

Photonics and Lasers Capability

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1.0 Foreword

Patrick Mallon

C.Eng. FRAeS

Photonics and laser technologies are at the heart of the 21st-century innovation economy. From enabling high-speed communications and precision manufacturing to advancing biomedical imaging and quantum computing, these technologies underpin a vast array of transformative applications. Yet, despite their critical importance, photonics remains a sector that is often underrepresented in strategic planning and public discourse.

This report presents a comprehensive assessment of Northern Ireland's photonics and laser capabilities, drawing on extensive engagement with industry leaders, academic researchers, and government stakeholders. It highlights the region's existing strengths-such as world-class research institutions, a skilled workforce, and a growing base of innovative companies-while also identifying key challenges and opportunities for future growth.

By mapping the current landscape and exploring emerging trends, this study provides a foundation for informed decision-making and targeted investment. It calls attention to the need for coordinated action to support infrastructure development, talent cultivation, and crosssector collaboration. The findings underscore the potential for Northern Ireland to become a globally recognized hub for photonics excellence, provided that strategic support and long-term vision are applied.

As global demand for photonics solutions accelerates, the insights offered in this report are both timely and essential. They serve not only as a guide for policymakers and industry leaders, but also as an invitation to innovators, educators, and investors to engage with a sector poised for exponential impact.

Thank you for your interest in this important work. We hope this report serves as a catalyst for informed decision-making and strategic action.

2.0 Executive Summary

Context and Purpose

This study, commissioned by Matrix on behalf of the Department for the Economy, assesses Northern Ireland's photonics and laser capabilities. It maps the current landscape, highlights global opportunities, identifies strengths and weaknesses, and sets out recommendations for industry and government to realise the sector's potential.

Photonics is the science of generating, controlling and detecting light and it underpins many of today's most rapidly evolving technologies. It also has real-world applications, including in data storage, medical imaging, telecommunications and defence.

Northern Ireland already has significant assets:

- **Industry anchors** such as Seagate (global leader in data storage) and Thales (defence and aerospace).
- Academic excellence at Queen's University Belfast and Ulster University across photonics-aligned fields.
- Public sector support, with UKRI and Invest NI providing funding and internationalisation pathways.

Photonics Framework and Key Areas

The report structures the sector into twelve interlinked sub-areas, ranging from well-established domains like optical communications, advanced sensors, data storage, and bio-photonics to emerging opportunities such as quantum photonics and neuromorphic computing. This framework enables a systematic analysis of applications, growth prospects, and relevance to Northern Ireland's economy.

Global analysis suggests that the strongest growth to 2030 will occur in industries relevant to:

- Situational awareness and autonomous sensing (LiDAR, autonomous systems, precision measurement).
- Optical communications (highspeed networks, data centres, telecommunications).
- Advanced sensors observation (energy, healthcare, manufacturing).
- Photonic materials (next-generation components for multiple sectors).
- Data storage (ultra-fast, energy-efficient, high-capacity systems).

Although narrower in scope, bio-photonics remains a strong opportunity for Northern Ireland given its existing research and industrial

Preliminary SWOT analysis

The report contains a preliminary SWOT analysis that highlights Northern Ireland's strengths, weaknesses, opportunities and threats in this area.

Strengths	Weaknesses
Existing foothold with presence of large firms with fabrication capacity & international recognition Broad engagement and history of innovation across range of photonics sub areas Knowledge base strong Dual market access (UK/EU) Existing strengths in electronics, sensors, medical tech and alignment with Smart Nano NI project - including adjacent skills and facilities	Education pipelines are not focused on skills development key to the photonics sector Difficulty grasping or 'selling' photonics to wider stakeholders (public, students, universities) Perception of photonics as `high science` weakening engagement Lack of knowledge of sector Lack of clarity on funding pipelines Lack of clear sector directionality or leadership – weakening visibility and identity of NI photonics sector
Opportunities	Threats
Spare manufacturing capacity Testing and packaging niches Whole-of-Ireland approaches Convergence with wider AI or Quantum government investment Access to EU UK and EU increases in defence spending Cuts to R&D funding & immigration constraints in US Enhanced Investment Zone and other untapped national and international funding sources	Geopolitical and trade uncertainty threatening supply chains Large lynchpin companies are potential risk if engagement lessens Risk of more accessible and urgent-seeming areas (life sciences / healthcare) dominating research and funding environment US approach weakens development everywhere (except China) Lack of clear leadership or representation of sector on national or international stage risks it failing to maximise investment/engagement Supply chain fragility – especially around Chinese or East Asian components



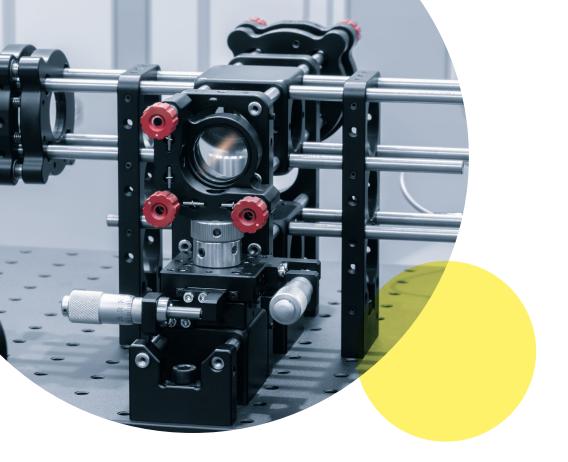
Recommendations

Recommendations

As a result of this work, we make five key recommendations.

- 1. Future proof major areas of opportunity. There are several areas of photonics that offer the greatest opportunity for the region. This research has identified Optical Communications, Situational Awareness, Advanced Sensors Observation, Photonic Materials and Data Storage as the areas representing the strongest opportunities for Northern Ireland's photonics sectors. In addition, Bio-Photonics is a particular opportunity for Northern Ireland given the strength of existing capability in the region (despite weaker growth prospects). Industry and government should take steps to future proof these areas of opportunity and develop long term plans to ensure continued development.
- 2. Invest in partnerships across UK and Republic of Ireland. Northern Ireland should look East-West and North-South to develop partnerships that maximise photonics potential. Collaborative funding opportunities could also be pursued across Ireland and the UK, accessing EU and UK funding where possible, sharing facilities, and aligning intellectual property strategies to maximise competitiveness.
- 3. Focus on promotion of photonics to wider stakeholders. The opportunity for photonics in Northern Ireland will be greater if more businesses and organisations currently not using the technologies can be encouraged to do so. NIPIC should focus on the promotion of photonics to wider stakeholders and identify more SMEs who could be important components of a broader photonics ecosystem. Industry should also play a matchmaking role - helping to identify where photonics solutions could be leveraged to solve business problems.
- 4. Exploit existing fabrication capabilities. Industry can utilise existing capabilities to position Northern Ireland as a photonics testbed location, working with public-sector partners to trial new technologies in real-world settings such as healthcare, agri-food, or environmental monitoring.
- 5. Invest in skills development. DfE and wider Northern Ireland government should work with industry and academia to invest in skills and education pipelines aligned to photonics. Importantly, this should focus on both technical skills development and wider capabilities that support the integration of photonics systems into devices - for example, design capabilities.





