



Evaluation and Space Qualification of laser diodes for ATV-Videometer and PHARAO projects

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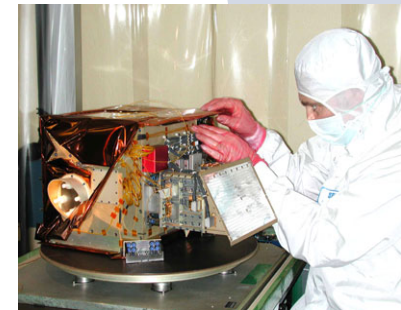
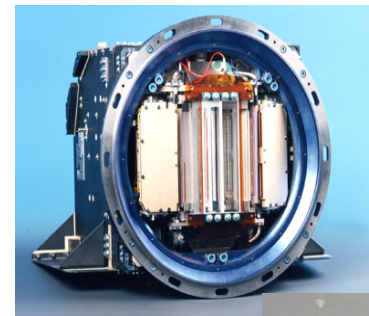
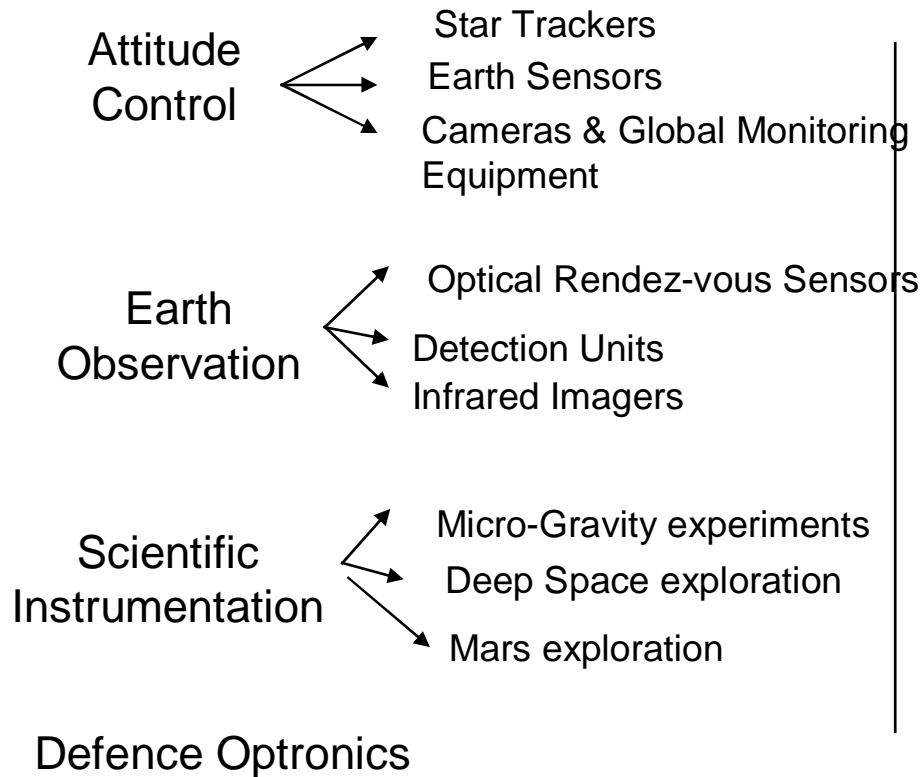
**Workshop Laser Diodes in Space
11-12 May 2006**

