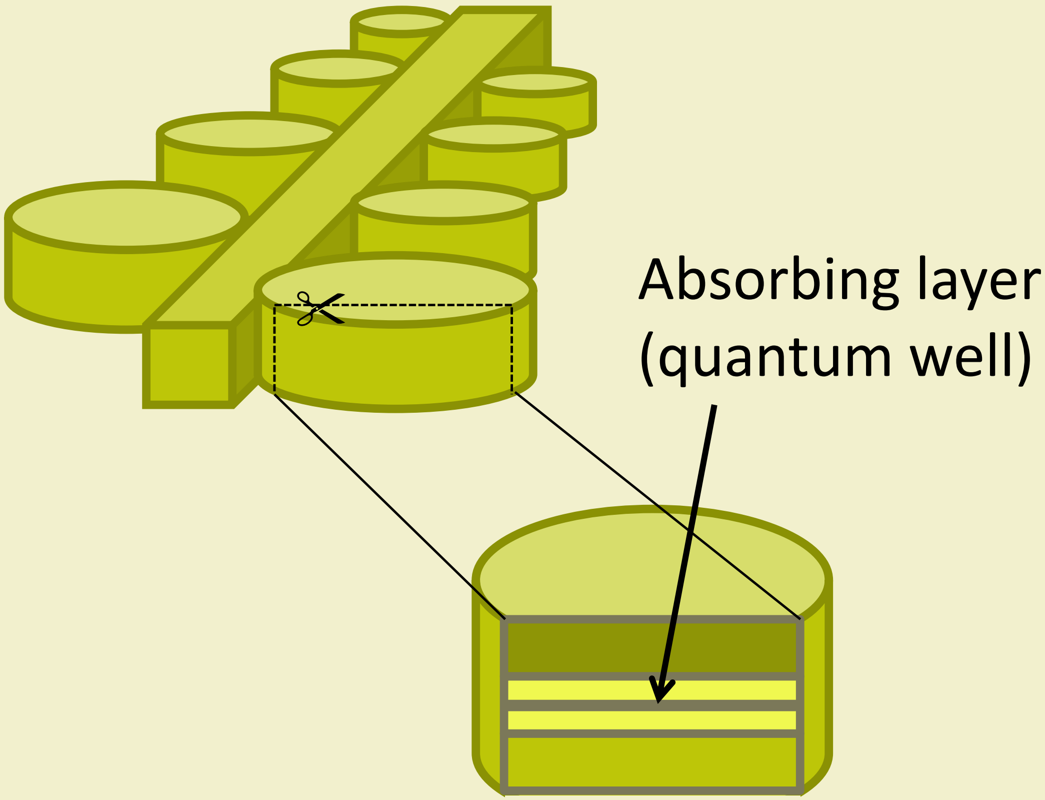
Our solution: Resonant Detector Array

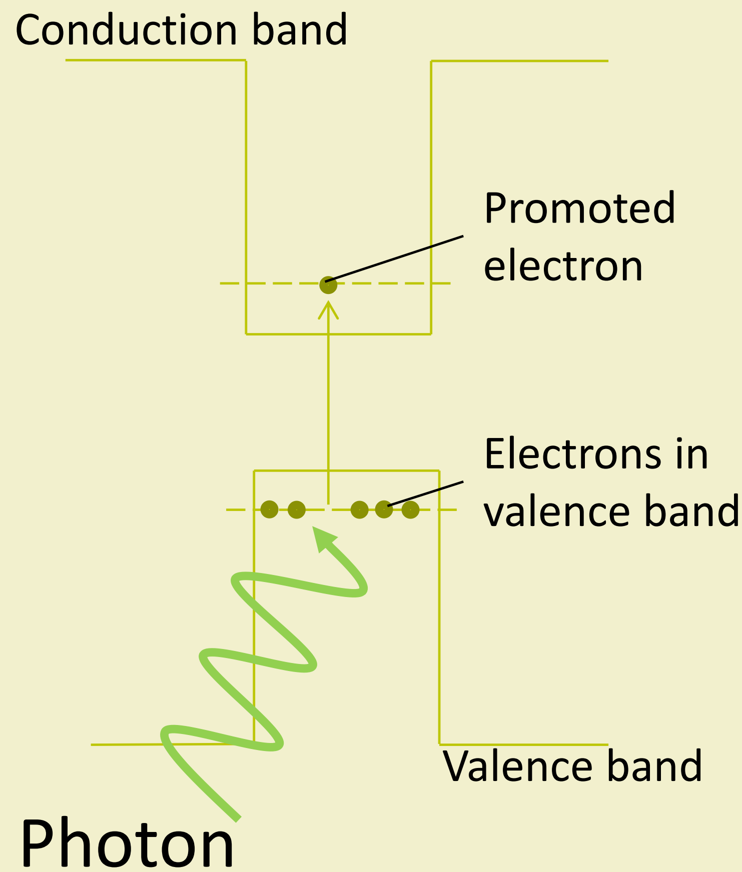


SolO Spectroscopy™

Diode-integrated Spectrometer Chip

Dispersion and detection in one





Advantages

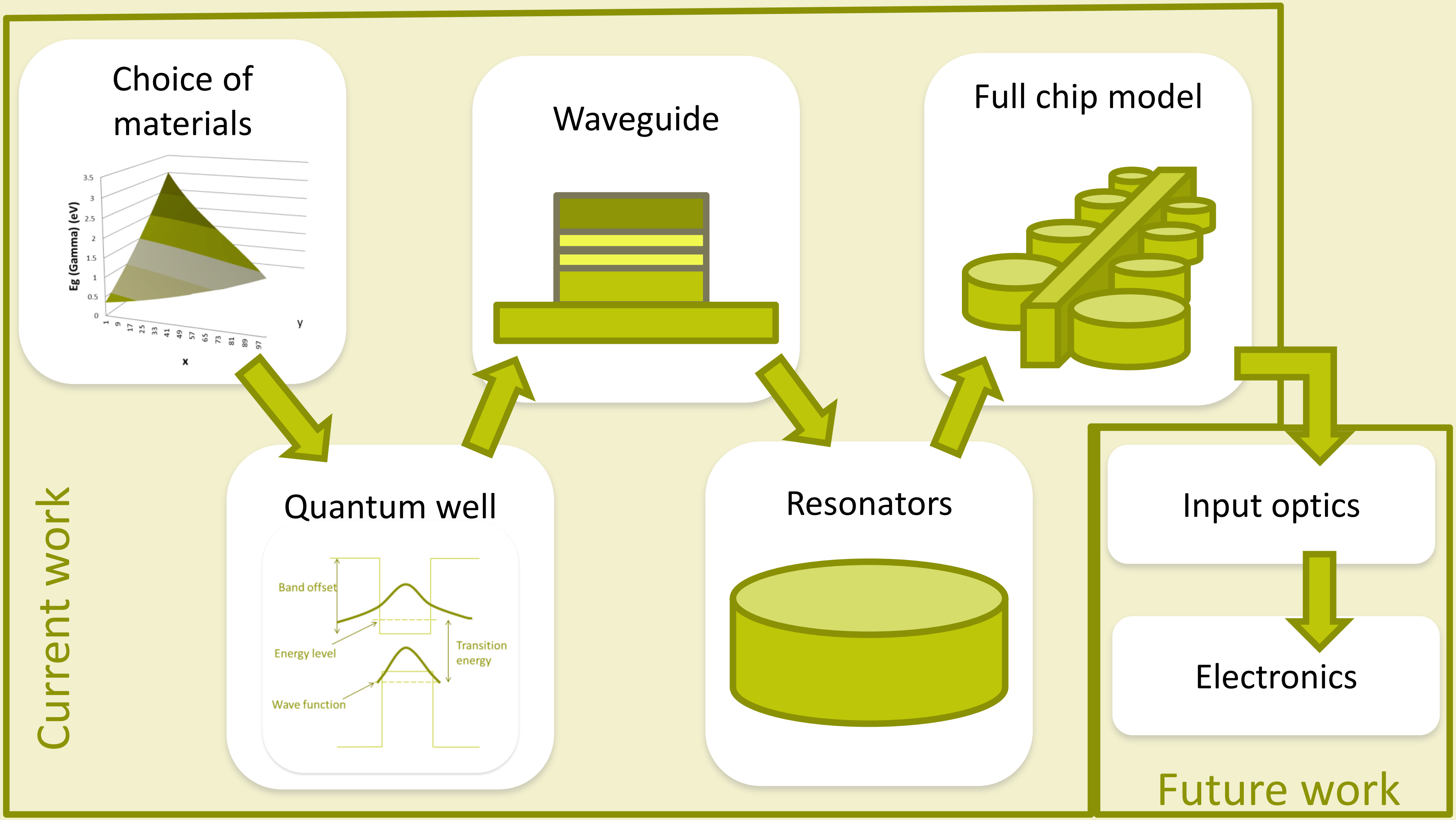
- Tiny footprint
- Low mass
- Low power consumption
- Robust:
  - Wavelength separation and detection within a single photonic element
  - No electrical or mechanically moving parts
- Fast data acquisition
- Thermally stable
- Tuneable spectral features
- Maintenance-free
- Potential for low stray light, high resolution
- Potential for wide spectral range

