

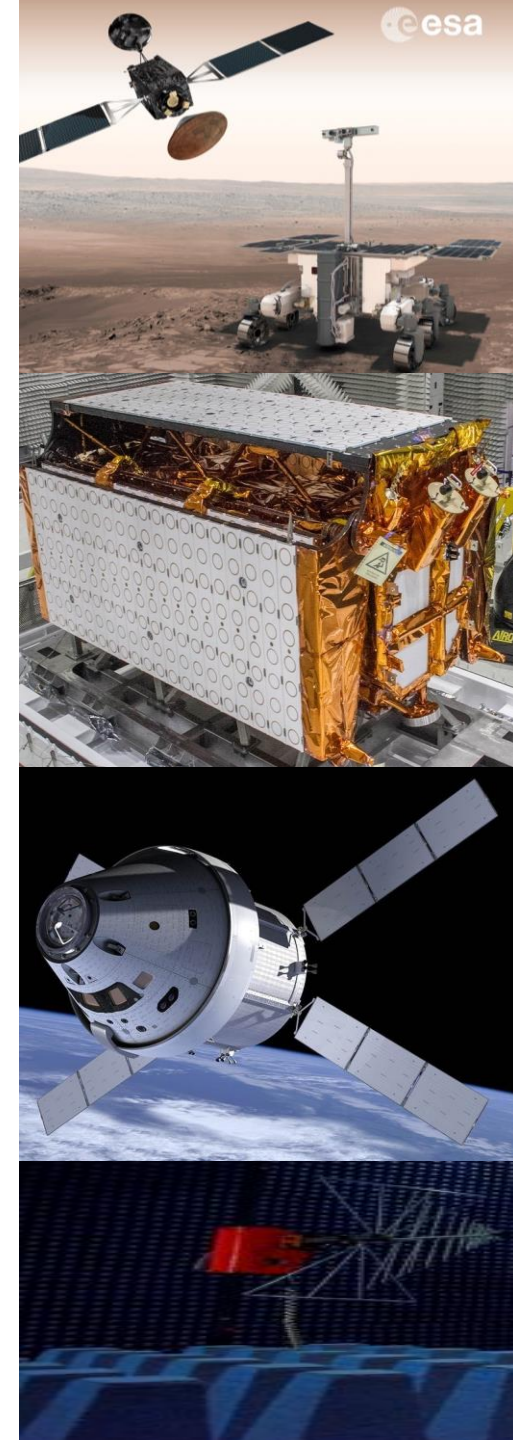
Optocap

Mark Day
BDM – Quantum Technologies

September 2019.

Packaging for Space & Quantum Technologies

- **Optocap Capability**
- **Optocap Space Heritage**
- **Space Qualified Photonic Device Example**
- **Optocap Quantum Solutions**



Optocap High-Reliability Packaging Capability

Optocap is a leader in the design, manufacture and test of *High Reliability* micro and Optoelectronics for *Harsh Environments*

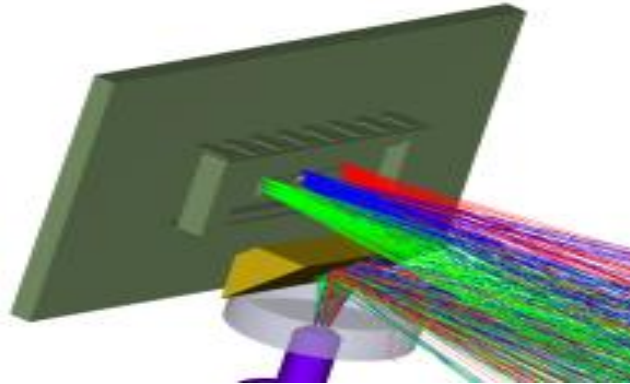
- Space
- Aerospace & Defence
- Oil & Gas
- Medical



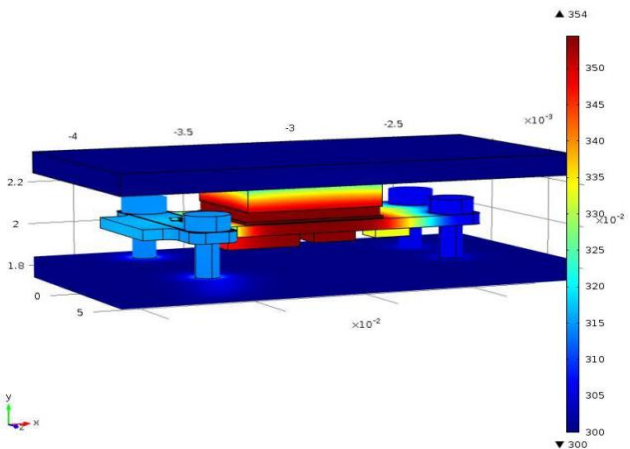
Experienced Hi-Reliability Manufacturer

- ISO7 Clean Room >200m²
- Laminar flow for ISO5 / Class 1000
- Wafer & die handling
- Precision die attach
- Al wedge wire bonding
- Optical alignment
- Hermetic sealing
- Manufacturing in accordance with MIL-STD-883 and ESCC standards