3.0 Introduction

Matrix is the Northern Ireland Science and Industry Panel and was established to advise government and inform academia and industry on the commercial exploitation of R&D and science and technology in Northern Ireland.

In this study, Matrix, on behalf of the Department for the Economy sought to understand more about photonics and lasers capability in Northern Ireland. The work has assessed the sector's strengths and weaknesses and identified key threats and opportunities to further development.

Photonics and lasers is a sub-sector where the UK has a potential future advantage, with a strong foundation in research and innovation. This has the potential to provide a competitive edge in sectors like smart manufacturing, autonomous systems, high speed data transmission and more. Photonics also intersects with other high potential growth areas like AI, quantum computing, 5G communications, life sciences and clean energy.

There is a particular opportunity within Northern Ireland, as there is already a substantial amount of activity already taking place:

- In the private sector there are a wide range of businesses engaged in both upstream and downstream photonics output.
- In academia, Northern Ireland's universities and research institutions play a vital role in the photonics and laser sector.
- In the public sector, UKRI has recently invested in the Northern Ireland photonics industry. Invest NI supports local photonics companies in accessing national and international markets and Photonics NI aims to educate companies on the uses of photonics to drive adoption.

Building on existing evidence, this foresight study has updated and expanded the insights into Northern Ireland's photonics and lasers sector, focusing on both upstream and downstream activities, technological advancements, and potential economic opportunities.

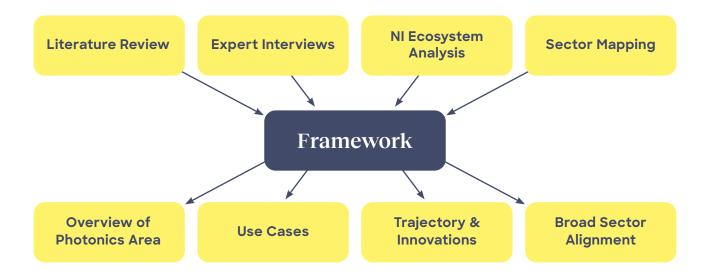


4.0 An overview of photonics

4.1 A framework of photonics technologies

Structuring our approach to building a framework for photonics in Northern Ireland incorporated inputs from a wide range of sources - including a prolonged literature review, engaging with both academic, industry, and government sources, a wide-ranging process of expert interviews from across those three areas, as well as more detailed analysis of the Northern Ireland photonics ecosystem and sector mapping.

This framework for understanding the key streams of photonics work within Northern Ireland has in turn helped us build a clearer picture of the photonics areas at play, use cases for Northern Ireland-based photonics applications, the trajectory and possible future innovations of or in those applications, alongside the broad sector alignment of those areas. These have been a key building block for the econometric analysis.



Upstream and downstream ecosystem

The first aspect of building a coherent framework for photonics in Northern Ireland was to build a better understanding of the upstream and downstream ecosystem present within the photonics industry - not just within Northern Ireland but also one reflected across most major economies and throughout the broader, interconnected, international photonics industry.

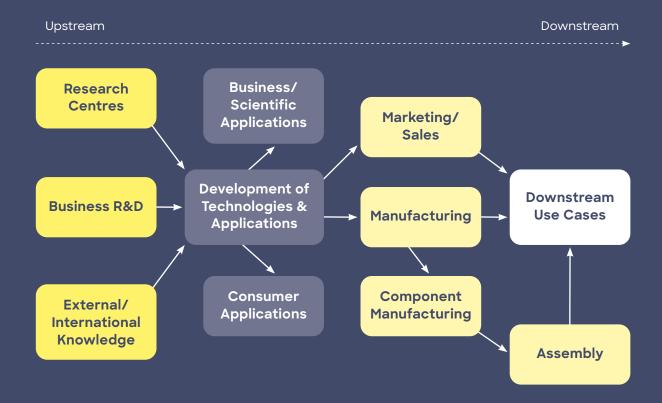
At the upstream level we find research centres, business-based research and development, and expert or international knowledge - each acting as a source of innovation and development that feeds further downstream into the photonics ecosystem.

These feed into the development or advancement of new or existing photonics technologies and

applications - with these applications being split, though not always neatly, into business or scientific applications and those applications more explicitly aimed at consumer use or demand.

In turn, these developments move further downstream to organisations involved either in the marketing or sales of these technologies or applications and those involved directly in the manufacturing, component manufacturing, assembly or packaging of photonics technologies.

Finally these drive downstream use cases and the wider adoption of photonics technologies amongst photonics engaged businesses, amongst those in ancillary or related industries, and through wider consumer or business adoption.



Framework for photonics in Northern Ireland

Turning to the Northern Ireland photonics sector explicitly, and in light of the needs of this project to identify key opportunities and growth areas within photonics in Northern Ireland, a framework that helps to further sub-divide the broad range of photonics applications and use cases into a more manageable and approachable structure

The structure taken forward within this report is one adapted from the Photonics UK classification of the broader UK photonics industry - adapted slightly to better suit the unique and existing ecosystem within Northern Ireland more specifically.

This adaptation was undertaken through consultation with both the Matrix Steering Group attached to this committee and with wider Northern Ireland sector experts and represents a broad framework of key photonics areas active within the Northern Ireland economy.

This has resulted in a slightly narrower classification, with areas such as solar power, augmented/virtual reality, and solidstate lighting being excluded due to low representation in the analysis of available Northern Ireland sector data - and with materials processing, a relatively low footprint sub-area within explicitly photonics-focused industry within Northern Ireland, being incorporated into the broader umbrella of directed energy.

This structure allowed us to break the photonics sector in Northern Ireland down into twelve, often interlinked but inherently different, sub-areas of photonics - broadly aligned by their applications or type of photonics technology used.

