



# FIBER OPTICS

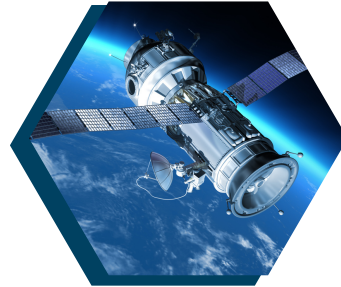
## PRODUCT & SOLUTIONS

### GUIDE



# G&H: A PHOTONICS SPECIALIST

G&H solves complex challenges for our customers by developing innovative photonics solutions that enhance **performance**, **reliability**, and **efficiency**. We are an award-winning name in the photonics industry with global reach and an established heritage dating back **75 years**.



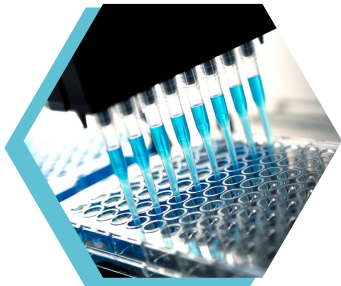
**Aerospace & Defense**

Emerging applications increasingly employ photonics as the enabler. Our customers require specialized, reliable and high-performance solutions. G&H pushes the boundaries in these key areas and provides differentiating product solutions. We maintain close and long-lasting relationships with our customers.



**Industrial & Telecom**

G&H is a photonics technology business headquartered in Ilminster Somerset, UK with operations in the USA and Europe.



**Life Sciences**

# BROAD GLOBAL EXPERTISE



Made in the UK



Made in the USA



**Ilminster, UK**  
49,679 ft<sup>2</sup>  
4,615 m<sup>2</sup>



**Fremont, USA**  
40,000 ft<sup>2</sup>  
3,716 m<sup>2</sup>



**Keene, USA**  
12,800 ft<sup>2</sup>  
1,189 m<sup>2</sup>



**Cleveland, USA**  
80,000 ft<sup>2</sup>  
7,432 m<sup>2</sup>



**Rochester, USA**  
43,226 ft<sup>2</sup>  
4,015 m<sup>2</sup>



**Moorpark, USA**  
50,000 ft<sup>2</sup>  
4,645 m<sup>2</sup>



**Plymouth, UK**  
22,000 ft<sup>2</sup>  
2,043 m<sup>2</sup>



**Torquay, UK**  
41,000 ft<sup>2</sup>  
3,850 m<sup>2</sup>



**St. Asaph, UK**  
9,149 ft<sup>2</sup>  
850 m<sup>2</sup>



**Ashford, UK**  
30,000 ft<sup>2</sup>  
2,787 m<sup>2</sup>

## A BETTER WORLD WITH PHOTONICS.

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G&H employs over 1,000 skilled employees across 10 manufacturing and design facilities. We also have 3 sales offices and a contract manufacturing partner in Thailand.

# MANUFACTURING CAPABILITIES



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## G&H FIBER-OPTICS

Since 1985, G&H has produced top-quality fiber optics and devices, including components for undersea, aerospace, and defense applications.

With engineering and manufacturing centers in Torquay, UK, G&H's renowned photonic engineering services and expertise ensure that their fiber optic products are durable, reliable, and designed to withstand extreme conditions.

Guaranteed to never fail, G&H's fiber optic products are made possible by the experience and expertise of the centers' advanced engineers and technicians.



# POLARIZATION DIVERSE RECEIVERS

Superior performance, compact design, and hermetic sealing

G&H's Polarization Diverse Receivers (PDR) are the perfect solution for high-performance and reliable signal detection at wavelengths of 1060, 1310, or 1550 nm.