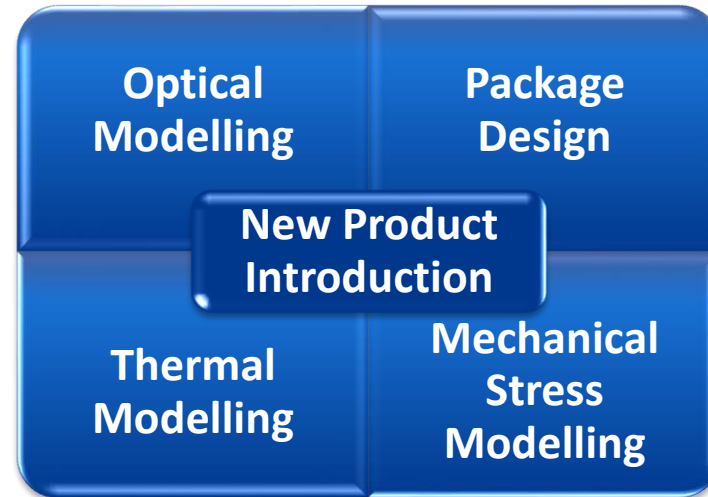
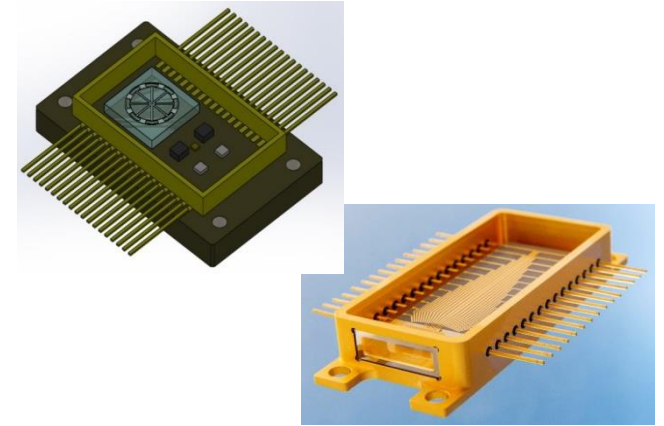
Optocap Design Capability (Experience > 16 years)



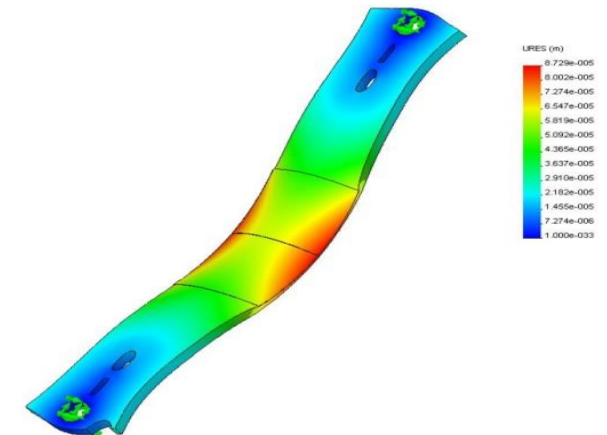
Hi-Reliability Packaging



Optoelectronic & Optical Packaging



Design for Manufacture



Microelectronic & MEMS Packaging

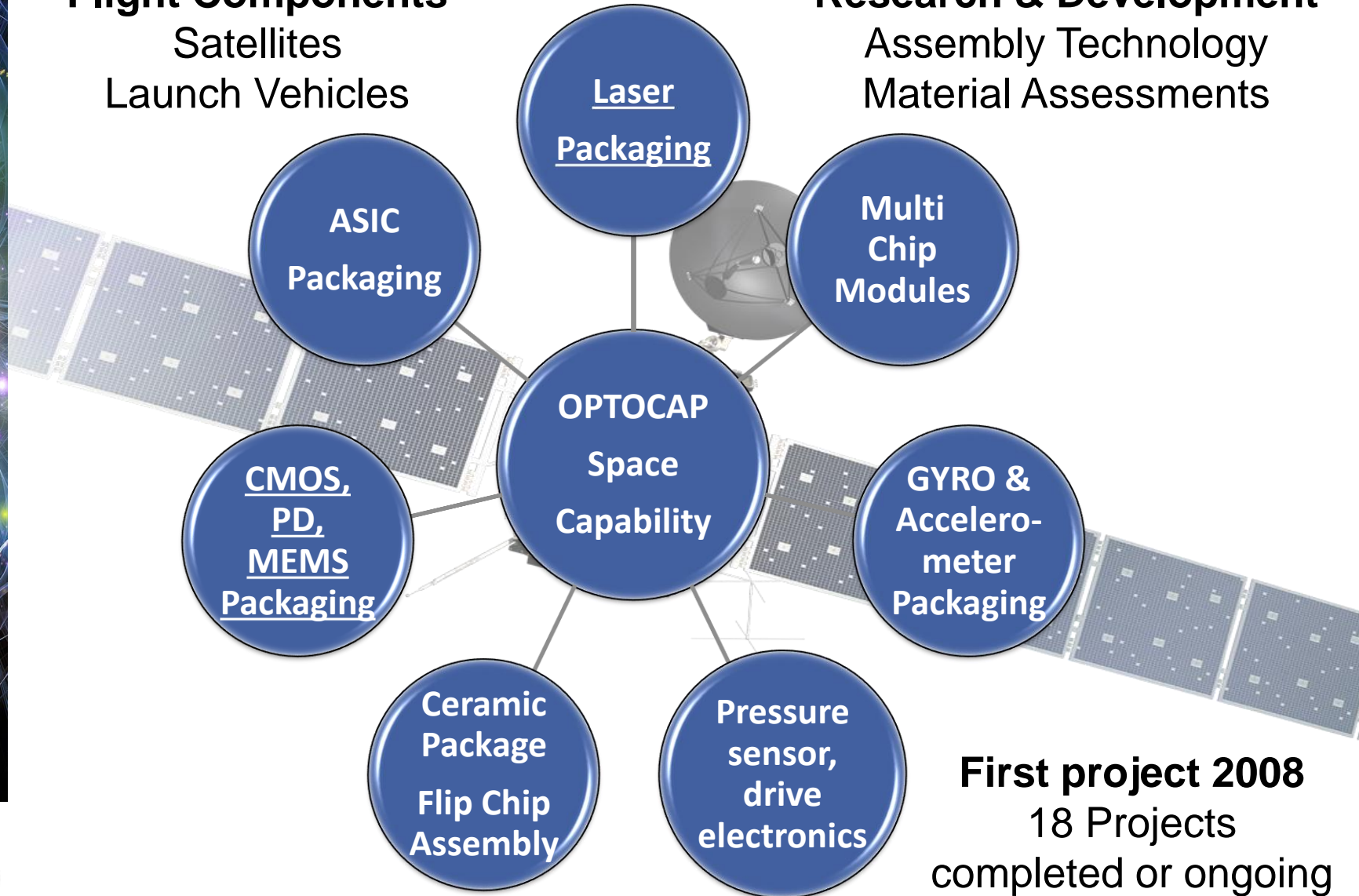
Optocap Space Heritage (>11 years)

