



**iXblue Photonics
Space Activities**

Introduction

iXBlue Photonics develops and produces

- **Optical LiNbO3 modulators** showing high reliability regarding space qualification : radiation, vibration, vacuum, lifetime, ageing, thermal cycling
- **RadHard fibers** specially designed and manufactured to hold high level of space radiation

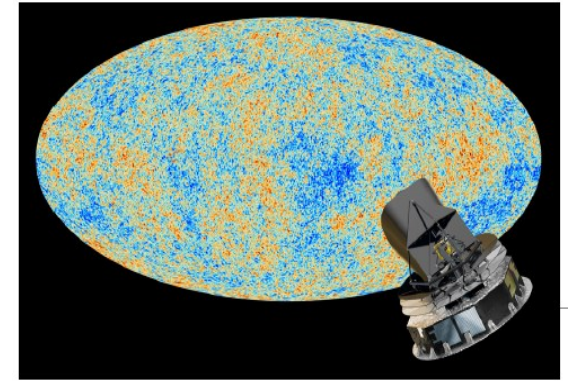
The **Photline*** Optical pulse space qualified modulators series and **iXfiber*** radhard optical fibers are dedicated to space application for communication, science, microwave signal processing...

**An iXblue brand*



iXFiber: Space compatible radiation hardened active fibers

- iXFiber has a strong space experience
- 20 flying navigation systems equipped
- Passive and Active fibers dedicated to space
- Fibers are designed to be used in embarked space optical amplifiers and fiber lasers
- Very low radiation sensitivity
- Fiber compatible with high cumulated irradiation doses



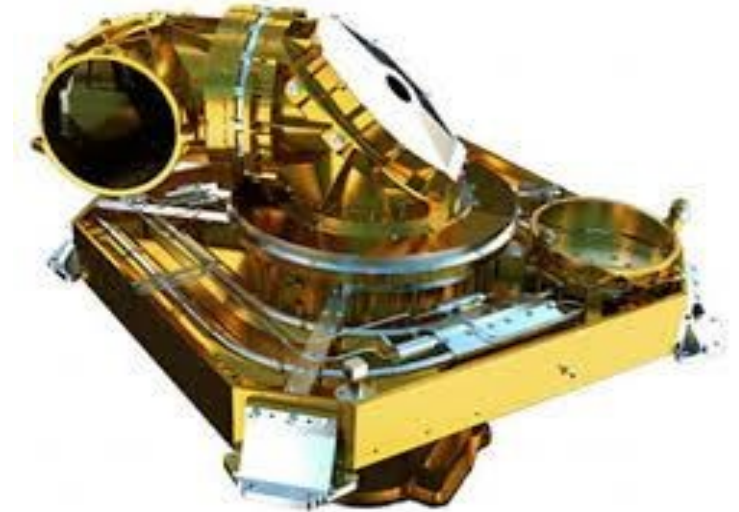
Fiber optic gyroscopes

- Application:
 - navigation, precision positioning
 - Photline customer: iXSpace (iXBlue group)
- End user: Airbus S&D (ex-Astrium) for Astrix IMU
- Technology
 - 3-4 x LN Y-junction phase modulators chips per unit
 - X-cut lithium niobate and APE process
 - wavelength: 1530 nm
 - low frequency: <100 MHz
- Quantities
 - about 200 hundred chips over 3 years program
 - as of today 101 axis delivered with 40 axis already launched and operating (satellites : PLANCK, PLEIADES, GAIA, GALILEO, ASTROTERRA, SOLO, MTG, AEOLUS, COMS)



Inter-satellites communications

- Application:
 - Laser Communication Terminals for LEO-GEO
 - Mission: Sentinel 1a and Sentinel 2a, and on the GEO satellite Alphasat
- Photline customer: TESAT for its LCT-series products
- Technology
 - each LCT requires 1 x NIR-MX-LN Amplitude and 1 x NIR-MPX-LN Phase modulator
 - X-cut lithium niobate and APE process
 - wavelength: 1060 nm
 - medium frequency < 5 GHz



On-board Laser cavity stabilization

- Application:
 - Laser cavity stabilization
 - Mission: GRACE 2, earth gravity cartography
- Photline customer: JPL-NASA
- Technology
 - 1 x NIR-MPX-LN Phase modulator per satellite (total: 2)
 - X-cut lithium niobate and APE process
 - wavelength: 1060 nm
 - low frequency: 100 MHz