The twelve areas, used as a framework throughout the rest of this report, are as follows:

Area	Summary
Advanced Sensors Observation	These sensors utilize light particles (photons) to detect, measure, and analyse different parameters such as light intensity, wavelength, phase, and polarization. One of their key advantages lies in their ability to offer highly sensitive, fast, and accurate measurements across a wide range of applications - with advancements around miniaturisation and other areas increasing their usability and applications.
Astronomy / Telescope / Earth Observation	Astrophotonics is the use of photonic techniques and devices to manipulate our collection and processing of light for the purpose of improving our ability to probe and hence understand the universe. It combines photonics technology with astronomical instrumentation to improve telescope capabilities and reduce costs. It leverages techniques like fibre optics and integrated photonic circuits to miniaturise instruments, increase multiplexing, and enable new photonic functions for astronomical observations.
Bio-photonics	Bio-photonics concerns the application of photonics to the life sciences, often exploiting the chemical specificity that is provided via the interaction of ultraviolet, visible and NIR radiation with electronic and vibrational transitions of molecules associated with biological tissues as an aspect of molecular biology. This has large applications to human health but also applies to wider environmental life sciences. Biophotonics employs various optical techniques, including microscopy, spectroscopy, and imaging modalities like Optical Coherence Tomography (OCT), to visualize and analyse biological structures and processes.
Data Storage	Photonics enables ultra-fast, energy-efficient data storage by manipulating light instead of electricity. Using optical signals, it allows higher density, faster retrieval, and lower heat generation compared to traditional electronics. Advances in photonic memory and integrated circuits promise scalable, sustainable solutions for meeting future data storage and processing demands.
Directed Energy	Directed energy photonics involves using concentrated electromagnetic energy, often in the form of lasers, to enable a wide range of technologies and applications – across defence, manufacturing, optical communications, human health activities, printing systems, and power transfer. These can range in size from micro-lasers used in microscopic research through to large scale lasers for use in drone defence or in space communication. This area incorporates some materials processing organisations due to their use of directed energy.
Machine Vision	Machine vision optics are optics and optical elements (illuminators, lenses, mirrors, prisms, and other optical elements) that are designed and built to enable visual inspection to be carried out in an automated manner, i.e., by a machine. Many tasks can potentially be tackled with machine vision systems, such as detection of cancer, classification of fruits into different grades, inspection of pass/fail on a production line, estimation of tumour volume, determination of crop ripeness, etc.

Manufacturing	Neuromorphic computing is inspired by the mechanisms of the human brain and uses physical, artificial neurons for computations. Photonics integration has the capability to reduce latencies, reduce heat dissipation and increasing functionality at high speeds.
Optical Communications	Photonics and optical communications are intertwined technologies where photonics, the science of light, is the foundation for building and operating optical communication systems. These systems utilize light to transmit data over long distances with minimal signal loss, forming the backbone of global communication networks.
Photonic Materials	Photonic materials are substances designed to interact with light, enabling its generation, detection, and manipulation. These materials play a crucial role in various technologies, including telecommunications, data storage, and energy-efficient lighting. These materials can be used to create devices or systems that focus, split or modulate light beams - and play a supportive role across a range of other photonic applications and use cases.
Quantum Photonics	Quantum photonics is a field that utilizes quantum optics principles to generate, manipulate, and detect individual photons. This field plays a crucial role in advancing technologies like quantum computing, quantum key distribution, and quantum metrology - as well as assisting in wider quantum research that includes the synthesising of quantum and photonic materials.
Situational Awareness / Autonomous Sensing	By leveraging the power of light, photonic sensors can provide precise measurements and enable advanced features like LiDAR (Light Detection and Ranging) and machine vision. This integration of photonics allows for high-speed data transfer and low power consumption, making it an ideal solution for complex autonomous systems. The reduced size, and often energy cost, of photonic sensors can help support autonomous systems by reducing energy need and allowing for wider networks of sensors - while also enabling greater real-time sensing capacity.
Spectroscopy / Spectral	Encompasses the analysis of how matter interacts with light, particularly by studying how it absorbs, emits, or scatters light. This analysis provides information about the composition, structure, and properties of the substance being studied and is integral to both sensing and monitoring systems, to research into pharmaceuticals, and to the analysis and synthesis of new photonic or quantum materials for use in other sectors. Has particular use due to its generally non-invasive nature – enabling wider applications in human health and in sensitive manufacturing applications.

4.2 The landscape of photonics in Northern **Ireland**

The photonics sector in Northern Ireland is characterised by both strong, internationally recognised anchor institutions and a more fragmented ecosystem of largely smaller organisations.

At the foundation of the ecosystem sits a strong academic base, with Queen's University Belfast (QUB) and Ulster University providing research excellence, skills development, and established links into industry. Both institutions maintain active programmes in areas aligned with photonics, supporting advanced materials, imaging, sensors and data communications. These academic drivers ensure a pipeline of innovation and a talent base that can feed into industrial activity.

The industrial landscape is anchored by two globally significant players: Seagate and Thales. Seagate, in particular, represents one of the most important centres of photonics-enabled research and manufacturing activity in the UK, with its operations forming a major hub for data storage technologies. The scale and significance of Seagate's local investment places Northern Ireland firmly on the global photonics map. Thales, meanwhile, contributes specialist defence and aerospace capabilities, with sophisticated applications in sensing, imaging, and secure communications. Together, these companies provide both an anchor for the sector and an international profile that smaller firms can leverage.

Beyond these major players, the photonics ecosystem in Northern Ireland is diverse but often atomised. A range of SMEs and niche businesses are active across research, development, application engineering, testing, and systems integration. These firms cover an array of photonics-related domains, but their activities are not always connected or visible within a coherent sector identity.

Figure 3: Landscape of photonics organisations in Northern Ireland



Complicating the picture further is a wider industrial base that makes significant use of photonics technologies but does not appear to identify as part of the photonics sector. Companies in manufacturing, healthcare, agri-tech, and digital technologies may deploy lasers, optics, or imaging systems as core enablers of their processes, but often without an explicit awareness of their role within the broader photonics economy. This creates both a challenge and an opportunity: with greater visibility, these users could become active contributors to the growth of the sector.

Seagate's facility in Northern Ireland is one of only five recording head plants in the world and has nano-manufacturing capability unique within the UK, which is capable of creating nanoscale dimensions smaller than any other UK site.

THALES

Overview: organisations in the Northern Ireland **Photonics space**

Below are some brief profiles of organisations in the Northern Ireland photonics landscape. Some are highly significant global players, others smaller and locally focussed organisations. These organisations have been selected for inclusion here either because of the significance of their operation, they represent part of the photonics framework, or they engaged with our project to provide information.

Thales is a global technology leader with more than 83,000 employees on five continents with most of its UK operations based out of its Belfast site.

The Group is investing in digital and "deep tech" innovations - Big Data, artificial intelligence, connectivity, cybersecurity and quantum technology - to strengthen its existing engagement in the defence and space sectors, with photonics research and development featuring across significant parts of its portfolio.