Flight Components

Satellites
Launch Vehicles

Research & Development

Assembly Technology
Material Assessments



First project 2008
18 Projects
completed or ongoing



Optocap Space Flight Projects 2017-2018



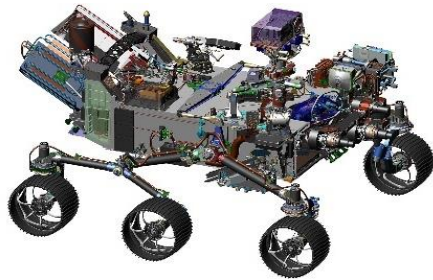
Meteosat Third Generation - Infrared sounder

Photodiode Array in Hermetic Package / Application: Weather Imaging

Jupiter Icy Moons Explorer (JUICE)

Image Sensor for Monitoring Camera

Instrumentation ASICs / Application: Space Exploration



Mars Environmental Dynamic Analyser (MEDA)

ASICs for Instrumentation / Application: Mars 2020 Rover

High Accuracy Star Tracker

CMOS Sensor Hermetic Package / Application: Star Tracker

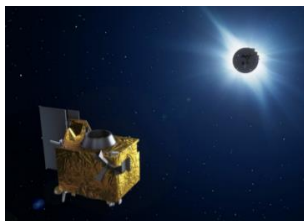
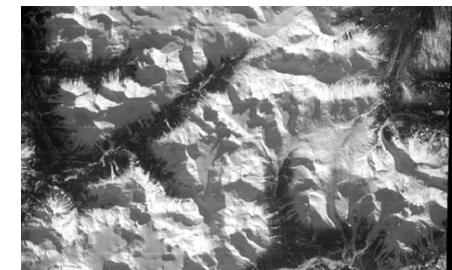


Sensor ROIC ASIC

MELCO / JAXA

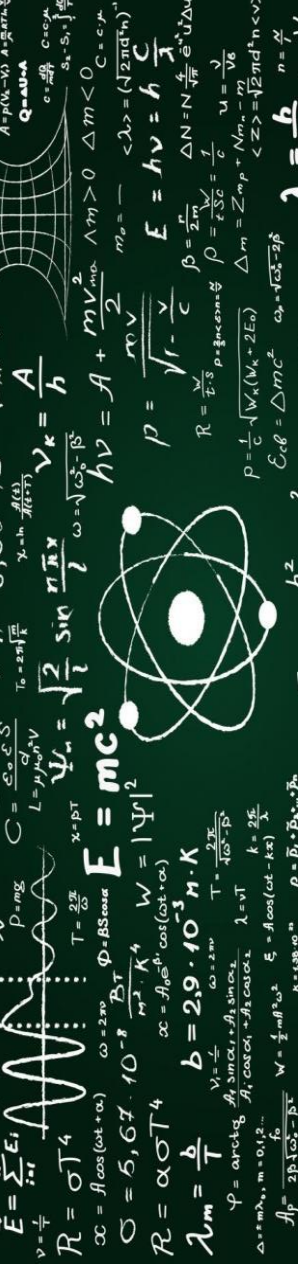
CCFA CCD sensor

Application: Earth Observation / Cube Sat



ESA PROBA-3

SiPM Hermetic Packaging



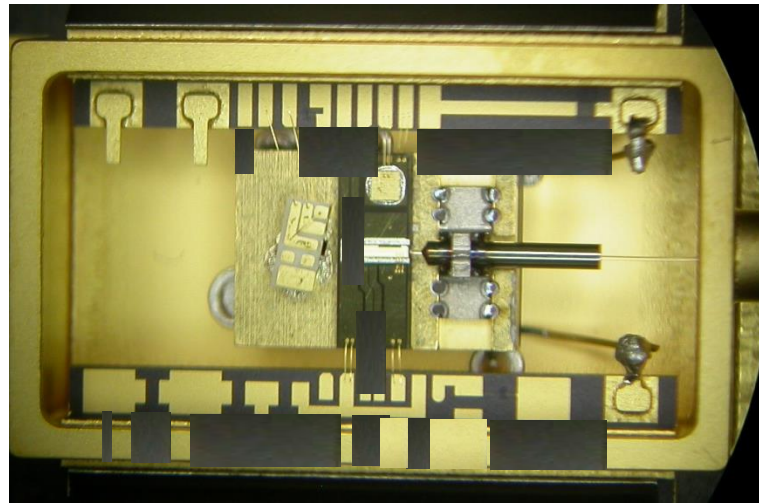
Example Optocap Space Qualified 14 Pin Butterfly

Bill of material previously qualified on space programs for single mode DFB laser diodes.

- Thermistor
- TEC
- Optical bench
- Monitor mount & monitor PD
- Fibre subassembly
- Expansion matched and thermally optimised design.