System Requirements

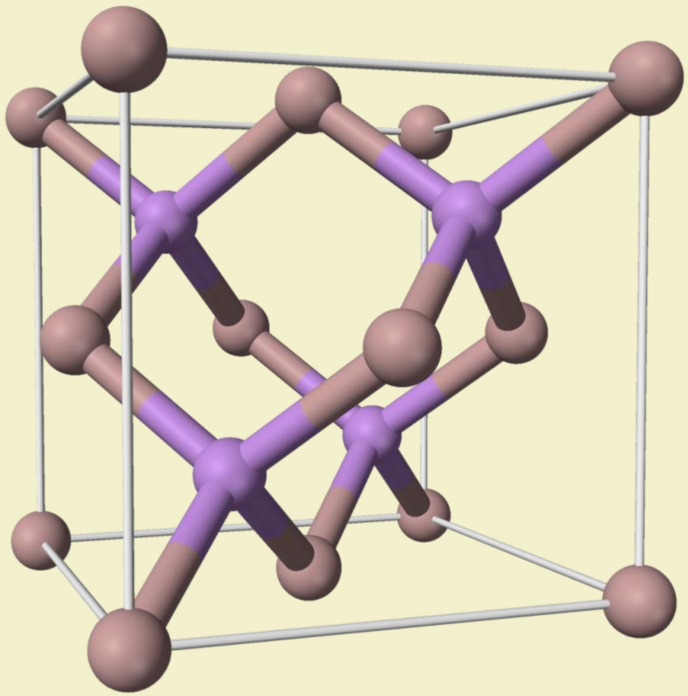
System requirements:

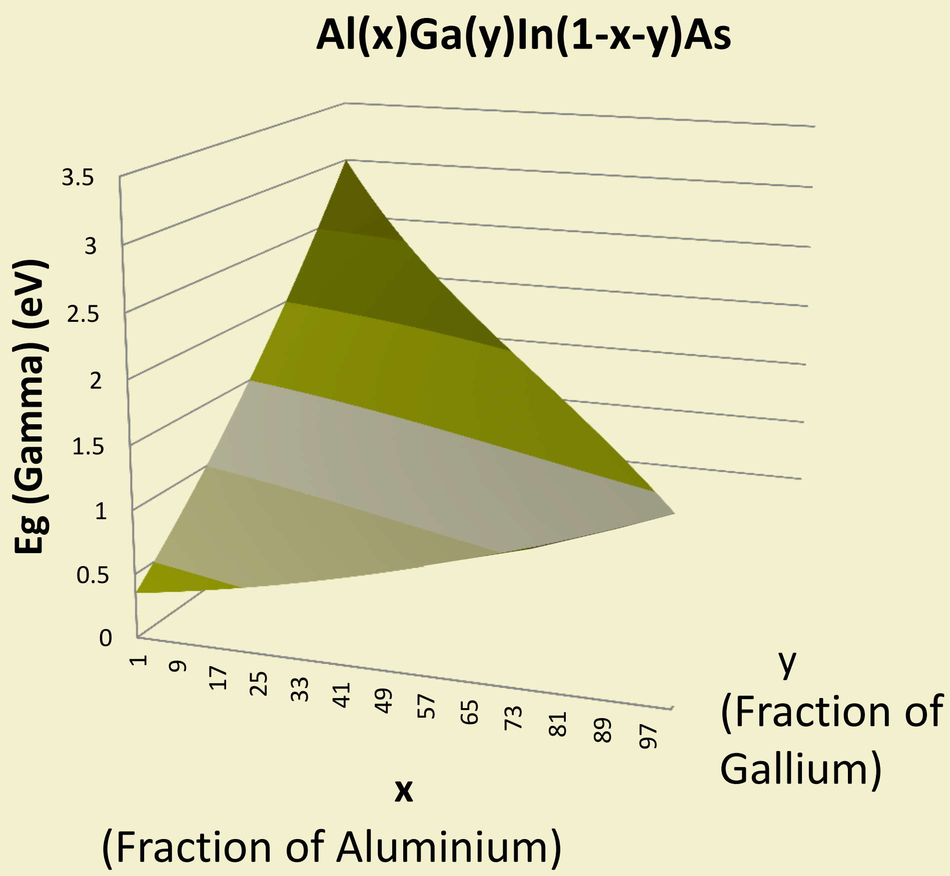
- Wavelength range: 750-1000nm (ultimate aim: 300-1000nm)
- Resolution:
  - 5-10nm (broad spectrum)
  - 0.1nm (specific spectral bands of interest)