Inter-satellites communications

- Application:
 - Laser Communication Terminals for LEO-GEO
- iXblue customer: NEC for its LCT-series products
- Technology
 - each LCT requires Amplitude modulator
 - X-cut lithium niobate and Ti:Diffusion process
 - wavelength: 1550 nm
 - medium frequency < 5 GHz

NEC



Microwave photonic payload sub-systems (project)

- Application: Analog modulation
 - generation of microwave Local Oscillators,
 - photonic RF frequency up and down conversion,
 - routing of microwave signals in repeaters,
 - antenna sub-systems and beam forming networks,
 - optical sampling for analogue digital conversion.
- Technology
 - low loss and low driving voltage intensity modulator
 - X-cut lithium niobate and Titanium indiffusion process
 - wavelength: 1550 nm
 - high frequency: 14 GHz to 30 GHz

Photline space R&D projects and communication

- 2002-2006 Sat'N'Light
 - with Thales Alenia Space,
 - photonic RF frequency up and down conversion
 - routing of microwave signals in repeaters
- 2006-2014 MGOM
 - ARTES 5, with Thales Alenia Space, ALTER, University of Madrid
 - optimized optical modulator
 - reliability assessment & evaluation
- 2008-2014 OMCU
 - ARTES 5, with Thales Alenia Space
 - special linear modulator
 - packaged modulator for integration in subsystems



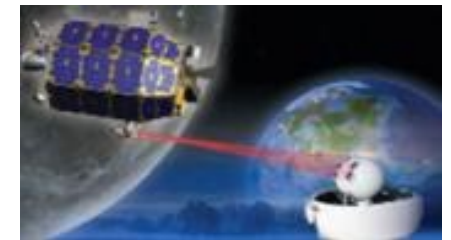
Photline space R&D projects and communicatio

- 2010-2012
 - evaluation of reliability of optical modulators for space conditions
 - definition of a space qualification program for optical modulator
 - published at ISROS
- 2012-2013
 - with Thales Alenia Space
 - study of a reflective modulator for array of antenna
 - optimized optical modulator
 - reliability assessment & evaluation
- 2013-2015
 - optimization of hermetic packaging aiming ideal compliance with space requests



Photline communication within the Space Community

- ISROS Conference (International Symposium on Reliability of Optoelectronics for Systems)
 - 2012 Cagliari, Photline Paper “Reliability of LiNbO₃ Modulators for Space applications”
 - 2014 Toulouse, (Houda Brahimi member of the industry liaisons committee), exhibition booth together with iXFiber
 - 2016 Otwock, Poland, iXBlue Paper “Reliability Assurance Guideline for Lithium Niobate-based Electro-optical Modulators”
- ICSO International Conference on Space Optics
 - Paper: H. Porte, Optimization and evaluation in space conditions of multi-GHz optical modulators, Tenerife, 7 - 10 October 2014



Laser Communication from Ground to Satellite

- Press release / Photline Website / ESA Rocket Science Blog
 - 2013: PHOTLINE has provided a seed laser and a ModBox data modulation unit to ESA for free space moon-earth communication between an ESA ground station in Tenerife, the Canary Islands, and NASA's LADEE (Lunar Atmosphere and Dust Environment Explorer)
- Application:
 - Lunar Laser Communication Demonstration (LLCD) from Ground to LADEE satellite
- iXblue customer: ESA
- Technology:
 - PPM reference Transmitter Modulation Unit
 - 4 Channels Transmitter
 - Turn-key Transmitter



<http://icsos2014.nict.go.jp/contents/pdf/S2-1.pdf>

Conclusions

- **iXblue photonics** masters two key technologies :
 - Optical specialty fibers (active & PM) and related components (FBG's, Filters, mirrors)
 - Lithium niobate optical modulators (phase & amplitude) and related active components (drivers & modulator bias controllers)
- The **iXblue modulators** passed successfully the tests of reliability to be used in space (radiations, vibrations, mechanical shocks, thermal cycling and lifetests in vacuum,...)
- The **iXblue active and passive fiber** are fabricated with a specific technology allowing to face space radiation level without any damages: RadHard fibers
- The **iXblue photonics components** have been integrated in fiber optic gyroscope (**FOG**) for inertial navigation and positioning. The **FOG** instruments passed successfully all qualifications tests
- They have been already launched in space through more than 13 missions since 2009 with successful operations
- The **iXblue Photonics components** (fibers & modulators) address the market of space applications with highly reliable solutions