Use of standard, high reliability, Space compliant assembly processes

- Organic and flux free construction
- Hermetically sealed



Au Wire bonding

- Automated wire bonding
- 25mm Au wire

Laser Welded Fibre Attach

- Sub micron alignment
- Polarisation maintaining fibre

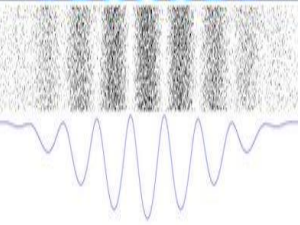
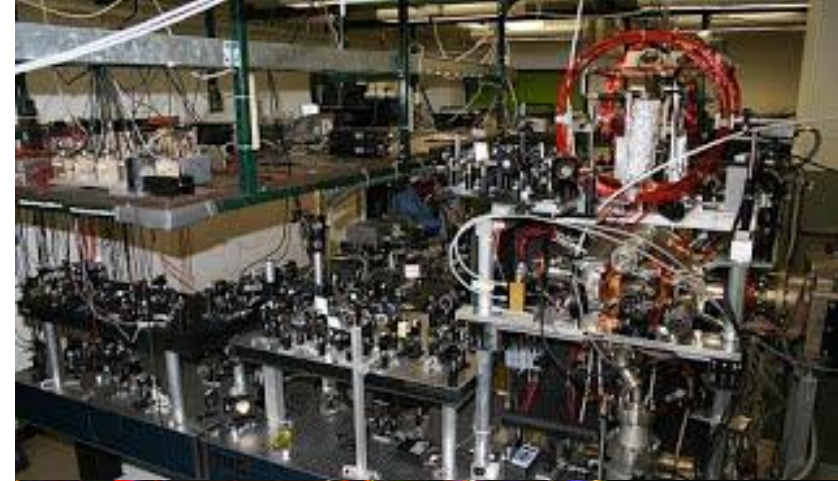
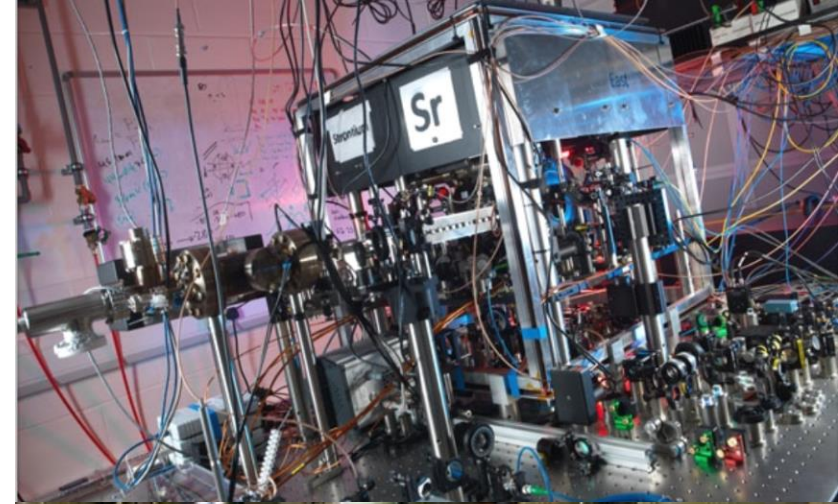
Fibre Features

- AVIM connectors – ruggedized
- Option to splice component
- Glass hermetic seals
- Tight buffer jacket
- Integrated lens – tip of fibre
- High performance AR coatings
- Multiple fibre types (PM, SM, MM)



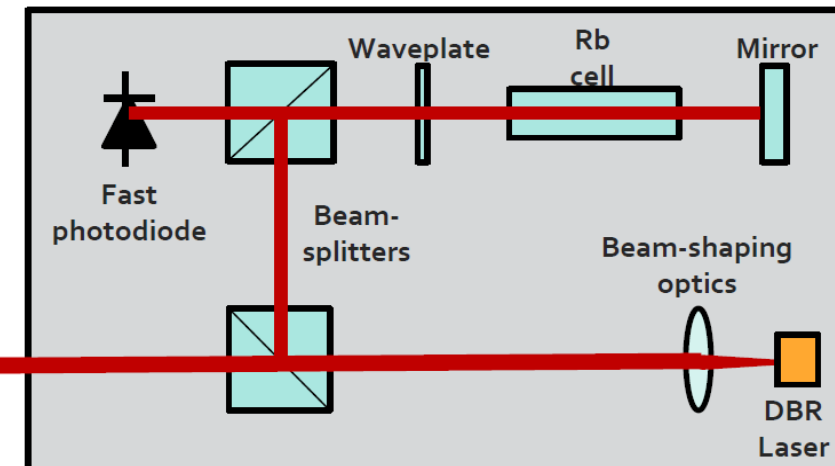
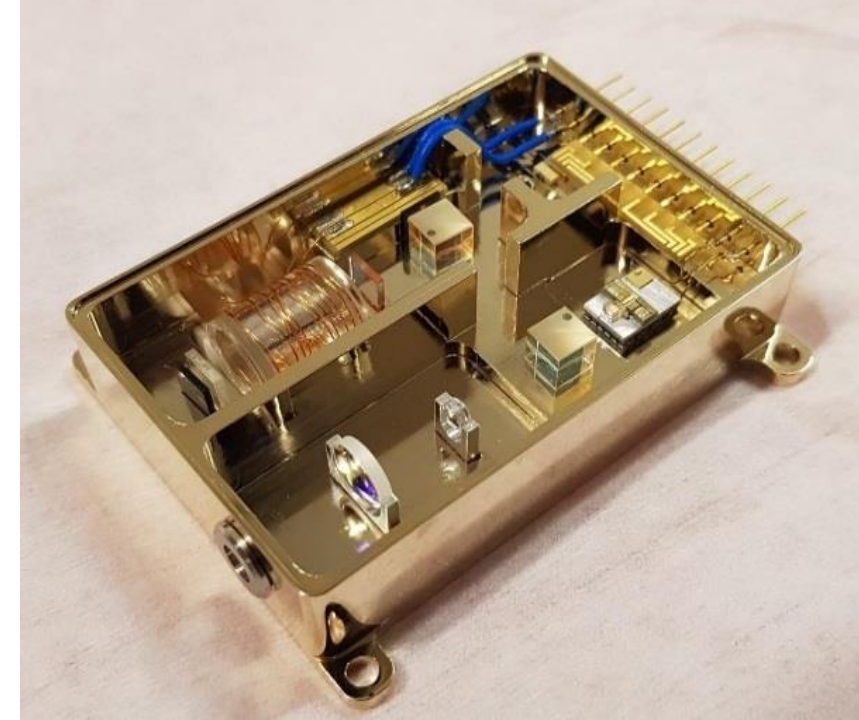
Narrow Linewidth SWaP-C Lasers are essential for Quantum Applications