Design Aspects

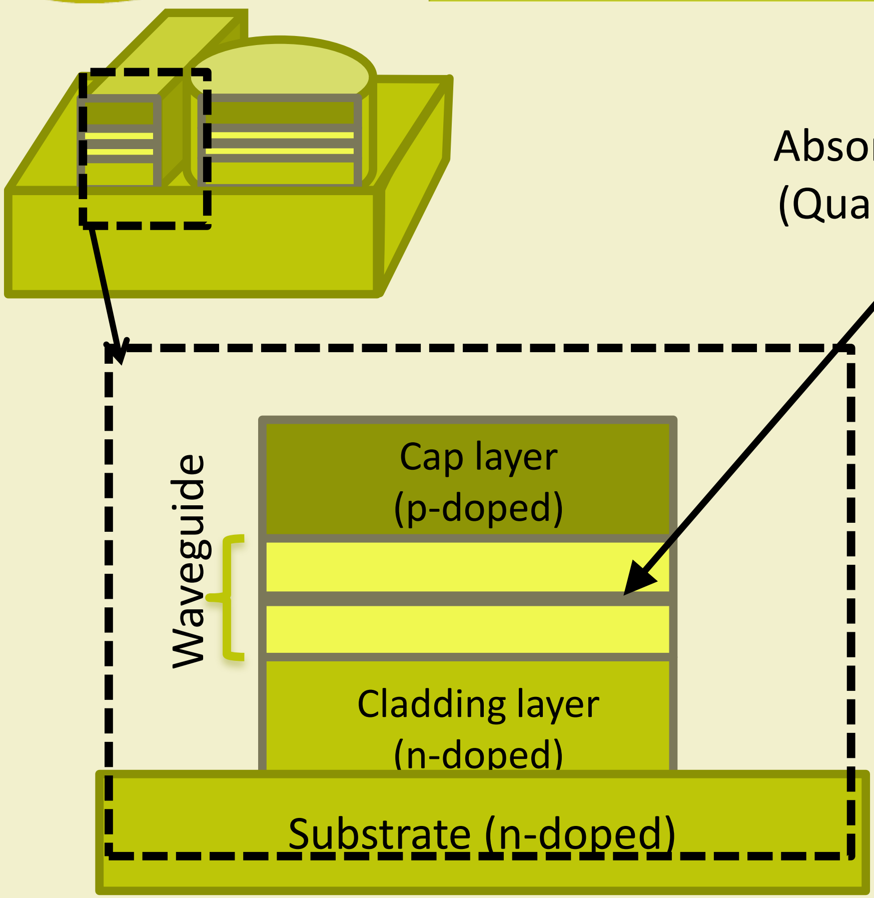


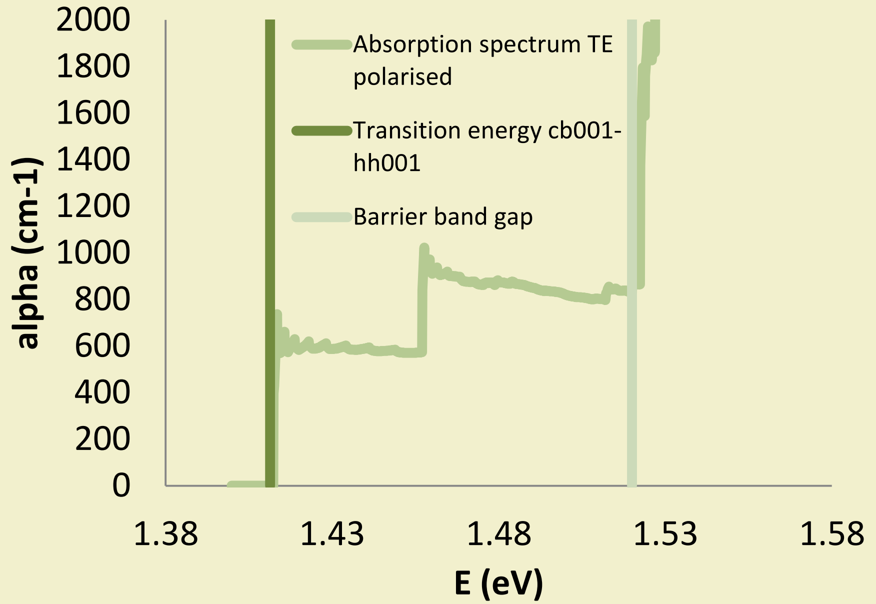
Choice of Materials



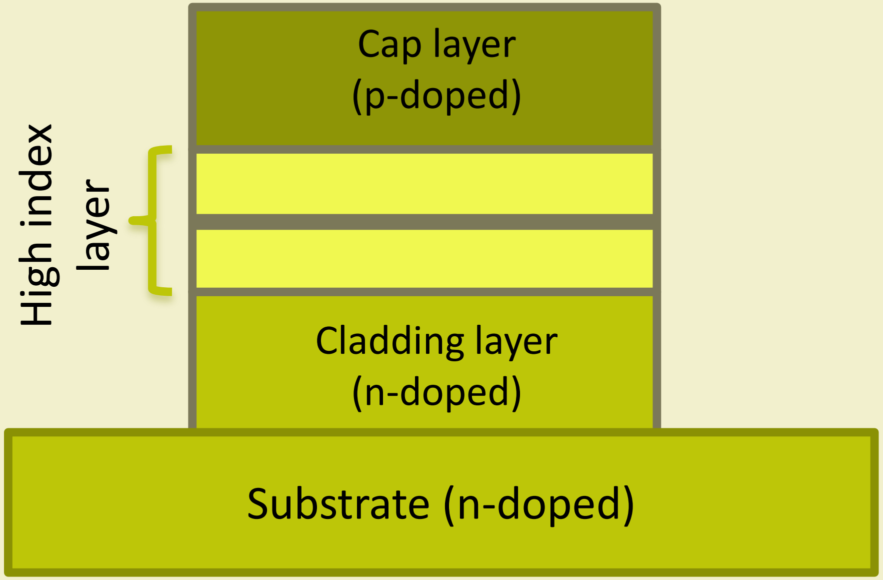


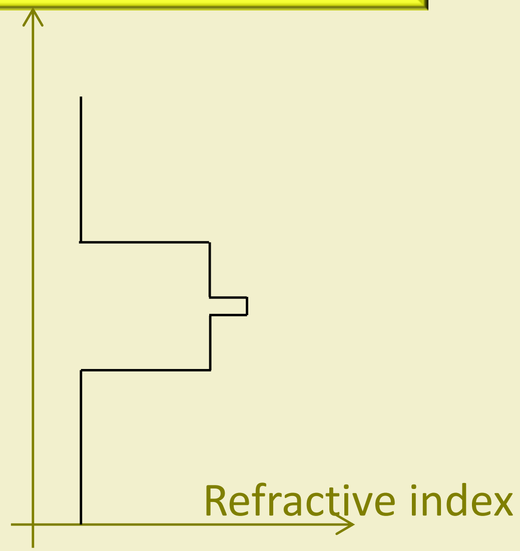
