



Photonic Packaging for Space Applications

Presented to :



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Space Photonics, Inc

- **Small Privately Held Corporation**
- **Located in Fayetteville, Arkansas**
- **Specialize in the Development and Manufacture of High Reliability Optoelectronic Network Components for the Aerospace Industry**

Our Mission is to Accelerate the Migration of Photonics into Aerospace Systems



Packaging & Implementation Drivers for Space Applications



Performance Drivers

- ▶ **On-Board Data Networks for Advanced Remote Sensing Applications must provide:**
 - ▶ **Data Throughput Capacity of 1 to 10 Gbps**
 - ▶ **Simultaneous Support for Multiple Real Time Sensors**
 - ▶ **Reliable Data Delivery with Minimal Bit Error Rates**
 - ▶ **Redundant Re-Configurable Architecture**
 - ▶ **Harsh Environment, Radiation Tolerant Implementations**
 - ▶ **IEEE-1156.4 Standard for Environmental Specifications for Spaceborne Computer Modules**
 - ▶ **Minimal Size, Weight, and Power**

Basic Space Qualifications

PARAMETER	NON-OPERATING CONDITIONS	OPERATING CONDITIONS	STANDARDS, REFERENCES & TEST METHODS
Thermal/ Vacuum	-46°C to +81°C	-46°C to +71°C 1 Cycle, 144 hrs hot, 24 hrs cold, $\Delta T/\Delta t = 10^\circ\text{C}/\text{min}$	IEEE-1156.4 EIA RS-455-52 IEEE-1393
Thermal Cycles	-46°C to +81°C	-46°C to +71°C 200 up to 1000 Cycles $\Delta T/\Delta t = 10^\circ\text{C}/\text{min}$ Attenuation rate <0.5 dB/km at 1300 nm.	IEEE-1156.4 IEEE-1393 EIA RS-455-52
Temperature shock		-46°C to +71°C $\Delta T/\Delta t = 30^\circ\text{C}/\text{min}$	IEEE-1393 DOD-Std-1678, method 4020, Test condition A
Outgassing		Maximum volatile condensable material content of 0.1 percent Maximum total mass loss of 1.0 percent	IEEE-1156.4 IEEE-1393 SP-R-0022 when tested in accordance with ASTM-E-595
Pressure	Sea Level to 5×10^{-6} Torr	Sea Level to 5×10^{-6} Torr $\Delta P/\Delta t = 100 \text{ Torr}/\text{sec}$	IEEE-1156.4 IEEE-1393
Relative Humidity	0 % to 95% Noncondensing	0 % to 95% Noncondensing	
Pyrotechnic Shock		30 G at 100 Hz, 3000G from 1 kHz to 10 kHz, 3 shocks per axis	IEEE-1156.4 IEEE-1393
Random Vibration		20 Hz - $0.125 \text{ G}^2/\text{Hz}$ 50 Hz - 800 Hz - $0.8 \text{ G}^2/\text{Hz}$ 2000 Hz - $0.125 \text{ G}^2/\text{Hz}$ 3 min in each axis. Attenuation rate shall not increase by more than 0.5 dB/km at 1300 nm. Peak acceleration must be at least 20 g.	IEEE-1156.4 IEEE-1393 EIA RS-455-11



Radiation Qualifications

RADIATION	TYPE	TEST LEVELS & DESCRIPTION
		After a total ionizing radiation dose of 10kRad(Si) (dose rate of 1300 Rads/min), the fiber attenuation rate shall not increase by more than 20 dB/km at 1300 nm over the attenuation rate due to other effects. The system shall operate when exposed to a proton flux of 10^5 protons/sq. cm IEEE-1393 EIA RS455-49
Total Radiation Dose per year	Trapped e- and p, heavy ion	30 to 200 krad(Si) per year *Special testing required for Military IEEE-1156.4 IEEE-1393
SEE Rate	Non-Destructive	$<3 \times 10^{-3}$ events per day IEEE-1156.4
SEE Rate	Destructive	$<3 \times 10^{-3}$ events per day IEEE-1156.4
		30 to 200 krad(Si) per year *Special testing required for Military IEEE-1156.4 IEEE-1393