- Laser cooling of atoms requires a number of laser sources.
- Narrow linewidths from $<1\text{MHz}$ - 500kHz down to Hz in some cases
- Wavelength stabilised to an atomic reference
- Real-world applications require robust, reliable, miniaturised, space-qualified, cost-reduced packaging of narrow-linewidth lasers



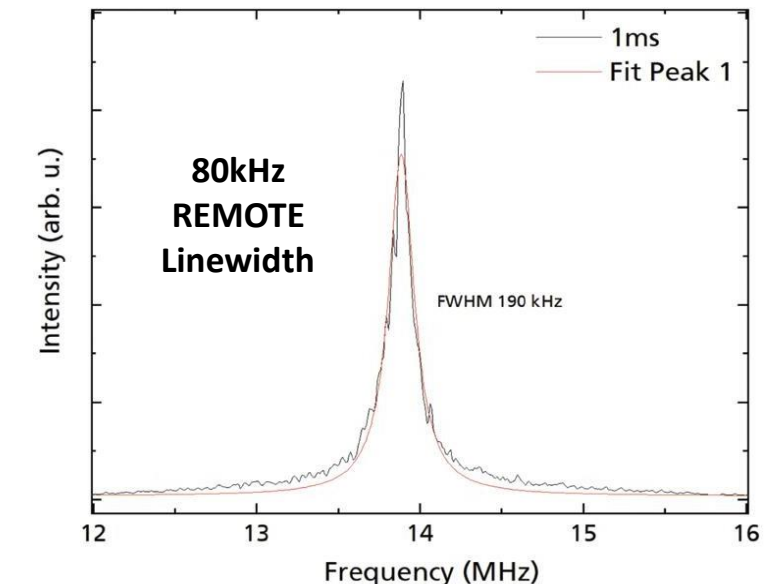
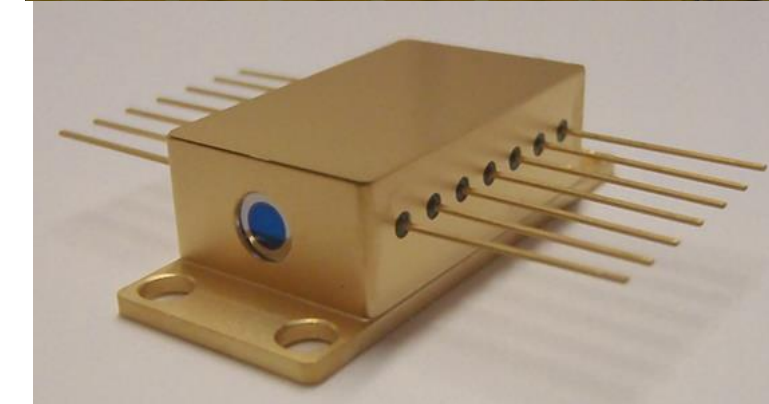
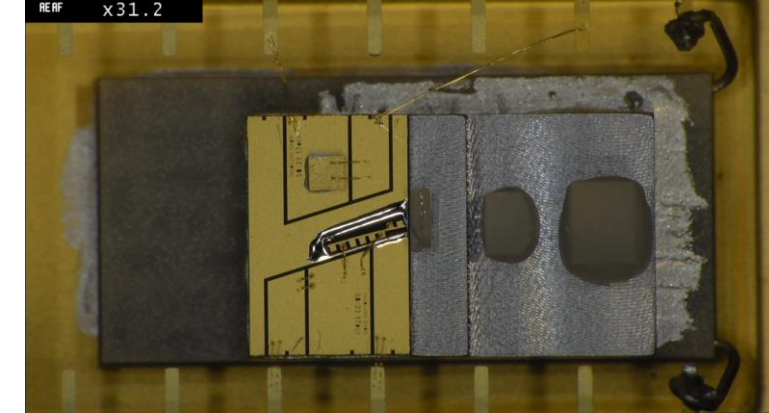
Optocap FLAME 780

- **Narrow Linewidth laser with integrated Rubidium atomic reference cell (852 with integrated Cs cell in development)**
- **780.24nm, <1MHz linewidth, >150mW**
- **SWaP-C optimised: only 60 x 40 x 16 mm³**
- **Cleanliness & low-outgassing:**
 - **Gold-coated components**
 - **flux-free soldering**
 - **low-outgassing space-qualified adhesives**
 - **proven cleaning techniques**
- **Maximise repeatability, minimise production time**
 - **Automated wire bonding**
 - **Pick & place alignment of many components minimise production time and maximise repeatability**