As the largest manufacturers of hard disk drives in the world, Seagate's Derry/ Londonderry factory and development centre is a core part of Seagate's global operations in this space.

One in every four hard drives in the world use recording heads manufactured at the plant.

Seagate has been engaged in a multiyear research and development effort to bring the photonics-supported Heat Assisted Magnetic Recording (HAMR) technology to market, and has completed the resulting product launch, named Mozaic. The Northern Ireland team successfully delivered new technologies to the HAMR effort in this time with specific recent focus on integrated lasers and integrated photonics.



Originating out of Queen's University Belfast in 1989, Andor has matured into a significant photonics organisation, measuring light down to a single photon and capturing events occurring within 1 billionth of a second.

Andor provides over 70 unique product solutions, with 10,000 customers in 55 countries and 400 staff in 16 offices worldwide including the UK, China, Japan and the USA and has been a part of the Oxford Instruments group since 2014 and sits as 1 of 7 businesses within the Group.



Based out of Lisburn, Camlin provides technological solutions to support and monitor the critical infrastructures that people, cities and communities around the world depend on.

Camlin provides smart, monitoring, solutions for electricity network faults and load management, monitoring and asset management enables electricity networks to run more smoothly, safely and sustainably. The organisation also provides systems and software for railway operators to help keep trains running in peak condition, enable reduced service interruptions and allow staff to work more safely.



Established in 2010, Cirdan is a leading provider of informatics software and imaging solutions that enhance and speed up the diagnosis of patients. Headquartered in Lisburn, with offices in Canada and Australia, Cirdan is recognised as one of the leading suppliers of laboratory information systems worldwide.

Following the acquisition of Belfast-based Philips Digital and Computational Pathology business (formerly known as PathXL) in July 2020 Cirdan has added digital pathology education software to its product portfolio and enhanced its digital pathology and artificial intelligence capabilities.



Causeway Sensors Limited, a Queen's University Spin Out Company based in Belfast, is developing breakthrough plasmonic sensors for commercial application in the world of drug manufacturing.

The beta programme for its TITAN bioprocess analysis system, currently ongoing, is based on over two decades of world leading research in nanofabrication techniques and understandings of how nanostructures interact with light.



Founded in 1997 and operating in Northern Ireland directly through its Northern Ireland offices since 2019, Amon Electronics Ltd is a leading distributor and Automation Specialist in the areas of Industrial Automation, Drive and products systems and solutions.

For over two decades Amon Limited has been delivering successful automation solutions to a variety of markets, including Pharmaceuticals, Life Sciences, Chemicals, Consumer Products, Plastics, Printing, Paper Production, Electronics, Food & Beverage, Transportation, Energy, and Military.



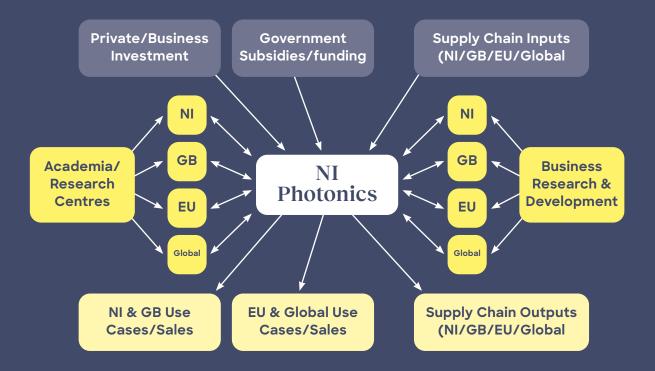
Based in Belfast, Inov8 Systems was created to research, develop and produce the innovative instrumentation and control systems - including, but not limited to, photonics measurement and monitoring applications - for use in sectors including Oil & Gas and Manufacturing & Chemical Processing.

Inov8's analysis systems are deployed in locations all around the globe and the organisation continues to develop its technology in response to new challenges.

Mapping the Wider Ecosystem

It is important to note that detailed information on the structure and scope of Northern Ireland's photonics landscape has historically been limited. This lack of clarity has hindered strategic development. The present mapping exercise represents a significant step forward in establishing a clearer picture of the sector's assets and dynamics.

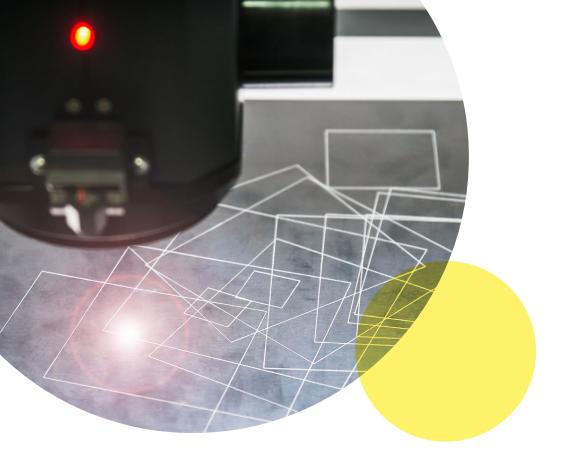
Figure 4: Mapping the wider ecosystem



The above mapping represents an outline of the relationship between the Northern Ireland photonics sector and other parts of the national and international photonics ecosystem.

This includes inputs from private or business investment, government subsidies or funding, as well as supply chain inputs from both national and international sources. It also indicates the back and forth relationship between the Northern Ireland sector and both academia / research centres and business research and development in both Northern Ireland and beyond – with expertise, innovation, research and applications moving both into and out of the Northern Ireland sector.

Finally, it also provides an overview of key outputs from the Northern Ireland photonics sector – including use cases and sales within Northern Ireland and Great Britain, use cases and sales within the EU and global markets, and supply chain outputs incorporated into wider assembly or production systems both within and outside Northern Ireland.



4.3 Photonics in the Wider World

Outside of Northern Ireland, photonics is increasingly a priority for many governments and institutions, though approaches vary considerably. Some regions emphasise competitiveness in semiconductors and photonic chips, while others prioritise manufacturing capacity, research and collaboration, or innovation-led growth.

In the European Union, photonics is viewed as a strategic technology underpinning industrial competitiveness, digital transformation, and sustainability. The EU benefits from a strong research base and a significant industrial base, but it faces significant challenges, including lower investment levels compared to global competitors such as the US and China, dependence on non-European sources for key raw materials, and the lack of an EU-wide photonics strategy.¹

Over the past decade, the EU funding approach has shifted from technology-led to market-driven, targeting areas such as health, ageing, and the environment, while public-private partnerships such as PhotonHub Europe and other coordinated initiatives continue to support industrial adoption.² ³ With targeted investment and dedicated policies, photonics could strengthen Europe's economic competitiveness and technological autonomy in the years ahead, but without significant action, there is a risk of further decline in its global standing.