Component Space Qualifications

OPTICAL FIBER	DESCRIPTION	CONDITIONS & REQUIREMENTS	STANDARDS & TEST METHODS
Type	1300 nm Graded Index Multimode	100 ± 3 microns Core 140 ± 2 microns Cladding 170 ± 2 microns Protective Hermetic Coating when required	IEEE-1393 EIA RS-455-58. EIA RS-455-45. EIA RS-455-55.
Performance		Cable lengths up to 200 m Attenuation ≤ 5.0 dB/km at 1300 nm Numerical aperture shall be 0.29 ± 0.01	IEEE-1393 EIA RS-455-46 EIA RS-455-50, Pr. A
Dispersion limited bandwidth		400 MHz-Km at 1300 nm	IEEE-1393 EIA RS-455-30, 54
Outgassing		Maximum volatile condensable material content of 0.10 % maximum total mass loss of 1.0 %	IEEE-1393 ASTM-E-595 SP-R-0022
Hermeticity		Fiber hermetically sealed when required. Hermetic coatings shall be 20 ± 5 nm.	IEEE-1393
Tensile Strength		Proof-tested tensile strength shall be at least 100,000 psi.	IEEE-1393 EIA RS-455-31
Life Requirements	Attenuation Aging Test 0° C to 110°C, 240 hours	Shall not increase by more than 0.5 dB at 1300 nm When returned to ambient temperature, the fiber coatings shall not be cracked or melted. No scratches, nicks, or inclusions in the stripped fibers or residual coating material on the stripped fiber which cannot be easily removed.	IEEE-1393 MIL-STD-202, method 8 EIA RS-455-31
CONNECTORS			
Attenuation Reflection		Maximum of 0.75 dB at 1300 nm Less than -40 dB	IEEE-1393 IEEE-1393
Connector Life	Attenuation & Aging Test 0° C to 110°C, 240 hours	Shall not increase by more than 0.25 dB at 1300 nm over losses attributed to the optical fiber or original connection	IEEE-1393 MIL-STD-202, method 8 EIA RS-455-31



Cost Drivers

► On-Board Data Networks

- **Must Implement Industry Accepted, Open Architecture Standards**
- **Interface Designs must be Flexible and Non-proprietary**
- **Development and Test Tools must be Inexpensive and Commercially Available**
- **Prototype Components must be Inexpensive and Commercially Available**
- **Radiation Tolerant Flight Components must be Available or a Commercial Conversion Path must be Defined and Costed**



Benefit Recognition

⇒ **Spacecraft Prime Contractors Slowly Recognizing the Benefits of Fiber Optics for On-board Data Handling**

⇒ **Benefits Include**

⇒ **Total Elimination of EMI and RFI**

⇒ **Significant Reduction in Size, Weight and Power**

⇒ **Greater On-orbit and I&T Flexibility**

⇒ **Significantly Reduced I&T Costs**



Bottom Line

- ➡ **Fiber Optics is the Only Cost Effective Way to Support the On-Board Data Handling Requirements of Remote Sensing Spacecraft and Aircraft**



Capital Intensive Barrier for a Small Company?

- ⇒ How Does a Small Company Overcome the Capital Intensive Barriers for the Successful Development and Manufacturing of Space Qualified Opto-Electronic Components?**



Small Business Incubation Facility



University of Arkansas Genesis Technology Incubator

- **Located Adjacent to the University of Arkansas**
- **Low Cost Office Space with State-of-the-Art Business Center**
- **State-of-the-Art Conference & Communications Facilities**
- **On-Site Support Staff**
- **Access to Local Business Professionals**



Strategic Alliances

Technology & Research Assistance



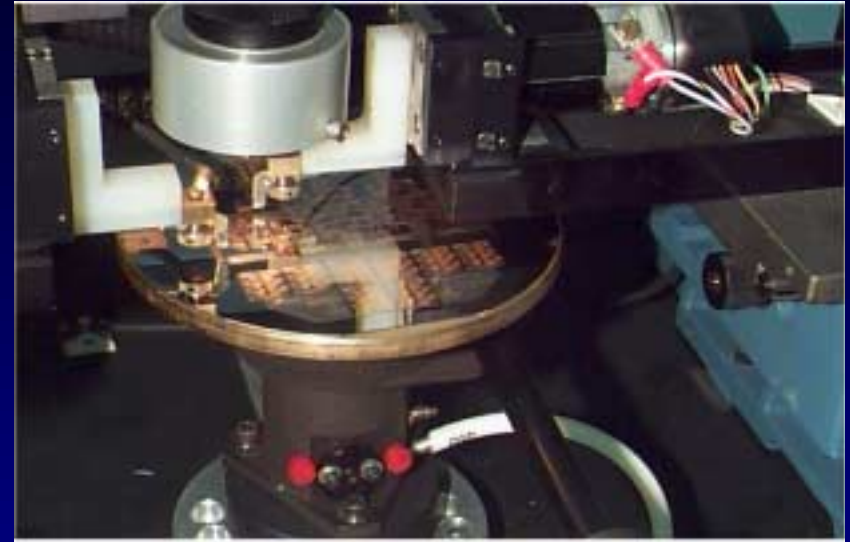
**University of Arkansas
Academic & Research
Support**