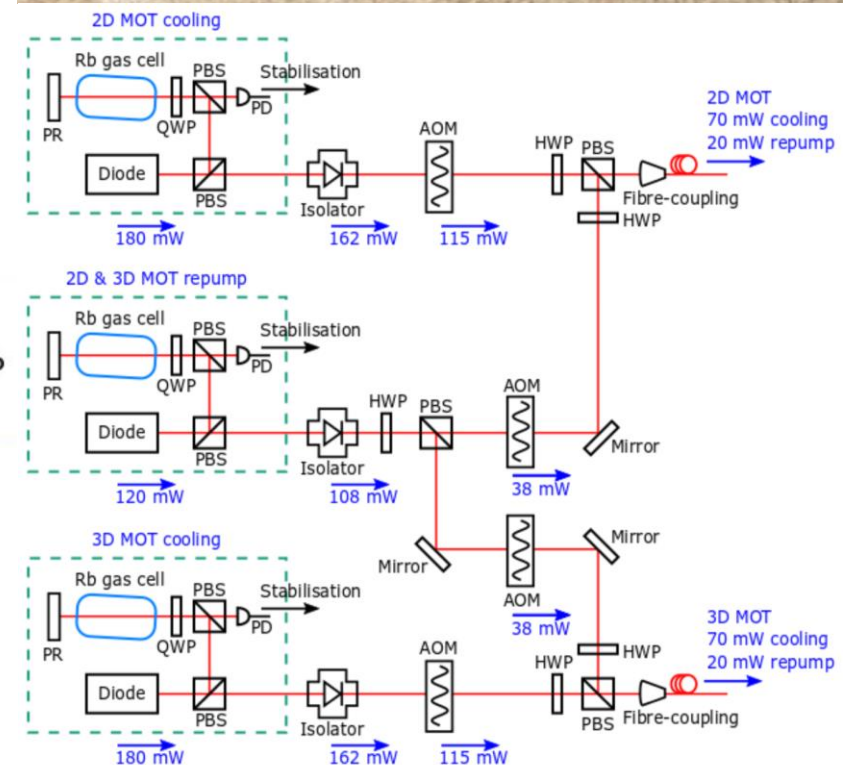
Optocap REMOTE 780

- **Narrow Linewidth laser**
- **780 nm, <100 kHz linewidth, >100mW**
- **SWaP-C optimised: only 30 x 12.7 x 8.9 mm³**
- **Cleanliness & low-outgassing:**
 - **Gold-coated components**
 - **flux-free soldering**
 - **low-outgassing space-qualified adhesives**
 - **proven cleaning techniques**
- **Maximise repeatability, minimise production time**
 - **Automated wire bonding**
 - **Pick & place alignment of many components minimise production time and maximise repeatability**



Optocap - Gravity Pioneer

- FLAME, REMOTE and amplifier modules to deliver a full functional system for a gravity gradiometer.
- Optocap extending FLAME, REMOTE and RAMPART system to provide robust and reliable laser cooling and interferometer Raman beam functions



Optocap - QUEST



Quantum Entangled Source for Quantum Communication

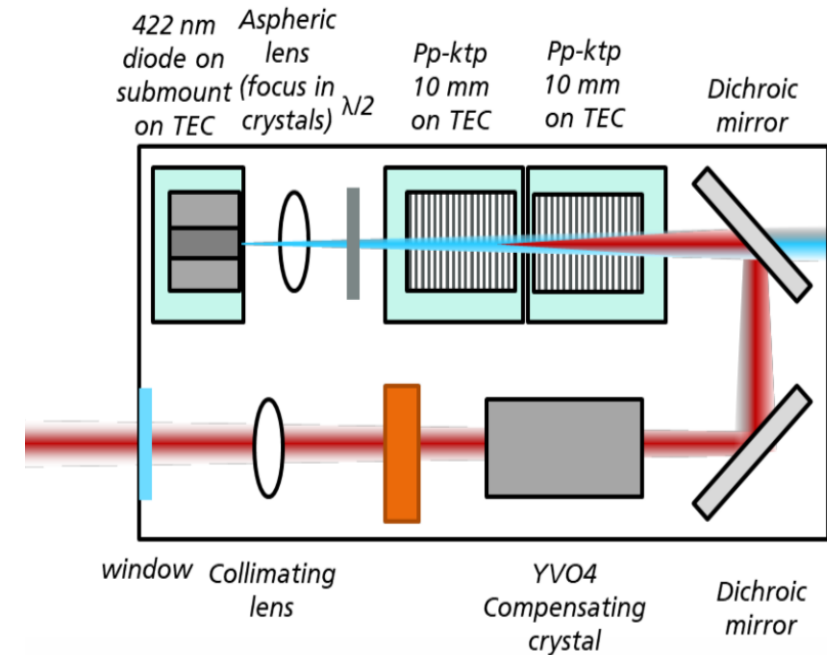
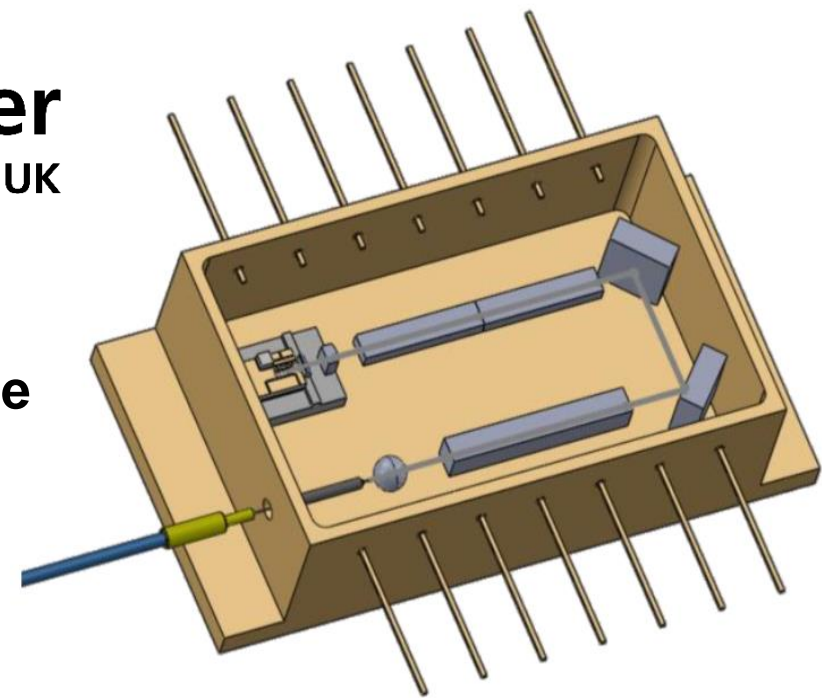
Quest-QKD is a feasibility study aimed at evaluating the potential of a device for the generation of entangled photons, targeting the emerging market of space quantum key distribution (QKD).