¹ https://www.photonics21.org/download/ppp-services/photonics-downloads/230421_Supply_Chain_Report_Final_ C3.pdf?m=1682499310&

² https://www.optica-opn.org/home/industry/2024/may/photonics21_surveys_a_changing_landscape/

³ https://www.photonics21.org/about-us/photonics-ppp/

In the United States, photonics is closely tied to national priorities of economic competitiveness, technological dominance, and defence. Policymakers and industry leaders have framed photonics as both a driver of economic growth and a critical technology in the geopolitical competition with China.⁴ Federal and private investment in photonics research and development remains substantial, particularly in defence, semiconductors, and quantum technologies.5 Yet the current administration has cut back federal funding for research projects, bringing uncertainty around securing funding, and fears that this will limit international collaboration, with some concerned about the future of photonics in the US as a result.6

China has placed photonics at the centre of its long-term industrial and technological strategy. It directly links photonics to national objectives of self-sufficiency and global leadership in emerging technologies.7 With considerable national and regional funding, integration with national semiconductor and quantum strategies and a vast research network, China's photonics strategy is characterised by scale, speed, and clear government objectives. This is reflected in its national network of photonics clusters, with these clusters typically combining research institutes, start-ups, and large companies with state-backed infrastructure and investment.8 China is particularly focused on silicon photonics and photonic chips, with the sector viewed as a potential "leapfrog" technology that could enable the country to overtake the United States in semiconductor dominance.

While China is pushing toward global leadership in the field, challenges remain around the industry's dependence on state subsidies and questions about long-term success of its rapid commercialisation approach. Additionally, external pressures, particularly from US export controls and geopolitical scrutiny, may constrain global partnerships and access to key technologies.

Elsewhere, emerging economies are also expanding their focus on photonics. Brazil has integrated photonics into wider industrial policy, linking it to economic progress in sectors such as agriculture, telecommunications, and manufacturing, supported by growing research networks and new funding programmes.9 India's photonics sector is also relatively small but expected to grow quickly, driven by national strategies that link photonics to semiconductor manufacturing, quantum technologies, and self-sufficiency goals.¹⁰ The sector has a major focus on manufacturing, largely on developing silicon chips and Photonic Integrated Circuits (PICs). Both countries remain at early stages of industrialisation but are investing strategically to expand their roles in global value chains.

⁴ https://selectcommitteeontheccp.house.gov/sites/evo-subsites/selectcommitteeontheccp.house.gov/ files/evo-media-document/10.27.24 SCC Letter on Photonics.pdf

⁵ https://www.photonics21.org/download/news/2024/Analysis_of_US_grants_for_Photonics_RD__funding_ Final_0.pdf

⁶ https://spie.org/community-support/advocacy-and-public-policy/federal-science-funding?

⁷ https://en.ndrc.gov.cn/policies/202203/P020220315511326748336.pdf

⁸ https://www.photonics21.org/download/ppp-services/photonics-downloads/EAC_Photonics21_Political_ Steering_Processes_in_China_Final_Report_C3.pdf

⁹ https://crei.skoltech.ru/app/data/uploads/sites/33/2020/11/10_2020-WG-BRICS-Photonic-English.pdf

¹⁰ https://www.pib.gov.in/PressReleasePage.aspx?PRID=1969480

Overall, the global photonics landscape reflects a mix of strengths and challenges. The EU benefits from strong research capabilities but risks being outpaced by faster-moving competitors. The US boasts considerable private investment and worldclass institutions but faces uncertainty around policy and funding stability. China continues to scale rapidly, leveraging state backing to push for global leadership, though questions remain about sustainability and external pressures. Meanwhile, countries such as Brazil and India are positioning photonics as a strategic enabler of industrialisation and technological development. These strategies highlight photonics as a globally competitive field that is increasingly central to economic growth, security, and innovation.



5.0 Expert Perspectives

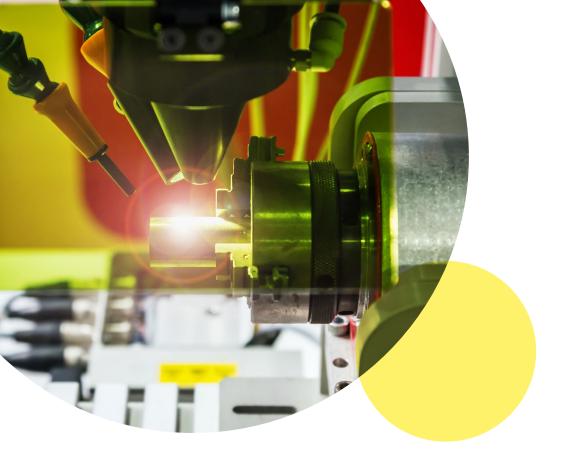
Throughout the research and analysis stage of this project a wide range of expert input and perspectives were sought. These expert perspectives provided insights on:

- The existing landscape of the photonics sector within Northern Ireland
- Strengths and weaknesses within the sector
- The relationship between Northern Ireland photonics and the rest of the European and global photonics markets
- Key future challenges and opportunities that will need to be overcome or maximised in order to strengthen the sector within Northern Ireland

More broadly, discussions also engaged with more specific elements of the photonics industry - highlighting key growth areas within photonics and feeding into the analysis of photonics sub-area opportunities that feature later in the report.

Name	Institution
Adnan Ahmad Cheema	Ulster University
Alan Wilson	Invest NI
Antony Murphy	Causeway Sensors
Beth McEvoy	QUB
David Quinn	QUB
David McGovern	Tyndall
Dr Cillian McPolin	Digital Catapult
Dr Katie Cavanagh	Yelo
Gerard Cooke	Innov8
Graham Wilson	Thales
James McLaughlin	Ulster University
Jason Wiggins	Smart Nano NI

Jo Wright	Digital Catapult
Marco Fiorentino	Hewlett Packard Enterprises
Mark Gubbins	Seagate
Mark Huddleston	jheSOLUTIONS Limited
Mark McAleer	Catalyst
Oded Raz	PhotonDelta Foundation
Patricia O'Hagan	Co-founder of Core Systems
Patrick Morrissey	Tyndall
Prof. Kenneth Grattan	City St Georges
Professor Jim Harkin	Ulster University
Raymond McQuaid	QUB/UKRI
Richard Furey	Yelo
Robert Bowman	QUB
Sharon Cousins	Invest NI
Dr Simon Grattan	Almac
Wim Bogaerts	University of Ghent



As an initial overview, throughout the interviews and discussions that have taken place across industry, academia, and government a few core themes and issues have arisen:

- Skills and education were core points of discussion, with interviewees highlighting brain drain to other areas of research, a lack of clear pathways from education and into photonicsrelated employment within Northern Ireland, and relatively low pay compared to both other competitor economies and sectors (e.g. computer science) as key issues.
- Tariffs and the international trade environment were also regularly highlighted as a concern - though not by all interviewees. Larger organisations remained generally more confident of navigating trade uncertainty, whilst others saw new trade barriers as a deeply problematic stumbling block likely to hinder further development of manufacturing capability within Northern Ireland.
- The scale and integration of Seagate Technology was repeatedly noted as a core strength of the NI photonics ecosystem offering established manufacturing capacity and international integration.

