



# ***Qualification status of photonics parts for Quantum Applications***

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## Why photonics?

- Almost **unlimited bandwidth**
- **Reduced propagation losses**
- **Immunity against electromagnetic interference**
- **Optimum mechanical properties**

## Reliability considerations



### Mechanical

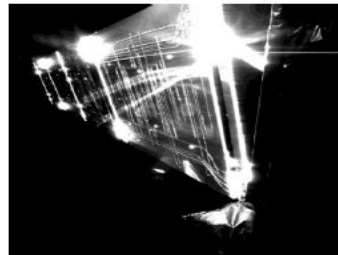
- vibration
- Pyro-shock

### Thermal

- Large temperature variations

### 15-20 years service life

- No maintenance
- Guarantee of end of life performance

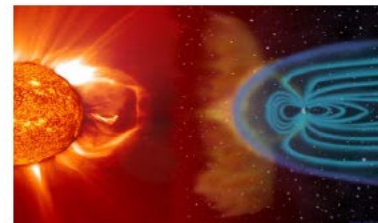


### Vacuum

- Outgassing
- Contamination
- Packaging

### Space radiation

- Displacement damage
- TID
- Charging due to interaction with charged particles



## ESA QUALIFIED PARTS LIST

<https://escies.org/download/webDocumentFile?id=64928>

**Section 18**

**Component Type: Optoelectronics**

Sub-Section	Page No.	Cert.	Type Designation	Manufacturer
			Currently there are no qualified sources of Optoelectronics	

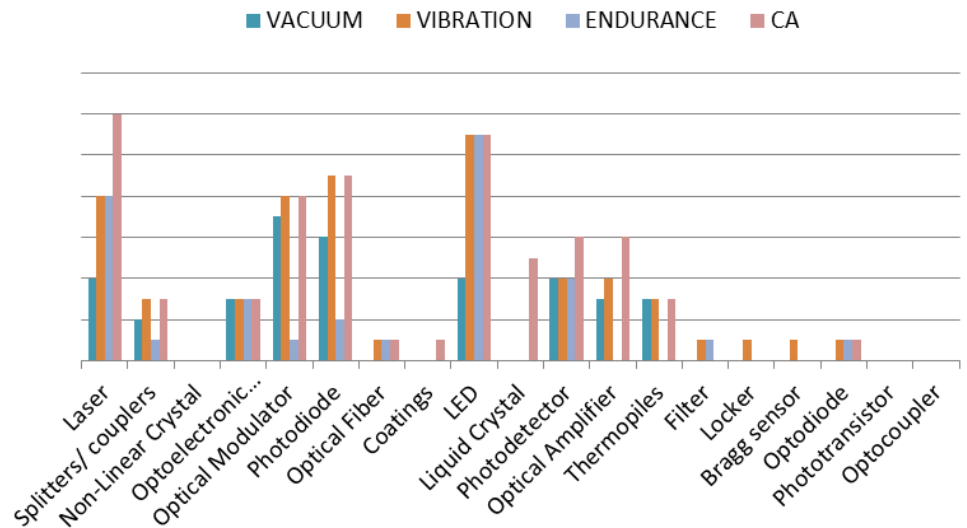
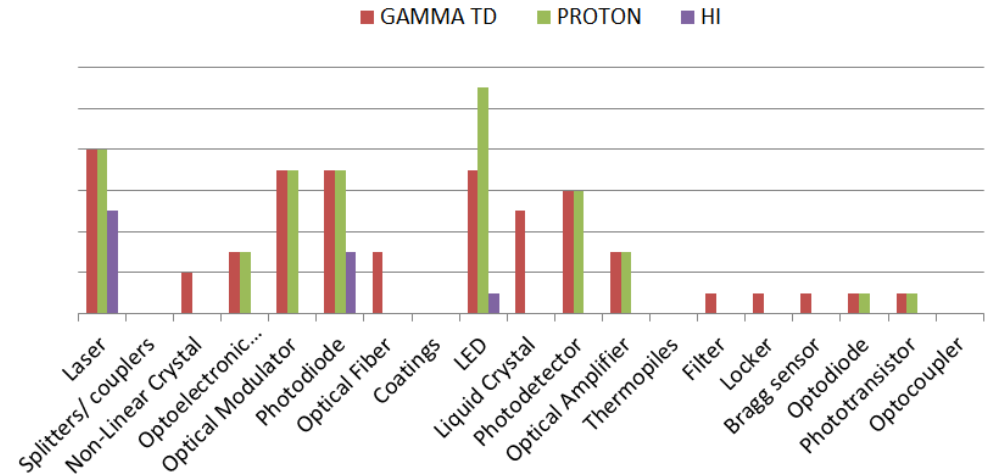
# ATN EXPERIENCE IN OPTOELECTRONICS