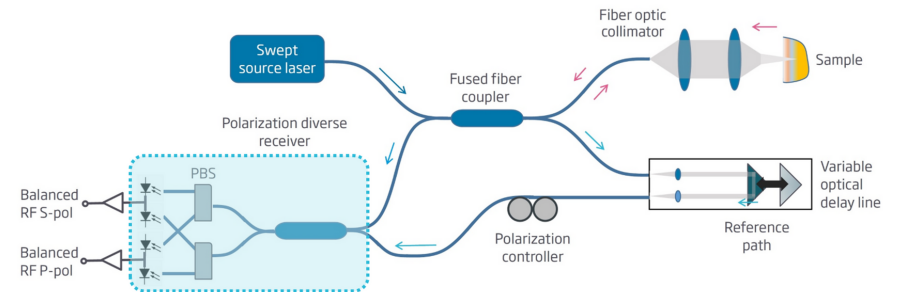
Our PDRs mix an incoming signal with a reference (local oscillator), effectively shifting any phase and amplitude fluctuations on the optical carrier to a carrier at an electronic frequency.



	Wavelength (nm)	Pigtail length (m)	Reference input	Connector
PDR-xxxxxxx	1060, 1310, 1550	0.5, 1	SM, PM	None, FC/APC, SC/APC, LC/APC

## SWEPT SOURCE OCT - INCLUDING PDR

- Eliminates polarization fading
- Enables PS-OCT



## ACCURATE POLARIZATION ANALYSIS

Using a pair of balanced detectors, our PDRs analyze the S and P states of polarization of the mixed signal, ensuring that the signal is accurately detected and interpreted.

Housed in a compact, hermetically sealed package, our PDRs feature direct electrical connections to their four photodiodes, making them easy to use and maintain.

## POLARIZATION STATE SPLITTING

The PDR works by first splitting the sample and reference signals with a non-polarizing beam-splitter, followed by polarization state splitting with a polarizing beam-splitter.

This process results in four channels (S+, S-, P+, and P-) that allow polarization diverse detection with common mode rejection, ensuring that the detected signals are of the highest quality and reliability.

# FIBER-Q®

## Combining micro-optical packaging capabilities and acousto-optic expertise

The award-winning Fiber-Q® series of fiber-coupled acousto-optic modulators is an elegant and robust solution for amplitude modulation of fiber and fiber-coupled lasers. With direct control over timing, intensity, and temporal shape of laser output, Fiber-Q® offers a high extinction ratio, low insertion loss, and excellent stability in both polarization-maintaining (PM) and non-PM formats at modulation frequencies up to 80 MHz for visible and infrared wavelengths.

## Rugged, reliable design for seamless integration

Built for reliability, the rugged hermetic design of Fiber-Q® ensures a compact, low-profile package that is ideal for easy integration into all-fiber and OEM systems, including medical laser systems. Additionally, Fiber-Q® provides a wider variety of pulse shapes, enabling more precise control over the temporal characteristics of the active output from a fiber laser. Its fast switch speed, high peak diffraction efficiency, and reliable performance make it a critical component in many amplified systems.

## Versatile and efficient modulation in multiple wavelengths

Fiber-Q® is available in wavelengths ranging from 400-2000 nm, hermetic and non-hermetic versions, and three port versions in addition to the standard two port. With its growing list of applications, Fiber-Q® continues to deliver stable high-efficiency performance and superior machining effects.

## APPLICATIONS

The Fiber-Q® has a wide range of applications in industries such as industrial laser materials processing, biomedical, and sensing applications. In industrial laser materials processing, Fiber-Q® is used for welding, cutting, drilling, and surface treatment, where precise control over the laser output is critical. Fiber-Q® is also used in medical laser systems for applications such as tissue ablation, cancer treatment, and dermatology. Its high stability, low insertion loss, and direct control over laser output make it a critical component in these systems. With the visible range of Fiber-Q® products, more compact all-fiber instrument designs are now possible in biomedical applications such as microscopy and flow cytometry.

Fiber-Q® is the result of G&H's core area of expertise in acousto-optics, combined with micro-optical packaging capabilities, to produce a market-leading device. With its growing list of applications, Fiber-Q® delivers stable high-efficiency performance and superior machining effects.



## AWARD-WINNING PACKAGING

G&H Torquay's expertise in photonic packaging led to the development of Fiber-Q® and received the Institute of Physics Award for Innovation, followed by the Queen's Award for Enterprise: Innovation in 2016. Since its introduction in 2009, the list of applications has grown, including industrial laser materials processing, biomedical, and sensing applications.