EADS SODERN



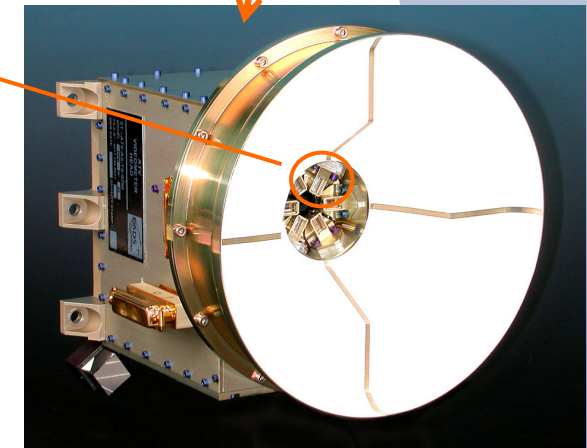
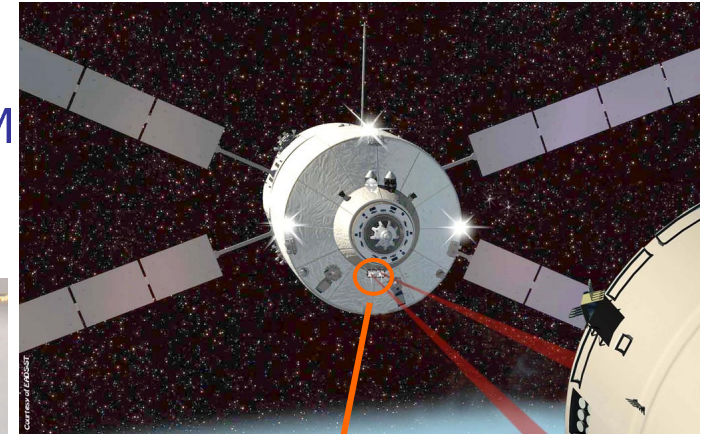
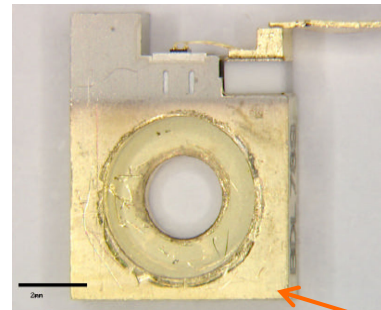
- **Created in 1962**
- **Shareholders :**
 - EADS Space Transportation 90%
 - AREVA (French Atomic Energy Agency) 10%
- **380 employees (out of which 270 hold engineering and technical degrees)**
- **Sales (FY 2005) €50 Millions**
- **Certified ISO 9001 (2000 version) in 2002**
- **Business Distribution :**
 - Space & Optics: 70%
 - Neutron : 30%

EADS-SODERN Space Activities



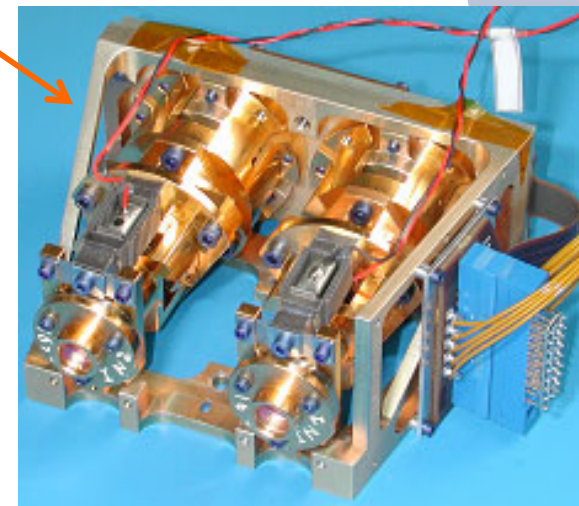
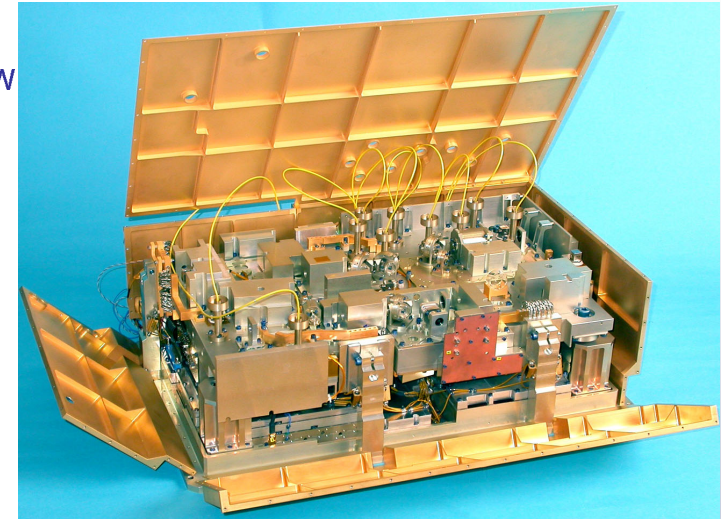
Laser Diodes Application : Videometer for ATV (European Automatic Transfer Vehicle)