Layer structure: quantum well

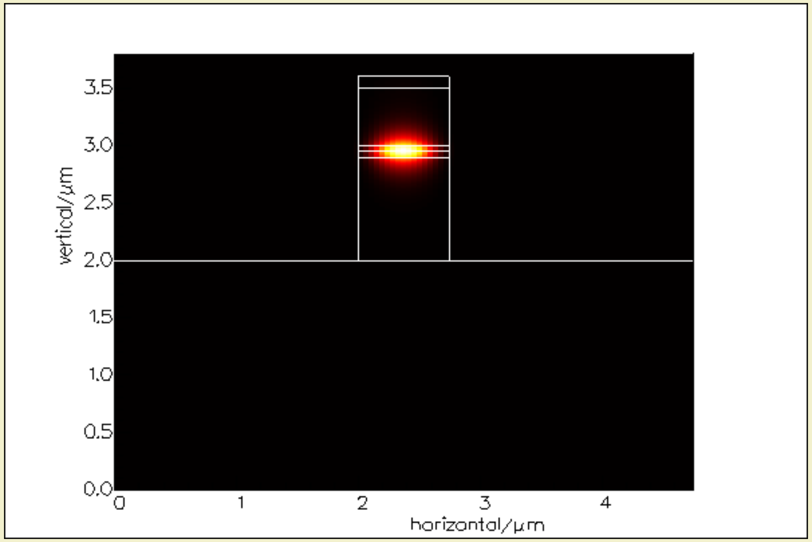




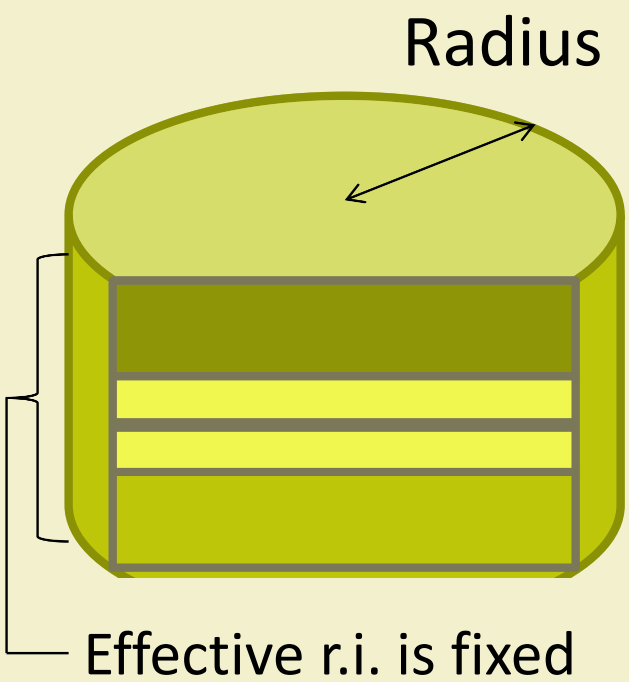
Waveguide Design

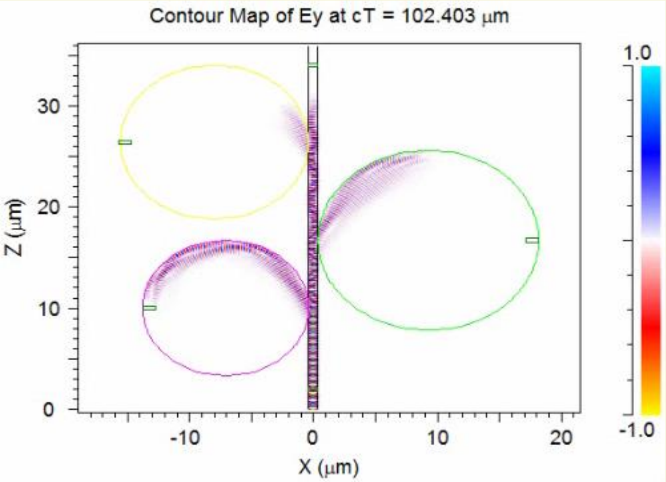