FIBER-Q®	Product code	Wavelength (nm)	Pigtail type	Rise / fall time (ns)	Frequency (MHz)
450nm 200MHz	S-M200-0.4C2A-3-F2P, S-M200-0.4C2A-3-F2S	450	PM, SM	25	200
532nm 200MHz	S-M200-0.4C2C-3-F2P, S-M200-0.4C2C-3-F2S	532	PM, SM	25	200
633nm 200MHz Fiber Coupled AOM	S-M200-0.4C2E-3-F2P, S-M200-0.4C2E-3-F2S	633	PM, SM	25	200
780nm, 150MHz Fiber Coupled AOM	T-M150-0.5C2W-3-F2P, T-M150-0.5C2W-3-F2S	780	PM, SM	50	150
PM 1060nm 200MHz Hermetic Fiber Coupled AOM	T-M200-0.1C2G-3-F2P	1030-1090	PM	10	200
1060nm 150MHz Non-Hermetic Fiber Coupled AOM	S-M150-0.4C2G-3-F2S	1060	SM	30	150
PM 1060nm 150MHz Hermetic Fiber Coupled AOM	T-M150-0.4C2G-3-F2P	1060	PM	30	150
1060nm 150MHz Hermetic Fiber Coupled AOM	T-M150-0.4C2G-3-F2S	1060	SM	30	150
1060nm 200MHz Non-Hermetic Fiber Coupled AOM	S-M200-0.1C2G-3-F2P	1060	SM	10	200
1060nm 200MHz Fiber Coupled AOM	T-M200-0.1C2G-3-F2S	1060	SM	10	200
1060nm 300MHz Hermetic Fiber Coupled AOM	T-M300-0.1C2G-3-F2P, T-M300-0.1C2G-3-F2S	1060	PM, SM	6	300
PM 1550nm 110MHz Hermetic Fiber Coupled AOM	T-M110-0.2C2J-3-F2P	1550	PM	25	110
1550nm 110MHz Hermetic Fiber Coupled AOM	T-M110-0.2C2J-3-F2S	1550	SM	25	110
PM 1550nm 200MHz Hermetic Fiber-Coupled AOM	T-M200-0.1C2J-3-F2P	1550	PM	10	200
1550nm 200MHz Hermetic Fiber-Coupled AOM	T-M200-0.1C2J-3-F2S	1550	SM	10	200
1550nm Fiber Coupled AOM	T-M300-0.1C16J-3-F2P	1550	PM	6	300
PM 1550nm, 40MHz (AMTIR)	T-M040-0.5C8J-3-F2P	1550	PM	100	40
1550nm 40MHz (AMTIR)	T-M040-0.5C8J-3-F2S	1550	SM	100	40
PM 1550nm 80MHz Hermetic Fiber-Coupled AOM	T-M080-0.4C2J-3-F2P	1550	PM	35	80
1550nm 80MHz Hermetic Fiber Coupled AOM	T-M080-0.4C2J-3-F2S	1550	SM	35	80
PM Polarization Maintaining 1550nm Hermetic Fiber Coupled AOM, 80MHz (Low Power Consumption)	T-M080-0.5C8J-3-F2P	1550	PM	100	80
1550nm Hermetic Fiber Coupled AOM, 80MHz (Low Power Consumption)	T-M080-0.5C8J-3-F2S	1550	PM	100	80
2000nm (2µm) 250 MHz Fiber Coupled AOM	T-M250-0.3C16Z-3-F2P	2000	PM	20	250
PM 2000nm 80MHz Hermetic Fiber Coupled AOM	T-M080-0.3C2Z-3-F2P	2000	PM	100	80
2000nm 80MHz Hermetic Fiber Coupled AOM	T-M080-0.3C2Z-3-F2S	2000	SM	100	80

# RUGGEDIZED COUPLERS

## Proven performance and reliability for undersea and space applications

The G&H line of HI-REL components are deployed in environments such as undersea and space where the costs of component replacement are prohibitive and reliability is of premier concern. G&H is established as a preferred supplier of these components to most major undersea telecommunications equipment manufacturers. Our HI REL capability is built upon the foundation of an extended history of also manufacturing very reliable components for land-based (or terrestrial) systems in volume.