- Optical “Rendez-Vous” sensor for the docking of the ATV to the ISS
- The laser diodes beams illuminate the Rendez-Vous Target (RVT) mounted on the ISS and composed of laser retro-reflectors. Reflected light towards the VDM is detected and analyzed
- 6 laser diodes per model
- Characteristics
 - ✓ Laser diode on submount
 - ✓ Fabry-Perot laser diode
 - ✓ AsGa/AlGaAs
 - ✓ 810nm
 - ✓ Multimode
 - ✓ 2W optical power
 - ✓ Modulated emission(10% DC maximum)
 - ✓ Au-Sn soldering
- Progress of the project
 - ✓ Laser diodes successfully qualified
 - ✓ Qualification model delivered
 - ✓ Flight models fabrication in progress



Laser Diodes Application: PHARAO atomic clock

- Scientific program under CNES contract
- Development of the laser diodes in charge of EADS-SODERN with the support of the CNES specialists (O. Gilard and G. Quadri)
- A cesium clock to fly aboard the ISS
- The Laser Source provides laser beams to perform
 - ✓ Optical capture
 - ✓ Selection of Cesium atoms
 - ✓ detection
- Laser diodes are used in Extended Cavity Laser Diode
- 8 laser diodes per model
- Characteristics
 - ✓ Fabry-Perot laser diode
 - ✓ AsGa/AlGaAs
 - ✓ 852nm
 - ✓ Monomode
 - ✓ 150mW optical power
 - ✓ Continuous emission
 - ✓ EM packaging : submount and Indium soldering
 - ✓ FM packaging : hermetic package and Au-Sn soldering
- Progress of the project
 - ✓ Engineering model delivered in March 2006
 - ✓ Up-screening and qualification of the Flight models laser diodes in progress



Context at the beginning of the projects

- For PHARAO/Videometer, as for other programs , EADS-SODERN has designed and made space equipments using commercial active/passive key components
- Use of commercial component may be a cost effective solution
- But, following aspects must be treated appropriately
 - ✓ Selection of the technology and the manufacturer
 - ✓ Evaluation of the space environment integrity
 - ✓ Screening and LAT to be performed on Flight Models
 - ✓ Implementation of Laser diodes (temperature, packaging, ...) in the equipment
- Laser diodes market
 - ✓ Small quantities (modest budget compared to telecom market)
 - ✓ No qualified components (space or Telcordia)