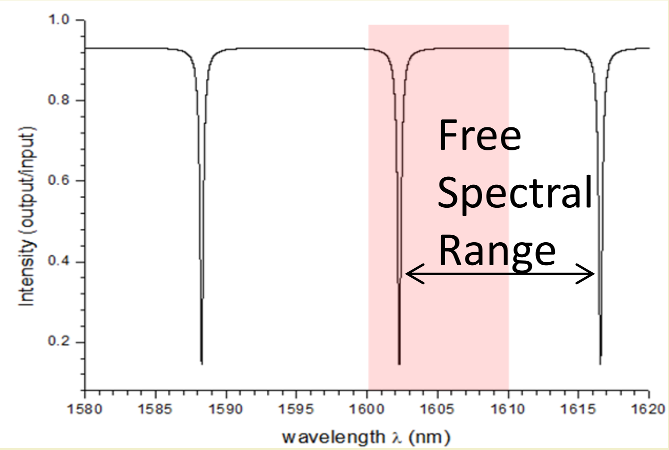




Resonator design



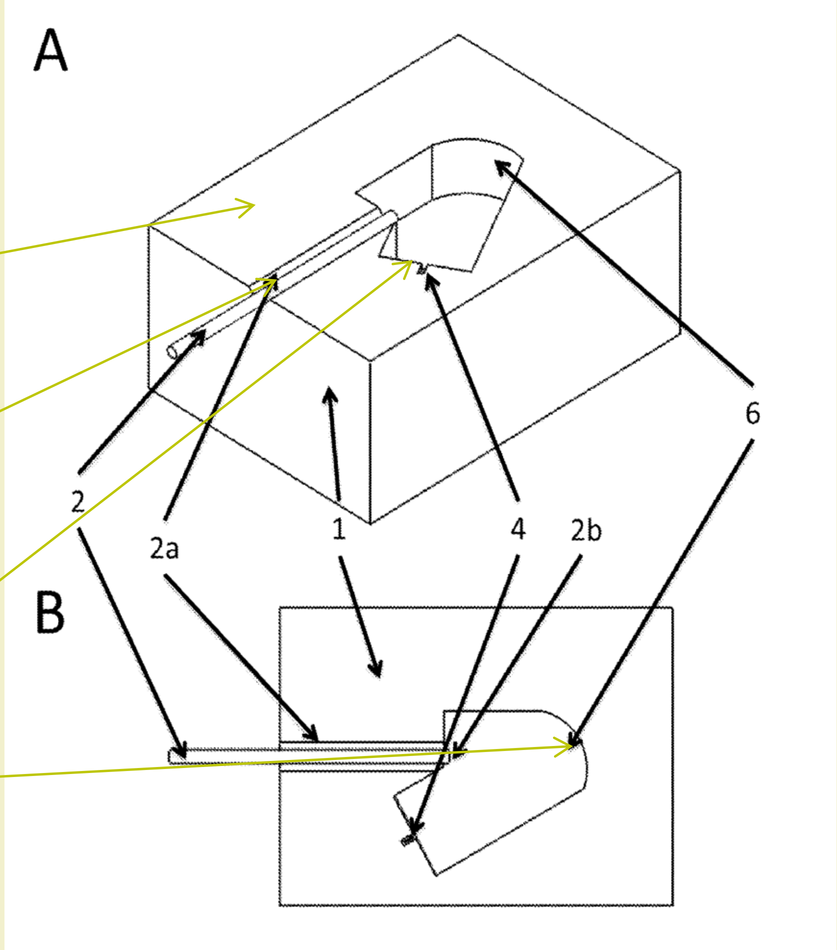




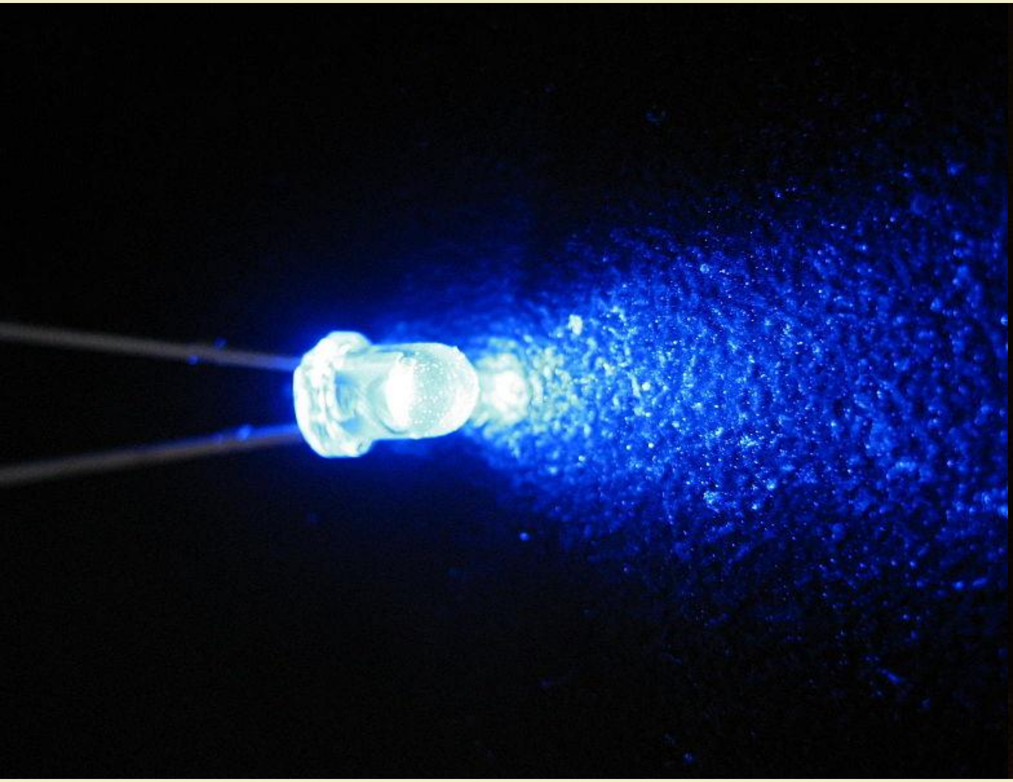
Future work: input optics

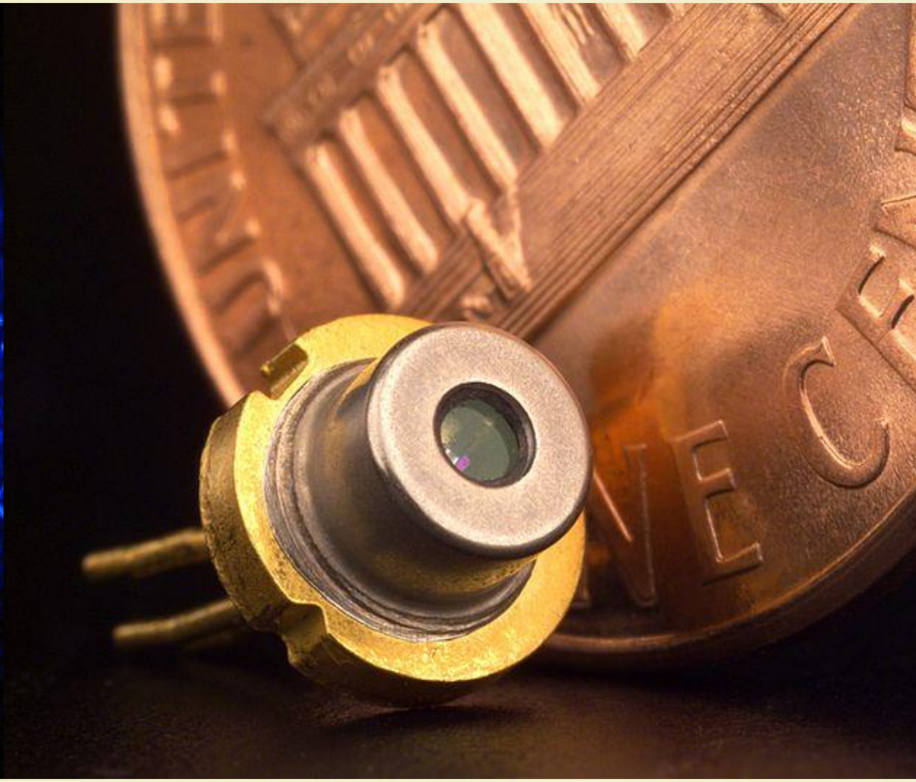
Optical motherboard (UK Patent application GB2494640A)

- Housing made of semiconductor or insulator
- Groove for bare optical fibre cable
- Groove or recess for sensor (in butterfly package?)
- Mirror