Partners:

- Optocap (Lead)
- Fraunhofer Centre for Applied Photonics

Optocap Responsibilities:

- Project management
- Component drawing set
- Component procurement and process development
- Assembly and testing of packaged source
- Final reporting and road-mapping



Optocap - Single Ion Microtraps

Atomic quantum technology experimentation & development

The use of microfabricated ion traps coupled with scalable entanglement techniques facilitate advances in atomic clocks and quantum processors.

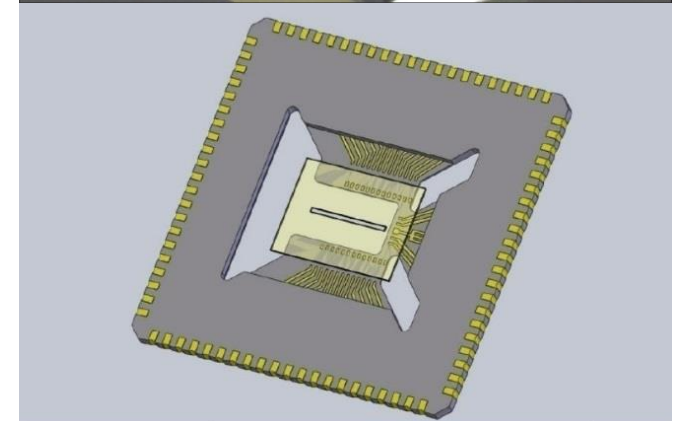
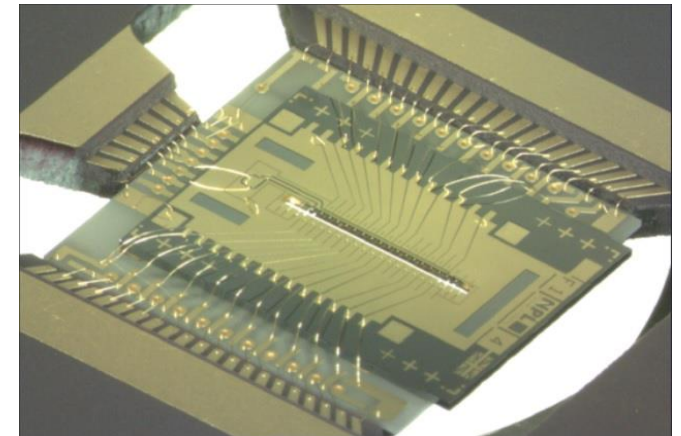
The aim of this development was to achieve a repeatable low cost, high volume design and repeatable sub-assembly process solution for a double sided MEMS ion trap devices for use in UHV (ultra high vacuum) applications

Partners:

- Optocap,
- NPL, (lead)
- Kelvin Nanotechnology

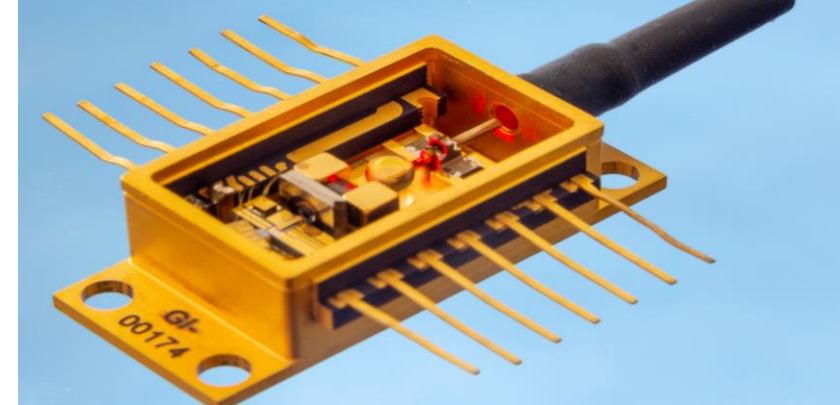
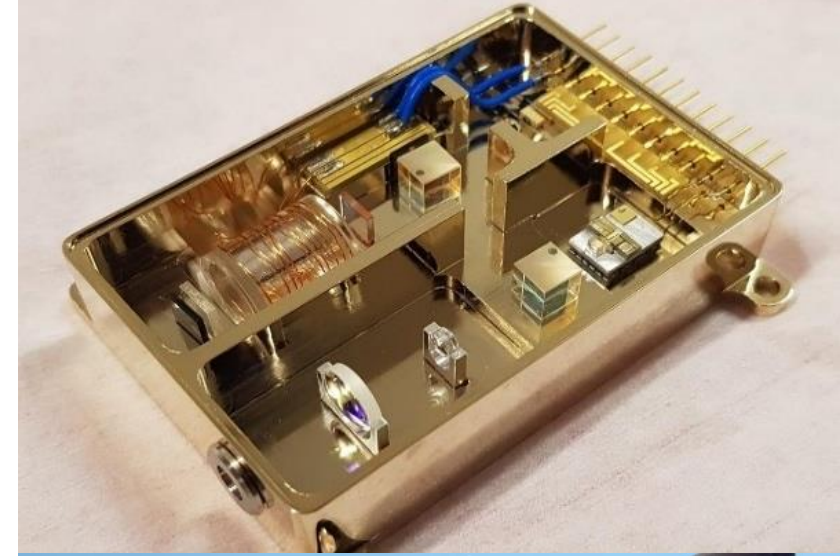
Optocap Responsibilities:

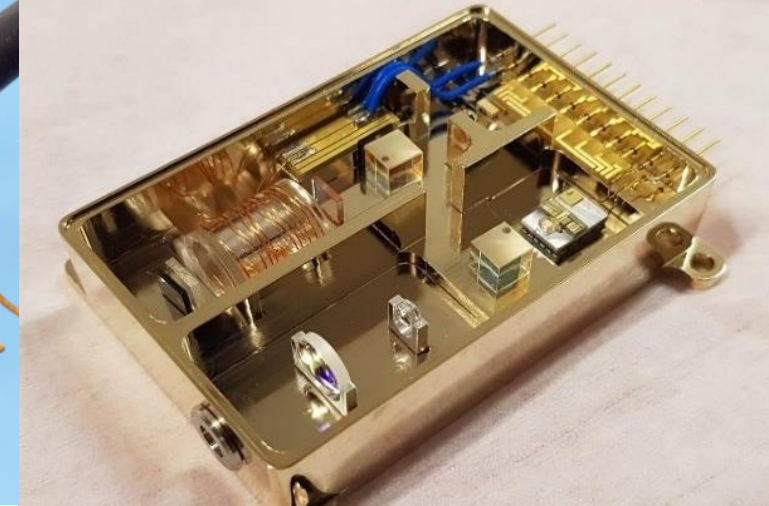
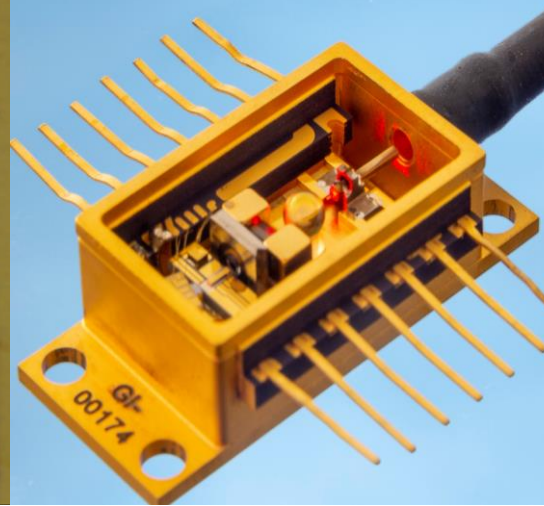
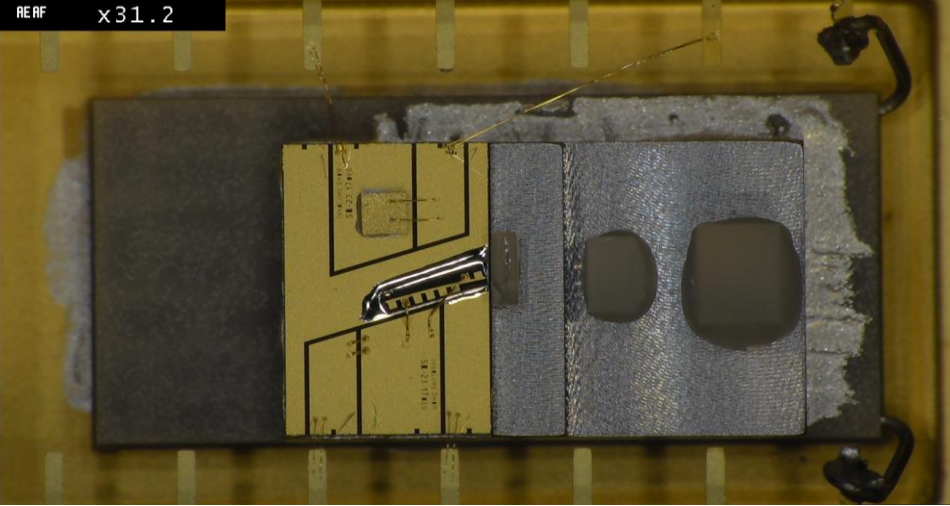
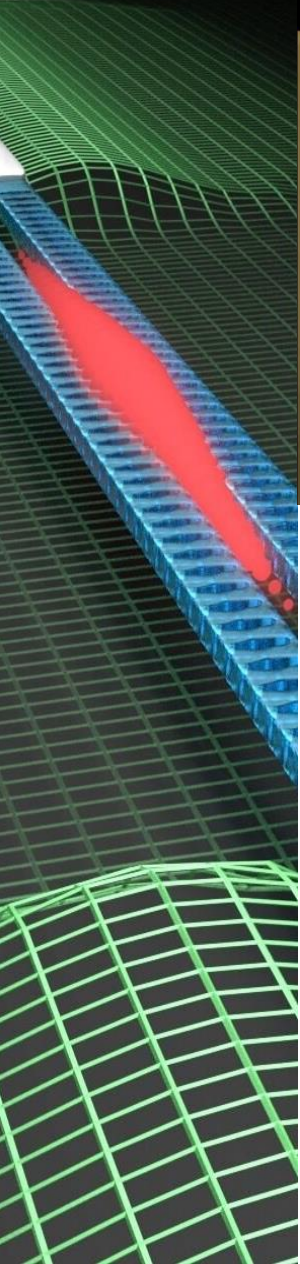
- Design and manufacture of a bespoke ITCC (Ion-Trap-Chip-Carrier) to hold a double sided MEMS silicon chip.
- Development of bespoke and scalable assembly processes
- Demonstrate confidence test data showing compliance to withstand UHV (ultra high vacuum) application requirements
- Materials analysis and procurement
- Pilot assembly of assembly solution



Optocap Conclusion

- **Optocap provides photonic and microelectronic packaging capabilities**
- **Experienced in qualified space, aerospace, telecoms ... devices**
- **Through funded QT projects we are continuing to develop our own product line of rugged / miniaturised narrow linewidth lasers for SWaP-C space ... applications**





- **What we can offer: package development to deliver demonstrator units to final products.**
- **What do we want: more blue diode chips – Yb, Ca, Sr Clock: 369, 397, 399, 421, 423. New methods for TA coupling to fibres ...**

THANK YOU

email: mark.day@Optocap.com / Website: www.optocap.com

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