Description of the proposed approach

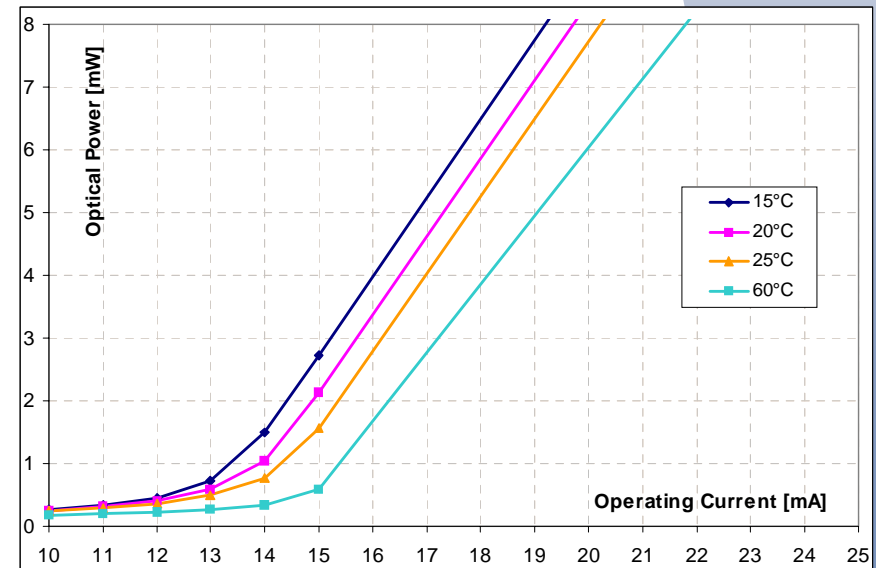
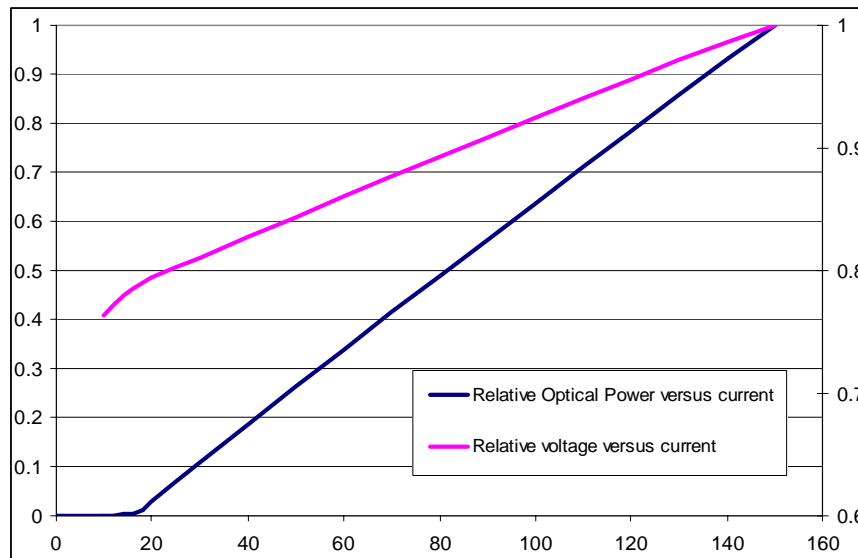
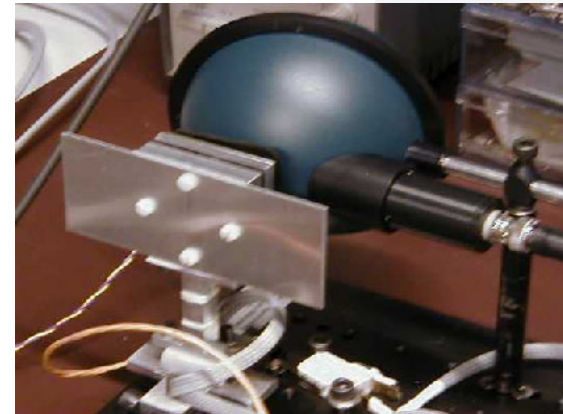
- Re-using expertise and know-how in component development plan
 - ⇒ Validation in different steps:
 1. Selection of appropriate manufacturers according to data-sheets (parameters, flexibility)
 2. Procurement of commercial devices from the different selected manufacturers
(2 for ATV-Videometer)
 3. Pre-Evaluation (Environments and E/O tests) ⇒ select a manufacturer
 4. Evaluation of the selected manufacturer
 - ⇒ validation of the manufacturer and the possible use of this device for space application
 - ⇒ Taking into consideration for the system the results of E/O performances in operating conditions
 - ⇒ Define the screening and LAT to be performed
 5. Procurement of Flight Models Laser diodes (same production lot)
 6. Up-screening
 7. Lot Acceptance Tests (similar to Evaluations Tests)

E/O Characterizations performed (I)

- Development of specific test benches for E/O characterizations
 - ✓ Optical power
 - ✓ Voltage
 - ✓ Emission Spectrum
 - ✓ Farfield pattern
- Development of specific test benches for environmental tests
- Adaptation of the E/O according to the project needs
 - ✓ Temperature (wavelength shift)
 - ✓ Continuous or modulated current
 - ✓ Stability of the farfield

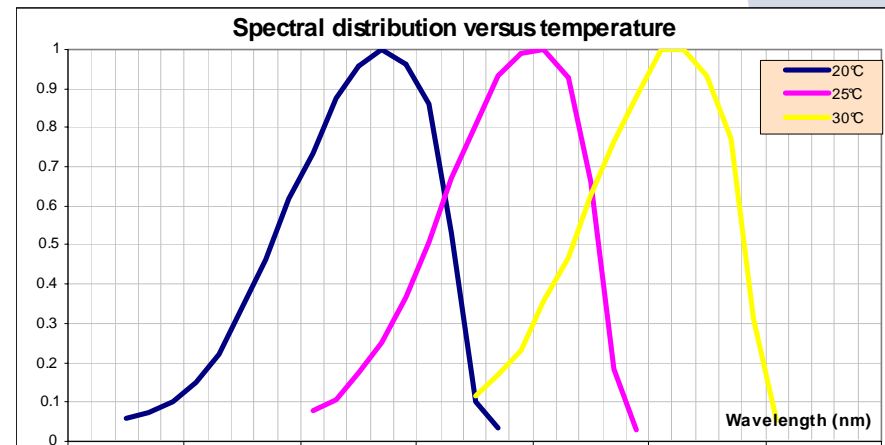
E/O Characterizations performed (II)