## Ultra-low loss

The ultra-low loss of G&H fused fiber components helps to promote low noise figure and improved system margin in undersea transmission systems. Components are supplied in regular (bare fiber), semi-ruggedized (0.9 mm sleeving) or custom housings, depending on the installation environment. The newest addition to the range is our pump combiner, which allows erbium-doped fiber amplifier (EDFA) designers to double pump powers. This enables higher power EDFAs and in turn greater data carrying capacity.

	Function	Wavelength
High reliability fused coupler, 980nm band	Tap coupler	980nm
High reliability C or L band fused coupler	4x14mm	C, L-band
High reliability pump signal WDM	WDM	980nm, C-band
High reliability pump signal WDM	WDM	1480nm, C-band
High reliability pump combiner	Combiner	980nm

## APPLICATIONS

In space applications, photonics is expected to displace current RF/microwave satellite technology for transport of data between satellites, and between satellites and the Earth. In addition to offering higher data carrying capacity than the present radio wave systems, the reduced size and weight of optical systems will enable smaller, lighter next generation satellites. The G&H HI REL space range of fused fiber components builds on the quality and reliability for which our undersea couplers are known, adding features such as material lot unicity, qualification in high radiation environments and lot validation testing. Services for HI REL customers include custom qualification programs, dedicated workstations, full traceability of materials and processing, advanced fiber management, and customer-specific validation tests.



## HI REL TESTING FACILITIES

G&H has established full reliability testing facilities to carry out customer specific HI REL qualification programs, which can include accelerated aging and Weibull analysis. Failure rates for undersea telecommunication systems and components are often described using a FIT rate (Failures in Time). The fused fiber couplers from our HI REL coupler range offer a very low 0.1 FIT rate, equivalent to one failure in roughly fifty thousand components in 25 years.

# HIGH POWER COUPLERS

## The highest performance fused fiber couplers and high power combiners

Our precise fusion techniques form the basis for our range of multimode pump combiners, designed for pumping high-power fiber lasers. To meet the demands of complex fiber amplifier designs, we have developed a signal feedthrough fiber at the center of the multimode fiber bundle, which is both single-mode and polarization-maintaining. Our product line includes Nx1 multimode combiners as well as N+1x1 combiners with a signal feedthrough fiber, with standard components available in 3x1, 7x1, 2+1x1, and 6+1x1 configurations. Additionally, all variants are available with custom pump, signal, and output fibers to meet specific application requirements. To streamline integration into beam delivery systems, output fiber pigtails can be directly integrated into the system.

## High power multi-mode pump combiners

Our range of pump combiners for high power fiber lasers is based on precise fusion of multi-mode fiber techniques. For pumping of complex fiber amplifier designs, we have developed a signal feedthrough fiber at the center of the multi-mode fiber bundle, which is both single-mode and polarization-maintaining. All variants are available with custom pump, signal, and output fibers.

	Function	Wavelength (nm)
6+1X1 Power Combiner with signal feedthrough	N+1x1	900-1000, 1064, 1550
6+1X1 Power Combiner with PM signal feedthrough	N+1x1	900-1000, 1064, 1550
2+1x1 Power Combiner with PM signal feedthrough	N+1x1	900-1000, 1064, 1550
2+1x1 Power Combiner with signal feedthrough	N+1x1	900-1000, 1064, 1550
2+1x1 Power Combiner with active PM signal feedthrough	N+1x1	900-1000, 1064, 1550
2+1x1 Power Combiner with active signal feedthrough	N+1x1	900-1000, 1064, 1550
2+1x1 Power Combiner with active signal feedthrough	N+1x1	900-1000



## SM COUPLERS

### Accurate monitoring and splitting of optical signals

G&H single-mode couplers are a reliable choice for accurate monitoring and splitting of optical signals, with a range from 1% to 50%. In addition, we offer Wavelength Division Multiplexers (WDMs) for multiplexing and demultiplexing optical signals at different wavelengths. Our couplers and WDMs are available in both standard and polarization-maintaining (PM) versions, including slow axis, fast axis, and axis-independent variants.