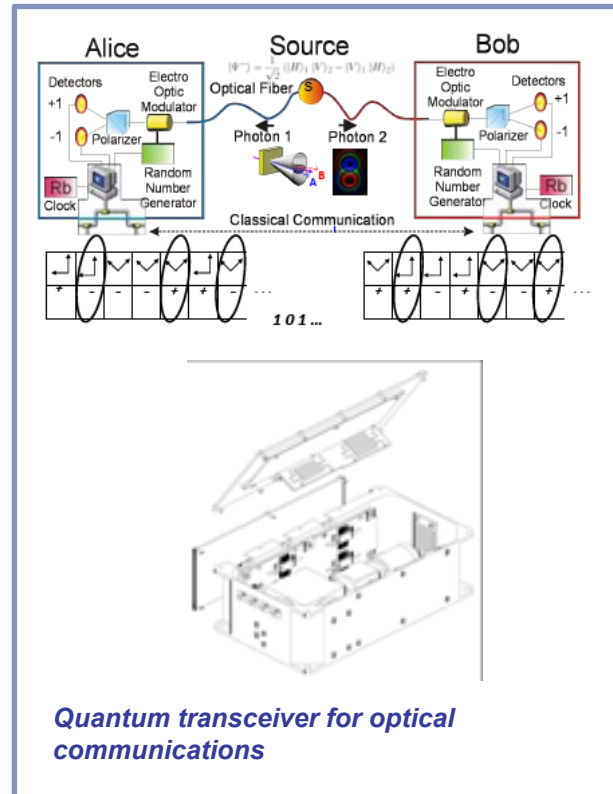
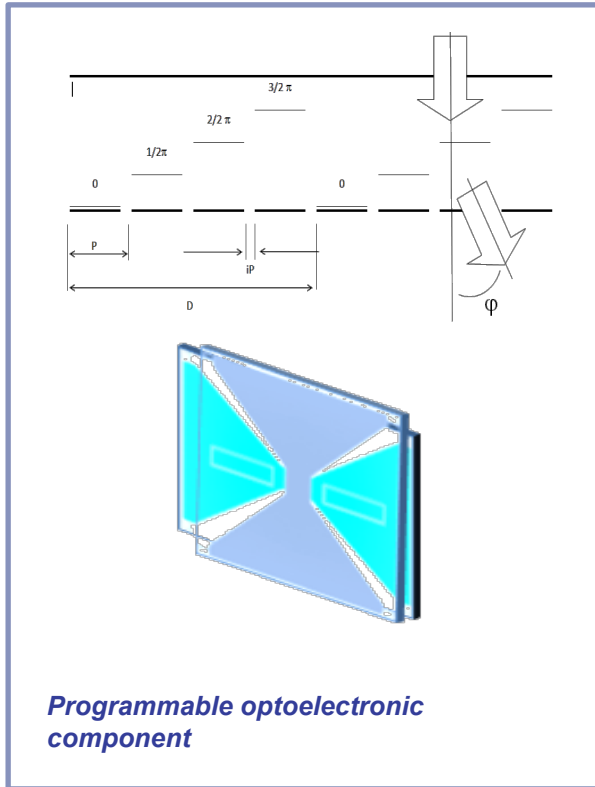
*ALTER TECHNOLOGY GROUP has gathered a large experience and knowhow in optical and reliability packaging & testing on photonics parts covering the full range of different technologies.*

## Range of optoelectronics and photonics parts:

- Laser & Leds 250 to 5000 nm.
- Receivers modules (180 to 11000 nm).
- Optical Amplifiers & Optical modulators
- Switches and splitters.
- MOEMS
- Optocouplers & Photodiodes
- Multimode and monomode Fibers
- Liquid Crystal Devices
- Image Sensors
- Optical Transceivers