Future work: On-chip light sources

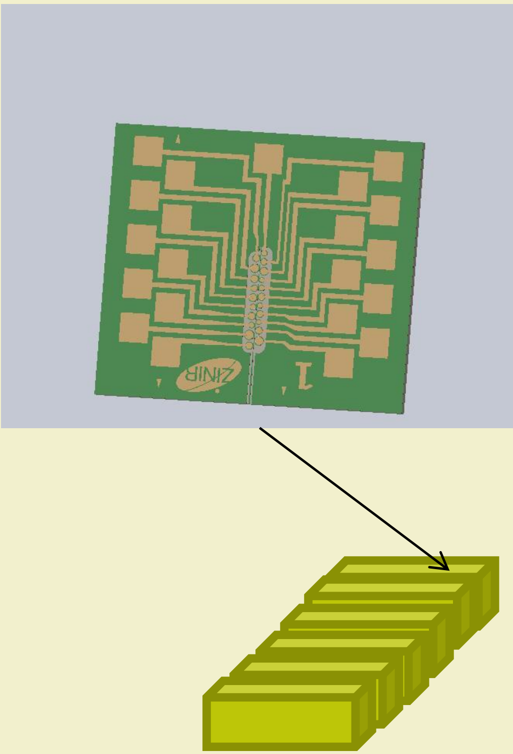


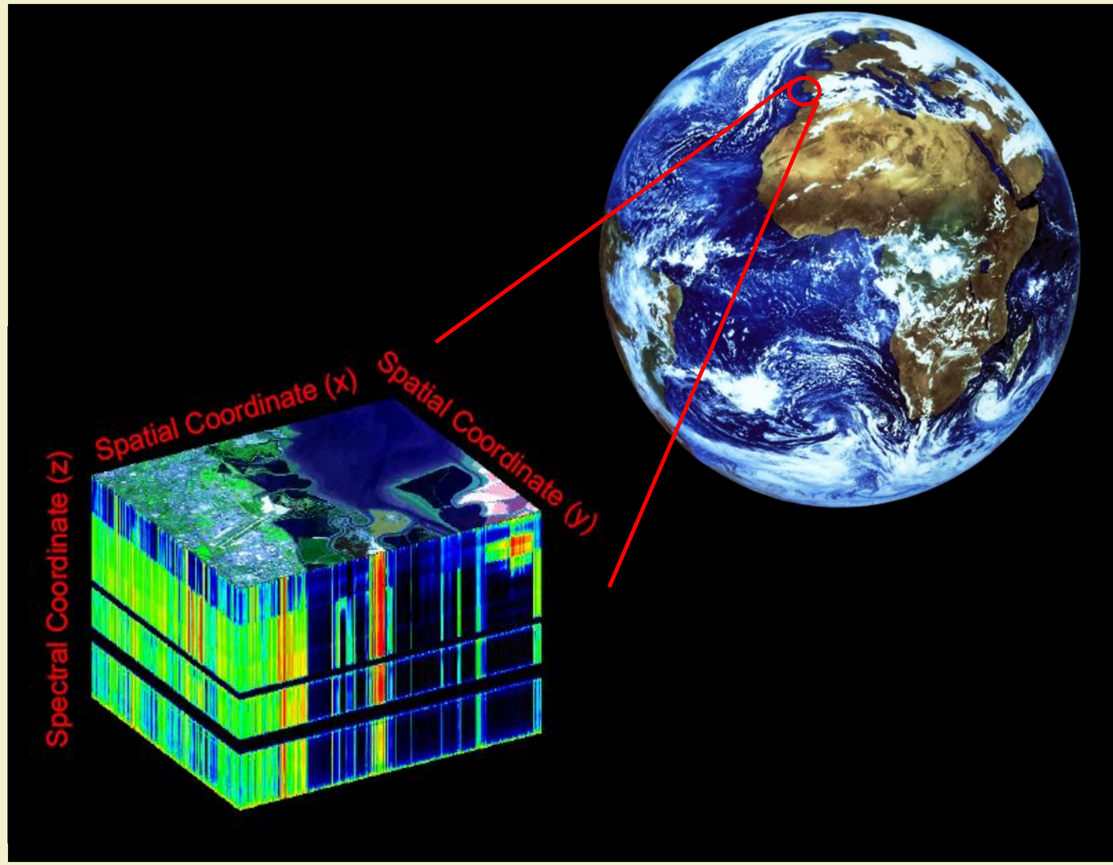


Possibilities include a Quantum dot LED or a DFB laser

Image credit: Hoenny (Wikimedia)

Future work: hyperspectral imaging





Other applications

- Biomedical science
- Environmental/remote monitoring
- Industrial quality control
- Mobile technology

Summary and Future Work

- Summary:
  - ZiNIR's chip-based spectrometer integrates dispersion and detection elements on a single chip
  - Current application: calibration of Earth observations
  - Design stages:
    - Choice of material
    - Quantum well and waveguide
    - Resonator optimisation

- Future work:
  - Front-end optics
  - Electronics
  - On-chip light source
  - Hyperspectral imaging

- Other applications
  - Biomedical
  - Remote monitoring
  - Industry
  - Mobile technology

Acknowledgements

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