Outside of these three cross-cutting themes, expert perspectives also coalesced around several other areas including:

- Global growth areas for photonics
- Strengths and weaknesses of the Northern Ireland photonics sector
- The `Skills Question` and other educational and skills based issues within the UK and Northern Ireland economies
- Roles for government and for sector bodies in supporting the growth of Northern Ireland photonics
- Broader approaches to structuring a futurefacing Northern Ireland photonics sector
- The importance of, and approaches to, wider collaboration with both mainland UK and Republic of Ireland based photonics clusters and organisations
- Linkages between the Northern Ireland photonics sector and the international photonics market, as well as lessons to be learned from the global photonics markets

Global Growth Areas for Photonics

Interviews highlighted several core and ancillary growth areas across the wider photonics ecosystem:

- Data storage, bio-photonics, and optical communication were seen as both already well-developed areas and ones set to see further strong growth within the near-term future
- Sensing was also widely mentioned with often smaller individual applications but a large capacity for wider use across a range of sectors and industries
- Packaging was also as an area that will become more advanced as demand from other photonics areas grows - with a relative lack of competition from other established photonics clusters also noted
- In the longer-term, quantum computing and artificial intelligence were seen as areas likely to significantly advance, but real growth and concrete growth within photonics related applications likely lies outside the timeframe of this report
- Smaller more nimble areas (e.g. testing and packaging) seen as smaller prizes in terms of immediate economic returns but nevertheless highlighted as worth engaging with where skills and capacity exists within Northern Ireland
- The core message across the interviews was that the relatively established nature of the global photonics market, certainly when compared to the Northern Ireland sector, means it is likely to be extremely difficult - if not impossible - to compete everywhere on everything. Northern Ireland will need to pick its proverbial photonics battles and target areas of established capacity or achievable returns.

Strengths and Weaknesses of the Northern Ireland Photonics Sector

Discussions highlighted a range of existing strengths and weaknesses within the sector:

- Northern Ireland's proximity to both the UK and the EU was noted as a clear competitive advantage – offering the opportunity for close engagement with both interior and exterior markets and expertise
- The presence of `big players` such as Seagate and Thales within the Northern Ireland ecosystem offers a strong base from which it is possible to build a wider ecosystem around or alongside
- The academic knowledge base at both Queens University Belfast and Ulster University, and their strong ability to capture interested students from within Northern Ireland due to a relative lack of competition, adds to Northern Ireland's academic and research strengths
- Skills and education gaps remain a weakness though one not unique to Northern Ireland or indeed to the UK as a whole. Yet brain drain is a significant issue driven by competition both from the mainland UK and the Republic of Ireland and from US and European based competitors. Whilst a lower cost of living within Northern Ireland was noted, the relative inability of the sector to provide internationally competitive wages was repeatedly highlighted as a core issue
- The relatively small scale of the Northern Ireland photonics ecosystem and the broader economy is likely to hinder economies of scale as the Northern Ireland sector looks to expand
- Lack of government and sector body knowledge of the form and extent of the Northern Ireland photonics sector remains a real drag on further development weakening understandings of required support and sector needs.



The `Skills Question`

Lack of skills and wider issues around the education-to-employment pipeline were raised across a range of interviews:

- The current lack of knowledge of the wider Northern Ireland photonics ecosystem raises the difficulty of presenting clear pathways into work for students interested in photonics
- Other areas of research/skills gain are often perceived as having greater financial returns (e.g. computer science) or clearer pathways into jobs
- Concerns were raised that the focus on other areas of research (e.g. healthcare) at educational institutions could draw away funding or students from photonics - with several experts arguing that photonics needs to better sell its benefits and use cases in order to receive greater focus at an institutional level
- Upfront costs for PhD sponsorships and other education grants were seen as significant for individual businesses - with greater cross-sector, or cross-border, collaboration on educational funding noted as a possible solution
- More broadly within research an existing gap between applications development and external funding was repeatedly raised - highlighting a `chicken and egg` issue of needing to prove demand for innovative new photonics applications before receiving funding as a key blockage on academic research
- The foreign direct investment (FDI) landscape remains unclear and often opaque within Northern Ireland - with better funding systems in the US and EU - incentivising photonics start-ups to move abroad and further exacerbating existing brain drain.

Roles for Government and for Sector Bodies

Ways forward for both government and sector bodies to support Northern Ireland photonics emerged from the discussions:

- There was general agreement that it was important that direction of travel in Northern Ireland was led by sector rather than explicitly by government - but interviewees from a range of both industry and academic origins noted that it can be hard to find sector leadership that does not already have vested interests in parts of ecosystem
- The concept of a `matchmaking` body or role within the sector came up repeatedly - helping link different parts of the upstreamdownstream environment and supporting the building of new relationships or the unearthing of new applications. The Netherlands' PhotonDelta organisation was highlighted as an already existing example of this form of organisation
- More funding certainty from both the Northern Ireland and wider UK governments were seen as intrinsic to future success - though the possible impact of State Aid legislation on more significant central funding was also noted
- A `build it and they will come` concept emerged around sector leadership. A more active organising body will inevitably build more knowledge of the sector as it engages with it - allowing it to provide more targeted and effective support in turn

Broader Approaches to Structuring a Future-Facing Northern Ireland Photonics Sector

Several different, though often complementary, approaches to strengthening the Northern Ireland photonics ecosystem emerged:

- Seagate was highlighted as a core node around which the ecosystem can be strengthened - offering international recognition and an existing knowledge and industrial base that can be expanded to support other applications through its spare capacity and through current and future collaboration with other parts of the Northern Ireland photonics ecosystem
- A broader increase in collaboration and knowledge sharing across Northern Ireland was seen as required - with a lack of knowledge and a fear of competition between organisation acting as a drag on progress
- Building stronger links with both wider
 UK and Republic of Ireland based
 companies and academic centres is a
 key opportunity not solely in terms of
 business collaboration but also in regard
 to helping bridge skills gap and strengthen
 international recognition
- A focus on big developed areas, e.g.
 data storage, where Northern Ireland
 has competitive advantage is the most
 immediate opportunity to strengthen the
 ecosystem- but there will also be a need to
 develop more niche areas (e.g. packaging)
 that are not as internationally competitive
 and so can offer longer-term growth
 opportunities
- The Northern Ireland sector should not focus solely on fabrication, though the scale of existing capacity and opportunity is high. Outside of the largest Northern Ireland photonics companies, much of the sector's competitive is in applications and in development within its more diverse SME ecosystem
- Design can also play a key role here –
 especially as organisations, including
 Seagate, may have spare capacity in their
 production capabilities to support new

applications. Design and research agencies that can drive commercial applications from the research pipeline will need to be central to this more diversified *but* targeted future approach

Wider Collaboration with the UK and Republic of Ireland

The importance of collaboration outside of Northern Ireland was highlighted:

- Greater collaboration with other UK clusters was perceived as a clear future direction of travel. Existing concern that UK clusters may be in competition with each other was largely contradicted by the expert group with it being highlighted that the clusters tend to be complementary in their areas of focus rather than directly competing
- A renewal of more `Whole of Ireland`
 approaches to cross-border collaboration,
 on research, on operational collaboration,
 and on bridging skills gaps, was seen as
 a direct route to ameliorating existing
 weaknesses around skills and international
 recognition
- With Northern Ireland being a relatively small economy compared to many of its competitors, greater collaboration with both Republic of Ireland and wider-UK based organisations could help build economies of scale alongside international recognition

Linkages and Lessons from the International Photonics Ecosystem

Broader insights into the global photonics ecosystem also emerged:

- The success of the European Union photonics cluster system, as well as the support gained from central government efforts throughout the EU, was noted as a key example of how centring photonics can act as a significant accelerator for photonics within a region
- US was regarded as the global photonics leader - both in terms of demand for goods and services and as key player in research and development. This has both positive and negative roll-on impacts on Northern Ireland - offering a route for FDI and collaboration through strong US-NI cultural and business links but also driving brain drain within the sector
- Other global regions were also highlighted - with less business engagement but strong student engagement from Indian subcontinent. The Chinese photonics market was noted as both developed and large but geopolitical blocks on engagement remain and are likely to continue acting as a drag on investment or collaboration. Existing engagement with photonics clusters within South East Asia, including Vietnam, Taiwan, and Thailand, were also raised as key linkages.
- International geopolitical concerns, over both trade volatility and `black swan` events (e.g. disruption in the South China Sea region), remain a central area of concern amongst the experts who engaged on this project - with strengthening resilience and further diversifying the Northern Ireland photonics sector seen as important to shoring up against such risks.



6.0 Future Opportunities

6.1 Quantification: sizing future photonics opportunities

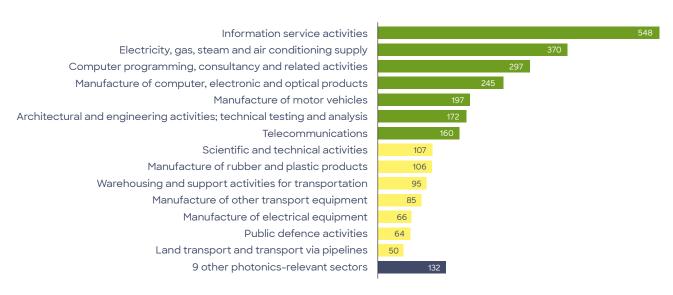
The potential opportunities afforded by the various areas of photonics development were quantified by applying the Photonics Framework (an output from the Literature Review stage of the project) to sector-wise projections of industrial output across twelve¹¹ OECD countries.

OECD publishes historical economic activity data, measured in terms of annual gross value added (GTA, in local currency) by sector, for each of the 12 countries. We converted these data series so that they were measured in US\$ to enable a total figure (across all countries combined) to be calculated, and to allow each country to be assessed with respect to its contribution to change within each sector. The Photonics Framework indicated that 23 industrial sectors included some photonicsrelevant activity; the quantification of photonics focussed on these 23 sectors.

The historical data series were used as inputs into simple linear regression models to produce forecasts of projected value added, for the whole economy and for each of the 23 photonicsrelevant sectors, for the years 2023 - 2030. These forecasts indicated that total projected GVA growth from 2023 to 2030 (across 23 photonicsrelevant sectors, combined over 12 OECD economies) amounts to US\$2,677b. Of the 23 photonics-relevant sectors, 21 were projected to see significant growth (of more than \$10b between 2023 and 2030); growth is projected to be largest in sectors such as Information service activities (growth of \$548b), Electricity supply (\$370b) and Computer programming (\$297b), all of which are likely to benefit from developments in photonics over the rest of the decade.

Chart: Projected combined growth in photonics-relevant sectors across 12 OECD economies

Growth from 2023 to 2030, \$b

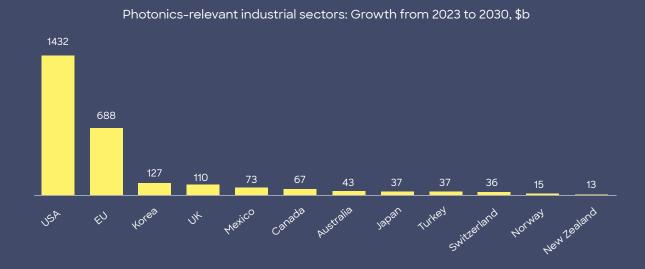


Industrial output analysis was conducted for 12 OECD entities: USA, EU, UK, Turkey, Switzerland, Norway, New Zealand, Mexico, Korea, Japan, Canada, Australia

Industrial output growth in the USA is projected to account for more than half (\$1,432b) of the total projected growth over the 12 economies combined, while projected output growth in the EU is projected to total \$688b across the 23 sectors. The US and EU are therefore the key OECD markets when considering the outlook for photonicsrelevant sectors overall.

Nevertheless, there are also significant opportunities in other OECD countries in specific sectors, and therefore in areas of photonics that are particularly relevant to those sectors.

Chart: Estimate of overall magnitude of the photonics opportunity arising from industrial output growth across the selected OECD markets



We used the Photonics framework to relate projected output growth to opportunity areas for photonics.