	Function	Wavelength
Fixed attenuator	Attenuator	Various
Dual window wideband coupler	Tap coupler	1310nm, C-band
Visible wavelength coupler	Tap coupler	400-700nm
Near infrared coupler	Tap coupler	700-1200nm
Ultra low ratio tap coupler	Tap coupler	700-1600nm
Fused coupler	Tap coupler	980nm, 2µm
NXN fused coupler	Tap coupler	980, 1310, S, C, L-band
Fused coupler, C or L band	Tap coupler	C, L-band
Subminiature tap coupler	Tap coupler	C, L, C+L, S-band
Fused coupler, C+L or S band	Tap coupler	C+L, S-band
3x1, 4x1	Tap coupler	400-2000nm
High temperature coupler >250°C	Tap coupler, WDM	400-2000nm
Visible wavelength combiner	WDM	400-700nm
Near infrared WDM	WDM	700-1199nm
2µm WDM	WDM	2µm
Fused pump signal WDM	WDM	980nm, C, L, C+L-band
Subminiature pump signal WDM	WDM	980nm, C, L, C+L-band
Duplexing WDM, 1x2 or 2x2	WDM	1310nm, C, L-band
Fused pump signal WDM	WDM	1480nm, C, L-band
Low reflection termination	Termination	1310nm, C, L-band

### VOLUME PRODUCTION

At G&H, we have extensive experience in the volume production of fused fiber components for telecommunications deployment. We offer customization of any of our designs to meet the needs of volume OEM applications, and our engineers are experts in designing custom products to meet our customers' unique needs. Whether it is for couplers, WDMs, or any other fiber optic component, we are committed to providing high-quality products and exceptional service.

## PM COUPLERS

### Accurate monitoring and splitting of PM optical signals

G&H offers a range of fiber optic components for accurate monitoring and splitting of optical signals. Our polarization-maintaining (PM) couplers, including slow axis, fast axis, and axis-independent variants, are available in ratios from 1% to 50%, and are manufactured using industry-standard fiber. We also offer a variety of other components, including combiners, taps, attenuators, and wavelength division multiplexers (WDMs), all of which are designed for maximum efficiency and reliability.



	Function	Wavelength
PM combiner	Combiner	980, 1060, 1450, 1550, 1650 nm
2+1x1 power combiner with PM signal feedthrough, 2 µm	N+1x1	750-850, 2000nm
6+1x1 power combiner with signal feedthrough, 2 µm	N+1x1	750-850, 2000nm
High power connectors and patchcords	Connectors	750-2100nm
PM coupler	Tap coupler	400-2000nm
PM bow tie fiber coupler	Tap coupler	900-1200nm
Axis-matched low ratio tap	Tap coupler	900-1600nm
Ultra low ratio tap coupler	Tap coupler	900-1700nm
3x1, 4x1	Tap coupler	400-2000nm
Fixed attenuator	Attenuator	400-2000nm
PM WDM	WDM	750-1600nm, 2µm
Low reflection termination	Termination	1310nm, C, L-band

### VOLUME PRODUCTION

With our extensive experience in volume production of fused fiber components for telecommunications deployment, we can customize any of our designs to meet the needs of volume OEM applications. Our engineers routinely apply their knowledge to design custom products for our customers, ensuring that they receive the highest quality, most reliable components for their specific needs.

# WIDEBAND COUPLERS

## Wideband couplers for high-resolution imaging in OCT systems

In the OCT light engine, fiber optic wideband couplers are used to form the interferometer that generates depth information.

G&H's wideband couplers provide accurate monitoring and splitting of optical signals over a broad range of wavelengths, ensuring that the OCT system can generate precise depth information for high-resolution imaging.