# SOME REFERENCE PROJECTS



# Tested Components

## Optical Amplifiers

- EDFA
- SOA

## Optical Modulators

- Lithium Niobate

## Optical Switches

## WDM

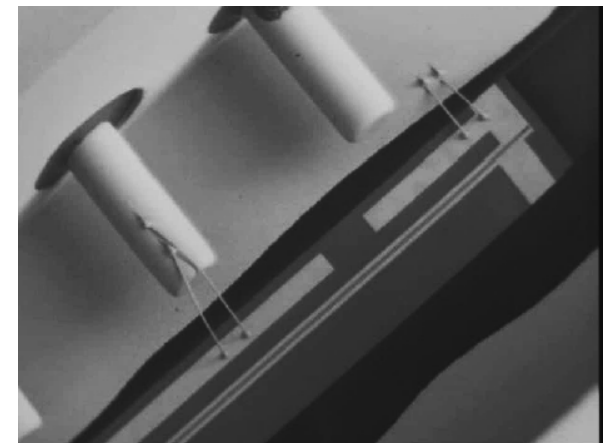
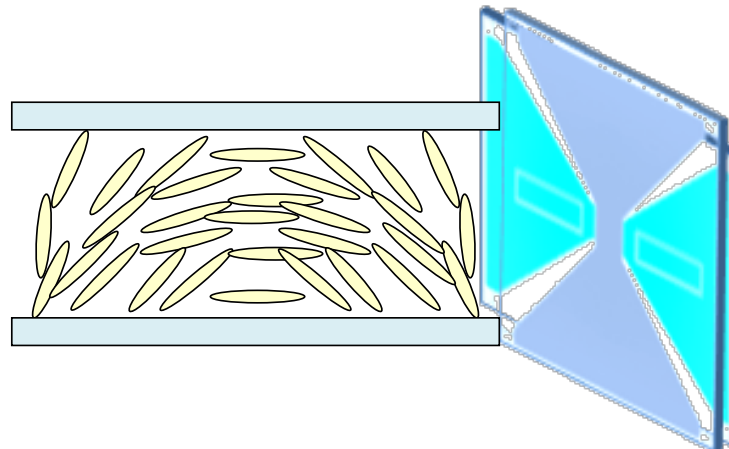
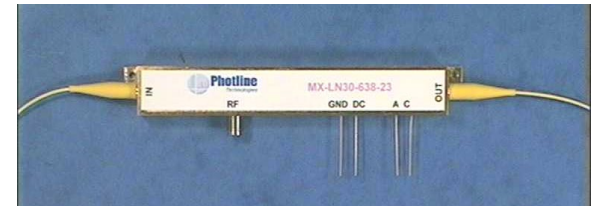
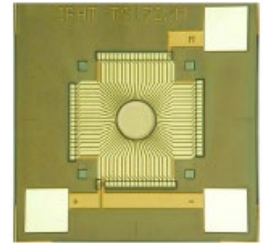
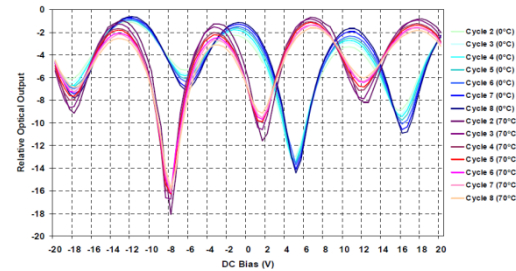
## Programmable Optical Elements

- Liquid Crystals

## Thermopiles

## Filters

## Coatings



# EXAMPLE OF TEST RESULTS

Laser Modulight			
Critical parameters	TEST		Measured Parameters
Optical spectrum, $I_{th}$ , P, $V_{ld}$	Optical Performance		Optical Spectrum I-P, I-V responses
	Lifetime (Monitoring Optical Output Power at I=120mA)	168H	Optical Spectrum I-P, I-V responses
		500H	Optical Spectrum I-P, I-V responses
		1000H	Optical Spectrum I-P, I-V responses
		2000H	Optical Spectrum I-P, I-V responses
	Thermal Vacuum (Monitoring Optical Output Power at I=120mA)		Optical Spectrum I-P response I-V response
	Proton Irradiation	Initial	Optical Spectrum I-P, I-V
		Step 1	I-P, I-V
		Final	I-P, I-V
	Gamma Irradiation	Initial	I-P, I-V
		10KRAD	I-P, I-V
		40KRAD	I-P, I-V
		80KRAD	I-P, I-V
		110KRAD	I-P, I-V
		140KRAD	I-P, I-V
		180KRAD	Optical Spectrum I-P, I-V
Vibration	Sine	Optical Spectrum	
	Random	I-P, I-V	