- Characterizations of the Optical power and Voltage
 - ✓ Versus current, temperature, modulations
 - ✓ Important drift of the threshold current versus t°



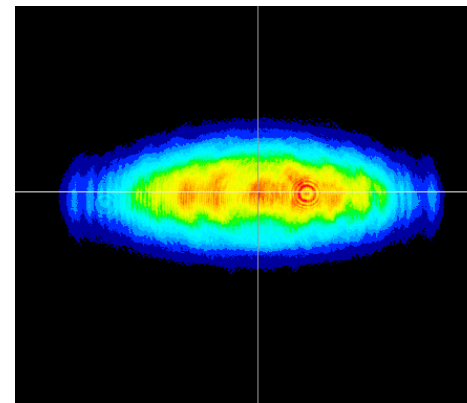
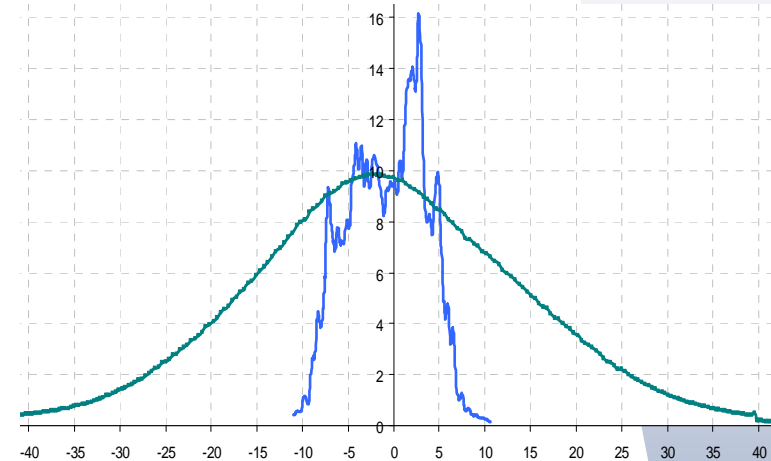
E/O Characterizations performed (III)

- Characterizations of the emission spectrum
 - ✓ Versus current, temperature, modulations
 - ✓ Important drift of the wavelength versus these parameters
 - ✓ $\sim 0.3\text{nm}/^\circ\text{C}$ measured, in accordance with the AsGa material