Our couplers are designed to meet the demanding requirements of OCT systems and offer excellent performance, reliability, and accuracy.

## Wideband optical couplers

The 1060 nm Wideband OCT Coupler offers uniform performance over a 50 nm wavelength range, making it ideal for high-end OCT instruments.

With its precise fusion of fibers, this coupler allows for accurate monitoring and splitting of optical signals. The 1060 nm wavelength is particularly suitable for imaging the retina, providing high-resolution images with excellent contrast and depth information.

For OCT systems that use both 850 nm and 1300 nm wavelengths, G&H offers the Wideband OCT Coupler. This coupler also has a bandwidth of 50 nm, providing uniform performance over a range of wavelengths.

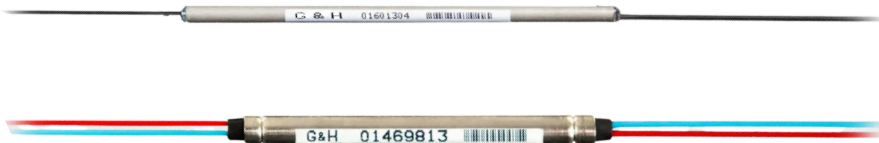
The 850 nm and 1300 nm wavelengths are commonly used in OCT imaging of biological tissue, making this coupler an excellent choice for a wide range of medical applications.

## Extremely wideband optical couplers

G&H wideband couplers are designed to meet the increasing bandwidth requirements of the latest generation of optical coherence tomography (OCT) systems. Traditional retinal scanning systems use optical sources with a bandwidth of around 30 nm, but with the move towards higher resolution imaging, the latest OCT systems require a bandwidth of over 100 nm.

G&H has developed the Extremely Wideband Optical Coupler (EWOC) to meet this need, with uniform performance over a 140 nm wavelength range, making it an ideal choice for high-end and future generations of OCT instruments.

	Wavelength (nm)	Bandwidth (nm)
1060nm wideband OCT coupler	1060	50
850 and 1300nm wideband OCT coupler	850, 1300	50
850, 1060, 1300nm extended wideband OCT coupler	850, 1060, 1030	200



# VARIABLE OPTICAL DELAY LINE

## For high-performance optical coherence tomography (OCT) systems

G&H's Small Form-Factor Variable Optical Delay Line is an essential component for high-performance optical coherence tomography (OCT) systems. Our team of experts draws on extensive knowledge and experience in the design of custom OCT modules to provide a complementary set of key optical elements.



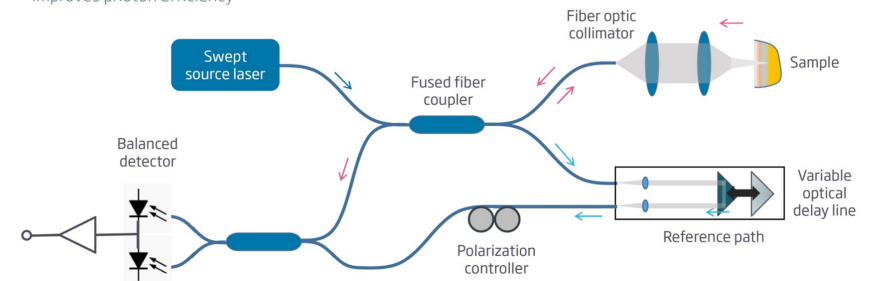
## Interferometer reference arm

Our optical delay line is designed to be used as an interferometer reference arm, offering stable optical performance over time, delay, and environmental conditions. This high-quality delay line enables precise control of the path length of the reference arm, allowing for accurate measurement of depth in OCT imaging.

Wavelength (nm)	Travel speed (mm/s)	Polarization control	Bandwidth (nm)	Port configuration	Fiber sleeving (mm)	Pigtail length (m)
850, 1060, 1310	50	None, Faraday rotator	100	Single fiber, Dual fiber	Ø.9, Ø2.0	0.5, 1, 1.5, 2

## SWEPT SOURCE OCT

- High speed, long range OCT
- Enables balanced detection
- Improves photon efficiency



## COMPACT FOR PORTAL SYSTEMS

Available in a compact, small form-factor design, our delay line is ideal for use in portable and handheld OCT systems.