# EXAMPLE OF TEST RESULTS

## NICHIA LDs results after Lifetime and thermal vacuum

	Results	Max Wavelength (nm)	Variation	Output Power (W) (IF=120mA)	Variation	Laser Voltage (V) (IF=120mA)	Variation
Nichia #95	Initial	405.1		0.070593		4.785159	
Nichia #95	After 500h LifeTest	405.1	0.00%	0.068547	-2.90%	4.478447	-6.41%
Nichia #95	After 1000h LifeTest	405.4	0.07%	0.068002	-3.67%	4.539122	-5.14%
Nichia #95	After 2000h LifeTest	405.4	0.07%	0.060838	-13.82%	4.792459	0.15%
Nichia #98	Initial	405.6		0.068017		4.646776	
Nichia #98	After 500h LifeTest	405.9	0.07%	0.067336	-1.00%	4.680439	0.72%
Nichia #98	After 1000h LifeTest	405.9	0.07%	0.064545	-5.10%	4.751692	2.26%
Nichia #98	After 2000h LifeTest	405.9	0.07%	0.060767	-10.66%	4.656412	0.21%
Nichia #91	Initial	405.1		0.068269		4.675349	
Nichia #91	After Thermal Vacuum	405.9	0.20%	0.062310	-8.73%	4.629806	-0.97%

**Test Conditions:  $I_{op} = 120\text{mA}$  and  $T=70^{\circ}\text{C}(1000\text{h})$  and  $T=60^{\circ}\text{C}(1000\text{h})$**

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# EXAMPLE OF TEST RESULTS

## Optical Output fluctuation during thermal vacuum for NICHIA LDs

	Test	Optical Output Variation(%)
Nichia #91	Initial	
Nichia #91	After 25cycles	-11.24
Nichia #100	Initial	
Nichia #100	After 15cycles	-10.56

	Results	Optical Output Ripple (%)
Nichia #91	1st cycle (-10°C)	
Nichia #91	1st cycle (60°C)	-8.00%
Nichia #91	7th cycle(-10°C)	
Nichia #91	7th cycle(60°C)	-7.78%
Nichia #91	14th cycle(-10°C)	
Nichia #91	14th cycle(60°C)	-7.11%
Nichia #91	21st cycle(-10°C)	
Nichia #91	21st cycle(60°C)	-7.41%
Nichia #100	1st cycle(-10°C)	
Nichia #100	1st cycle(60°C)	-10.36%
Nichia #100	7th cycle(-10°C)	
Nichia #100	7th cycle(60°C)	6.82%
Nichia #100	14th cycle(-10°C)	
Nichia #100	14th cycle(60°C)	-10.60%

# EXAMPLE OF TEST RESULTS

## Optical Output fluctuation during gamma and proton Irradiation for NICHIA LDs

	Results	Output Power (W) (IF=120mA)	Variation
		<b>PROTON IRRADIATION</b>	
Nichia #2	Initial	0.068525	
Nichia #2	Step 1 Proton Irradiation	0.069010	0.71%
Nichia #2	Step 2 Proton Irradiation	0.068961	0.64%
		<b>GAMMA IRRADIATION</b>	
Nichia #2	Initial	0.068900	
Nichia #2	10 kRad Gamma	0.068596	-0.44%
Nichia #2	40 kRad Gamma	0.069555	0.95%
Nichia #2	80 kRad Gamma	0.070270	1.99%
Nichia #2	110 kRad Gamma	0.066486	-3.50%
Nichia #2	140 kRad Gamma	0.068705	-0.28%
Nichia #2	180 kRad Gamma	0.066643	-3.28%
Nichia #2	Annealing 24hrs	0.067298	-2.33%
		<b>PROTON IRRADIATION</b>	
Nichia #3	Initial	0.067500	
Nichia #3	Step 1 Proton Irradiation	0.068661	1.72%
Nichia #3	Step 2 Proton Irradiation	0.068372	1.29%
		<b>GAMMA IRRADIATION</b>	
Nichia #3	Initial	0.069528	
Nichia #3	10 kRad Gamma	0.066873	-3.82%
Nichia #3	40 kRad Gamma	0.067107	-3.48%
Nichia #3	80 kRad Gamma	0.067110	-3.48%
Nichia #3	110 kRad Gamma	0.069265	-0.38%
Nichia #3	140 kRad Gamma	0.067952	-2.27%
Nichia #3	180 kRad Gamma	0.068558	-1.40%
Nichia #3	Annealing 24hrs	0.070668	1.64%