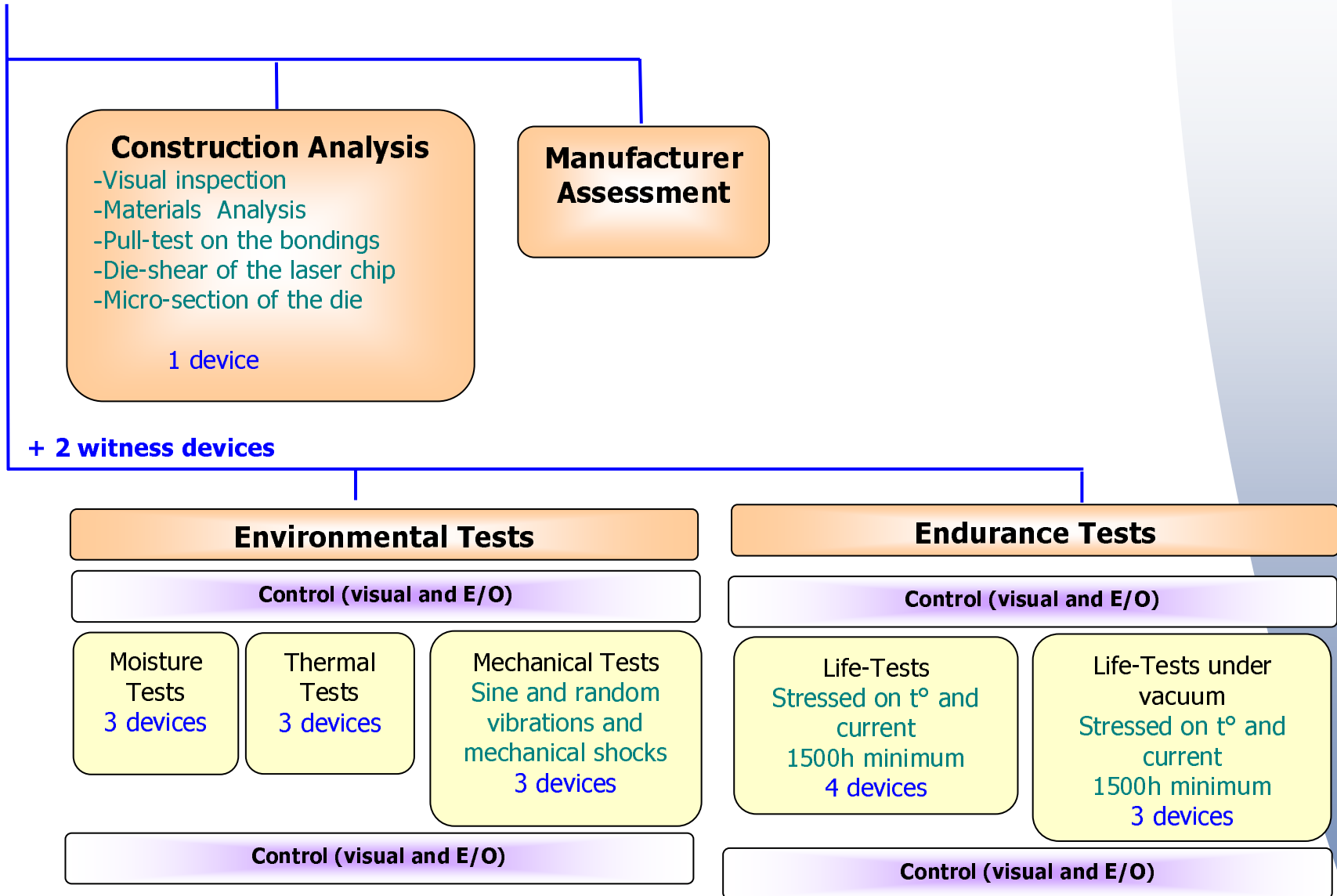


- Characterizations of the farfield pattern
 - ✓ For multimode laser diodes
 - Absolute intensity in the 2 axes: parallel and perpendicular to the junction
 - versus current and temperature
 - And characterizations of the temporal stability