- ▣▣▣▣ **University of Arkansas Academic Staff & Research Facilities**
 - ▣▣▣▣ **Department of Engineering**
 - ▣▣▣▣ **Includes the High Density Electronics Center (HiDEC)**
 - ▣▣▣▣ **Department of Physics**
 - ▣▣▣▣ **Includes an Ultra-Advanced Photonic Materials Processing Facility**
 - ▣▣▣▣ **Computer Systems Engineering Department**
 - ▣▣▣▣ **Microelectronics-Photonics Graduate Program**



Strategic Alliances

Microelectronic Packaging



- ⇒ **University of Arkansas High Density Electronics Center HiDEC**
 - ⇒ **6500 sq ft of Class 100 & 1000 Clean Rooms**
 - ⇒ **Complete Micro-electronic Fab & Test Capability**
 - ⇒ **Wafer Fabrication (Prototype & Low Volume Production)**
 - ⇒ **Wafer Probe Testing**



Strategic Alliances Production

Space Qualified Production Facility

Process Certifications

- ISO 9001/9002 Certified Production Processes
- Space Qualified (QML) Production Processes

High Volume, Automated Production Capability

- MCM Substrate Fab & Test
- Optoelectronic Component Fab & Test
- Optoelectronic Product Assembly & Test

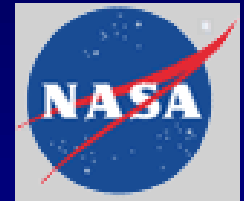


Government R&D Support



R&D Funding and Product Application Review

- NASA Goddard Space Flight Center
- NASA Jet Propulsion Laboratory
- Air Force Research Laboratory
- Department of Defense
- Arkansas Science and Technology Authority



Radiation Testing & Materials Certification

- NASA Goddard Space Flight Center
- Naval Research Laboratory





Capital Investment



Space Photonics Class 1000 Clean Room

- ▣ **Qualified Optoelectronic Engineering Professionals**
- ▣ **Optoelectronic Design Tools**
- ▣ **Space Photonics Class 1000 Clean Room**
- ▣ **Optoelectronic MCM Assembly Equipment**
- ▣ **High Speed (up to 40 Gbps) Optoelectronic Test Equipment**



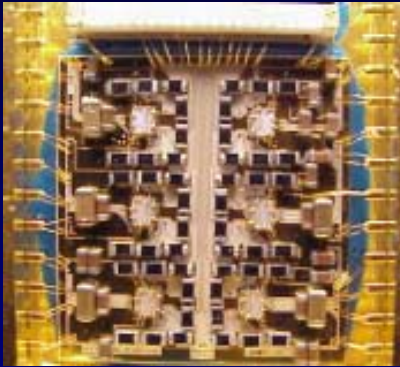
Results

➔ **What can be Achieved with the Right Strategic Alliances and Support**

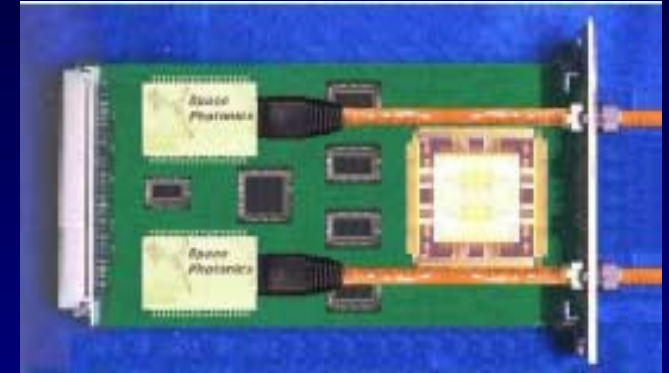





Space Qualified Product Lines

Micro Electronic Photonic Packaging



Miniature High Speed Fiber Optic Components



- 
FireFiber™ Multi-port 2.5 Gbps Fiber Optic Transmitters and Receivers
- 
FireRing™ Multi-port 2.5 Gbps Fiber Optic Network Interface Cards
- 
FireRing™ Multi-port Fiber Optic Switches



Space Photonics Products

- ▶ **Our Products are Specifically Designed to meet the High Data Rate, Real Time, Onboard Data Handling Requirements of Aerospace Remote Sensing Applications using NASA Approved Materials, Packaging Processes and Radiation Tolerant Devices**
- ▶ **Our Strategic Alliances and Support Network Relationships are the Key to Our Success**