- Small variations are due to lack of TEC during measurements

- There is not significant  $I_{th}$  displacements after either gamma irradiation or proton irradiation

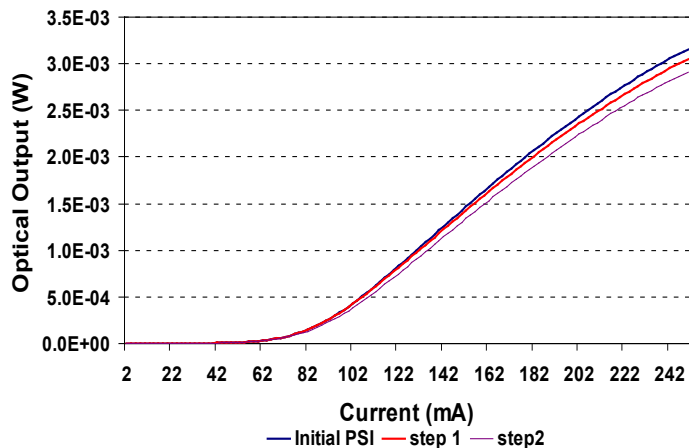
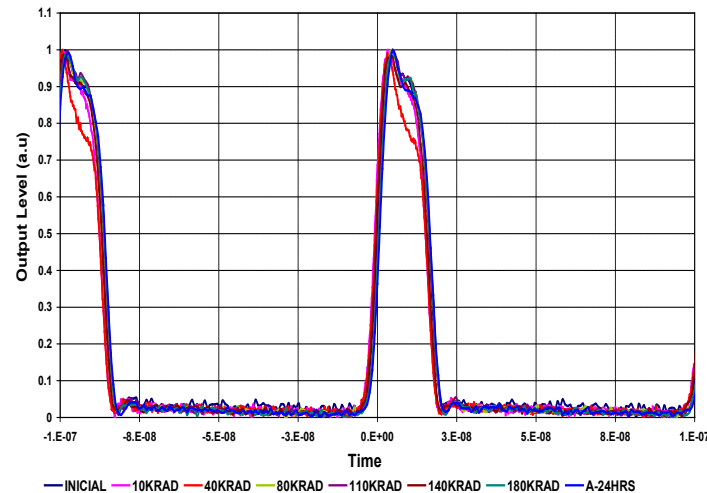
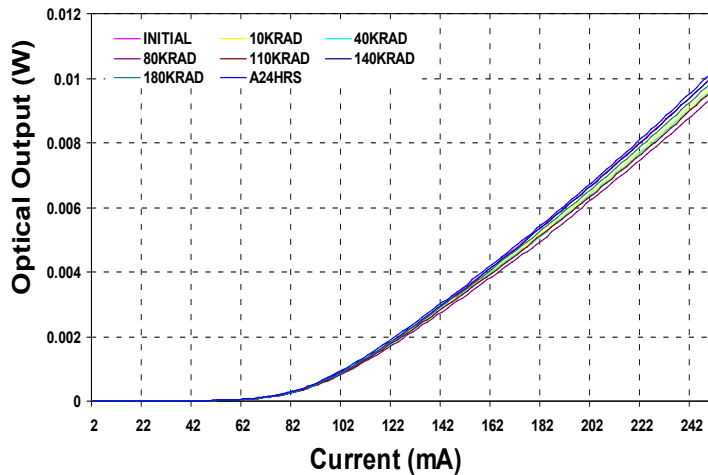
## NICHIA LDs GENERAL CONCLUSIONS

- External Inspection and constructional analysis tests passed in all samples
- **Some degradation was observed in both samples during thermal vacuum cycles. In-situ optical output power decreased 10.5% after 15 cycles for one sample and 11.2% after 25 cycles for the second sample.**
- Samples withstood lifetime test without any noticeable decrease in their functional performance after 1000H.
- There was a considerable  $I_{th}$  displacement of 7mA approx for both samples after 2000H. It was also reflected in the optical output power with a maximum decrease of 14% with respect to their initial value.
- Both samples withstood the proton irradiation total dose and gamma irradiation total dose.
- **AS LASER NICHIA IS WORKING AT  $21^{\circ}\pm 4^{\circ}\text{C}$  SHOULD WITHSTAND PROJECT REQUIREMENTS CONDITIONS**