 - ✓ For monomode laser diodes
 - Cartography of the diodes

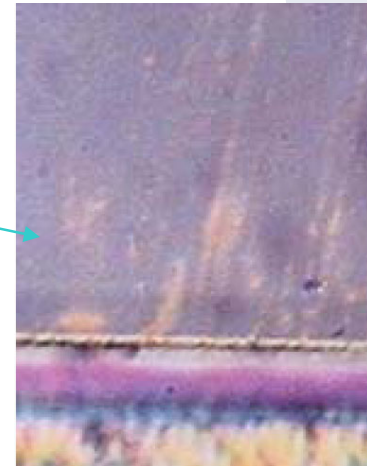


Evaluation Flowchart



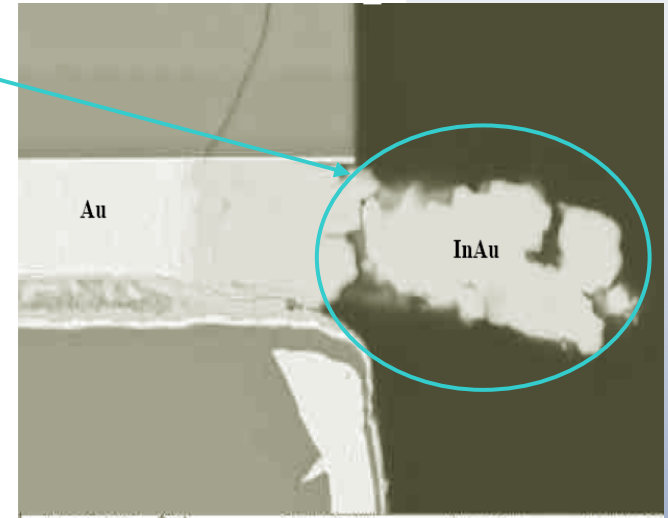
Control during tests

- E/O characterizations to check any drift
- Visual inspection of the die in particular the critical area which surround the active area
 - ✓ Discoloration
 - ✓ Contamination
 - ✓ Mirror coating defect
 - ✓ COD (Catastrophic Optical Damage)
 - ✓ Striation



Failure observed : soldering defect

- In Soldering defect
 - ✓ Observed specially on 1/3 procurement lot of monomode laser diodes after thermal vacuum
 - ✓ Overflow of the soldering with of In-Au intermetallic
 - ✓ Chipouts



- No problem noticed with Au-Sn soldering
- ⇒ **EADS-SODERN suggests to use Au-Sn soldering** instead of In soldering for space applications

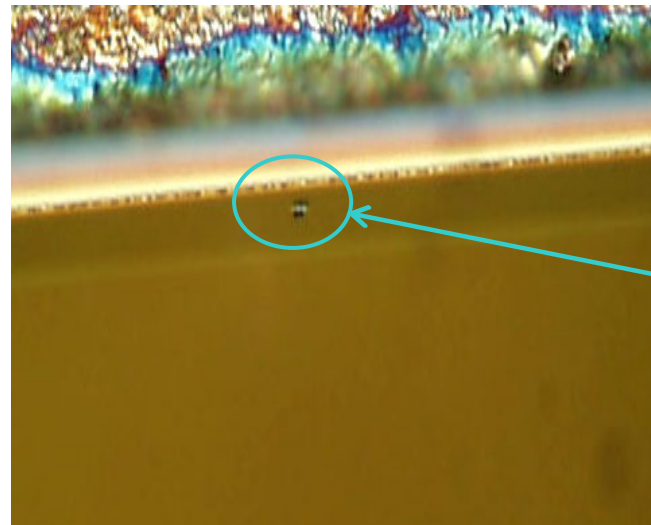
Failure observed: PIF (I)

- Package Induced Failure (=PIF)

In presence of **organic compounds** closed to the laser and in **lack of oxygen** and when the diode are in **operating mode**

⇒ **carbon deposition** in the active area

- ✓ At the beginning, few deposition ⇒ no evolution of the Power and Voltage
- ✓ Then, increase of the deposition ⇒ thermal runaway
- ✓ Up to the COD (Catastrophic Optical Damage) limit ⇒ instantaneously loss important of optical power (70% minimum) up to fluorescence



Defect in the active area

Failure observed: PIF (II)

- PIF was experimented by EADS-SODERN on the two types of laser diodes
 - ✓ monomode 852nm 150mW
 - ✓ multimode 810nm 2W
- See even at ambient temperature
- Duration without failure dependant of the tests conditions: could be in less than 100h
- Dependant of different factors
 - ✓ **Optical power density:** current, temperature and modulation
 - ✓ **Packaging:** organic compounds
 - ✓ Oxygen partial pressure
- A process of **regeneration under air** was **successfully** tested
 - ✓ Sequence of operating cycles under secondary vacuum then operating cycles under air to remove the deposition

Failure observed: PIF (III)

- To prevent PIF, EADS-SODERN suggests to evaluate laser diodes in the **conditions as close as possible to the flight model conditions**
 - ✓ **optical power density** (current, temperature, modulation)
 - ✓ pressure
 - ✓ **packaging**
 - ✓ during more than 1000 hours
- In case of non compatibility of the diodes in the conditions of the program under vacuum, the solution is to use or develop a specific hermetic package

- Overview of PHARAO and Videometer projects
 - ✓ Videometer : flight models in progress
 - ✓ PHARAO Source Laser: Engineering Model delivered
- Capability of laser diodes proved for space applications
- Concern of the vacuum sensitivity to be taken into consideration
- Large scale of possible missions
 - ✓ Lateral sensor for formation flights