The device features a variable delay range, allowing for greater flexibility and adaptability in a range of applications.

# OEM MODULES & SYSTEMS

## World-class expertise in fiber optics

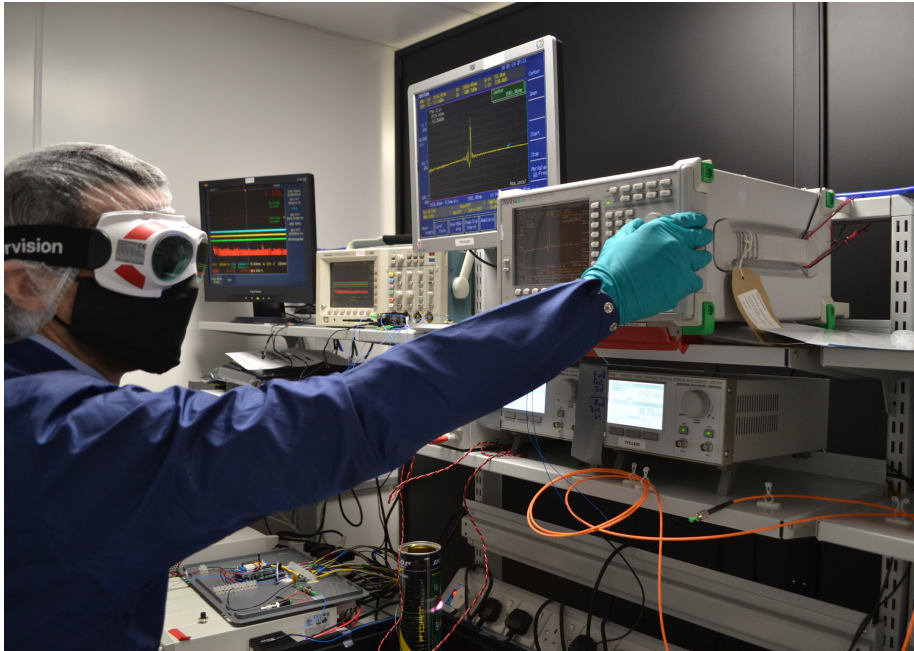
We are vertically integrated and offer fiber optic assemblies and custom sub-systems containing optoelectronics, driver circuitry, and firmware for biomedical, fiber sensing, and aerospace and defense. Some products are standard but most of our OEM customers have unique requirements and we are experienced in working with them to design and engineer the solution they need.

## Vertical integration for supply chain simplification

As a vertically integrated supplier, we offer supply chain simplification with a single source for design for manufacture and assembly (DFMA), engineering, test, manufacture, and integration. Even if we do not make all the subcomponents for your system, we are able to integrate third party components. All of our external suppliers have been through a rigorous qualification process with us, and we have confidence in our component suppliers. Thanks to our established buying power, design for manufacture focus, and continuous improvement, we can help customers overcome time to market and cost challenges.

## High performance, flexible designs

We understand our customers' need for high performance, as well as flexibility in design. We have the ability to look at a customer's schematic and know where the problems lay. We can help you to develop your system to get better image quality / resolution, speed, stability, smoothness, and reliability. For decades we have deployed integrated sub-systems, such as the critical fused fiber coupler, which was initially for the long-distance optical communications industry and is now available for OCT too. We have invested in R&D and listened to our customers' needs, developing key components such as the optical delay line, polarization diverse receiver (PDR), and collimator for OCT interferometers, as well as sub-systems and fully bespoke OCT systems.



## SYSTEMS & SERVICES

System manufacturing

Design engineering

## SUB-SYSTEMS

Spectroscopic instrumentation

Photonic subsystems

## COMPONENTS AND MATERIALS PROCESSING

Fiber optics

Electro-optics

Acousto-optics

Crystal optics

Optics

## MATERIALS

Crystals