# EXAMPLE OF TEST RESULTS

## SOA: QPHOTONICS

### Gamma Test 180Krad operating & non operating

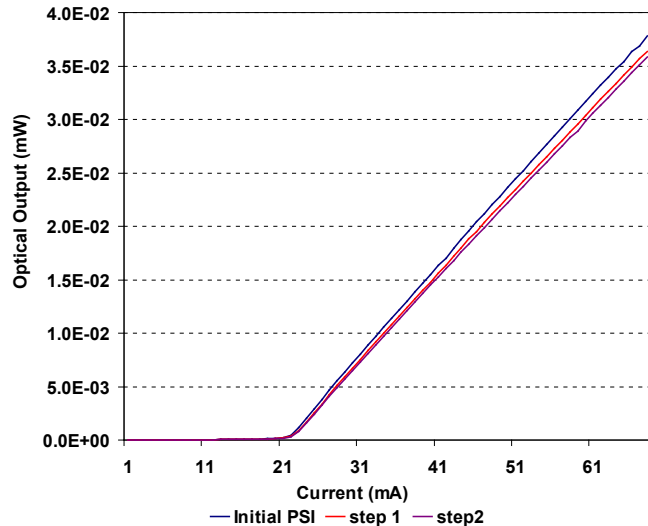
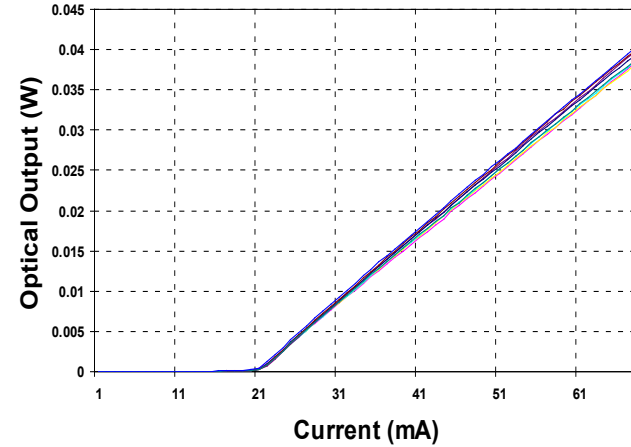
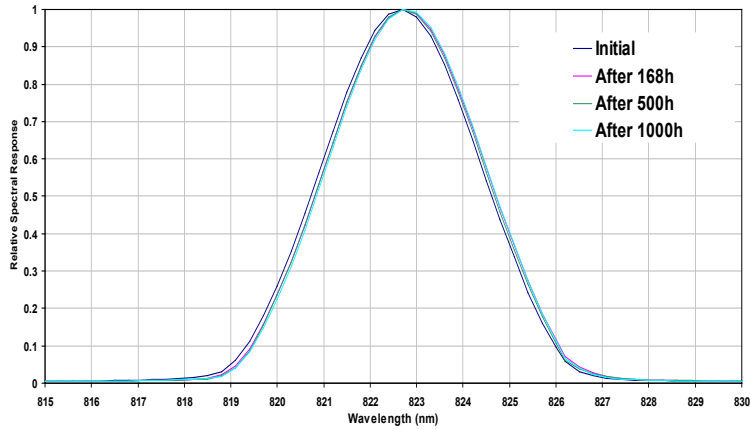


Proton Irradiation  
65MeV Total Fluence:  $2 \times 10^{10}$  p/cm<sup>2</sup>;  
Steps of ;  $5 \times 10^9$  and  $1.5 \times 10^{10}$  p/cm<sup>2</sup>

# EXAMPLE OF TEST RESULTS

## Laser Modulight

Modulight SN 426901 Evolution with Thermal Cycles  
Relative Spectral Response



**Proton Irradiation**  
65MeV Total Fluence:  $2 \times 10^{10}$  p/cm<sup>2</sup>; Steps  
of ;  $5 \times 10^9$  and  $1.5 \times 10^{10}$  p/cm<sup>2</sup>

*Number of tested technologies: > 500 from > 50 manufacturers*

- *Full Characterization at max / min temp*
- *Step Stress Test*
- *Radiation Tests*
  - Gamma, Protons & Heavy Ions*
- *Endurance*
  - 1000 / 2000 hours in max operating conditions with continuous monitoring*
- *Thermal & Thermal Vacuum*
  - Max & Min application temp + 10°C safety margin. Vacuum level down to 10-6mm*
- *Mechanical*
  - Mechanical Shock*
  - Sine & Random Vibration*
- *Constructional Analysis*

- *Full in-house capabilities*
- *Manufacturers assessment as well as procurement and follow-up*

***Thank you***  
***for your attention***

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