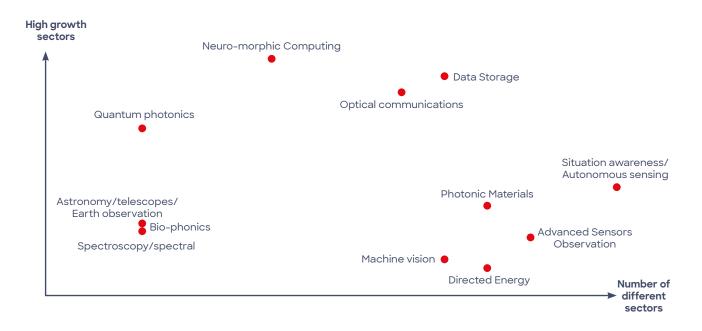
For each area of photonics development, the Photonics Framework identifies the industrial sectors that are likely to be affected by (or directly make use of) developments in the relevant area of photonics. For example, Optical communications represent an opportunity in the following sectors: Information service activities, Electricity supply; Computer programming; Telecommunications; Professional, scientific and technical activities; Civil engineering and specialised construction; Motion picture, video and TV production; Activities auxiliary to insurance and financial services.

Across the photonics-relevant industrial sectors, projected growth varies (both in magnitude and in the speed of projected growth). The growth outlook for each sector also varies across countries: due to their scale, the US and EU represent significant opportunities in all the sectors but selected sectors are also expected to grow significantly in other countries such as Electricity supply in Japan; IT services in the UK; Vehicle manufacturing in Mexico; Manufacture of Computer, electrical and optical products in Korea and Turkey.

We combined the sector-wise growth projections with the Photonics framework to impute growth projections for each area of photonics. For example, the opportunity in Optical communications is quantified by combining the growth outlooks of four sectors projected to grow strongly (Information service activities, Electricity supply; Computer programming; Telecommunications), one sector projected to grow fairly strongly (Professional, scientific and technical activities) and four sectors whose projected growth is moderate but nevertheless positive (Civil engineering and specialised construction; Motion picture, video and TV production; Activities auxiliary to insurance and financial services). Optical communications' relevance to four strong-growth sectors suggests that this photonics opportunity will benefit from being associated with numerous high-growth industrial sectors: in the mapping below it sits close to the top of the vertical axis.

Optical communications also sits towards the right of the horizontal axis since as a photonics opportunity it is relevant to a relatively large **number** of sectors. The horizontal position of each photonics opportunity area is determined by the number of sectors this type of photonics development is likely to be relevant to - see the Photonics Framework schematic above. This measure contrasts those photonics opportunities that tap into growth across a broad range of industrial sectors (towards the right) with those opportunities that narrower relevance across industrial sectors (towards the left).

Chart: extent of growth versus breadth of sector application



6.2 Opportunities in detail: specific areas of photonics

Using the results of this quantification we can identify specific export opportunities within each area of the photonics framework.

Within each area of photonics, some industrial sectors offer greater opportunity for growth than others, and some markets are particularly notable. For every area and every industrial sector, the largest markets are always the EU and the US.

In this section we illustrate the extent of likely growth in each industrial sector and the most notable markets, beyond the US and EU, that present export opportunities for photonics organisations in Northern Ireland. Industrial

areas shaded green are those that will see strong growth to 2030, those shaded yellow will see moderate growth and those shaded red will see weaker growth.

Situation awareness / autonomous sensing

Broad and robust growth. Total combined growth between 2023 and 2030 across the sectors relevant to this photonics activity: \$1,675 billion

Example opportunities include: Components of solar panels and wind-turbines; Development of gaming & other entertainment software; Optical precision instruments; computing and electronic components; Measuring & sensing components in vehicles, LiDAR

Industrial sectors	Notable markets (in addition to EU and US)
Electricity supply	Japan, Korea, Mexico
Computer programming	Canada, UK, Korea
Manufacture of computer, electronic & optical products	Korea, Mexico, Turkey
Manufacture of motor vehicles	Mexico, Korea, Japan
Professional, scientific and technical activities	UK, Australia, Korea
Manufacture of rubber and plastic products	Korea, Mexico, Turkey
Warehousing and support activities for transportation	UK, Korea, Australia
Manufacture of other transport equipment	Korea, Turkey, UK
Manufacture of electrical equipment	Mexico, Korea, Japan
Land transport and transport via pipelines	Mexico, Canada, Korea
Civil engineering and specialised construction activities	Mexico, Canada, NZ
Manufacture of machinery and equipment	Korea, Mexico, Switz
Manufacture of fabricated metal products	Korea, UK, Mexico

Optical Communications

Focussed, rapid growth. Total combined growth between 2023 and 2030 across the sectors relevant to this photonics activity \$1,569 billion

Example opportunities include: Apps, data hosting, web portals; Electrical supply networks; Networked gaming & other software

Industrial sectors	Notable markets (in addition to EU and US)
Information Services	UK, Korea, Japan
Electricity Supply	Mexico, Korea, Japan
Computer programming	UK, Korea, Canada
Telecommunications	UK, Korea, Canada
Professional, scientific and technical activities	UK, Korea, Australia
Civil engineering and specialised construction activities	New Zealand, Mexico, Canada
Motion picture, video and television production	UK, Mexico, Canada
Activities auxiliary to financial service and insurance activities	UK, Switzerland, Korea

Advanced sensors observation

Broad and robust growth. Total combined growth between 2023 and 2030 across the sectors relevant to this photonics activity \$1,445 billion

Example opportunities include: Solar panels and wind-turbines; Sensing components in computers, electronics & precision instruments; Sensing components in vehicles, LiDAR; Digital design & engineering; Optical networks

Industrial sectors	Notable markets (in addition to EU and US)		
Electricity Supply	Mexico, Korea, Japan		
Manufacture of computer, electronic & optical products	Turkey, Mexico, Korea		
Manufacture of motor vehicles, trailers and semi-trailers	Mexico, Korea, Japan		
Architectural and engineering activities	UK, Switzerland, Canada		
Telecommunications UK, Korea, Canada			
Professional, scientific and technical activities	UK, Korea, Australia		
Manufacture of electrical equipment	Mexico, Korea, Japan		
Public administration and defence; compulsory social security	UK, Korea, Canada		
Civil Engineering and Specialised construction activities	New Zealand, Mexico, Canada		
Manufacture of machinery and equipment	Switzerland, Mexico, Korea		
Human health and social work activities	UK, Korea, Australia		
Repair and installation of machinery and equipment	UK, Switzerland, Korea		

Photonic Materials

Broad and robust growth. Total combined growth between 2023 and 2030 across the sectors relevant to this photonics activity: \$1,404 billion

Example opportunities include: Solar panels and wind-turbines; Development of gaming & other entertainment software; Optical precision instruments; computing and electronic components; Optical communications networks

Industrial sectors	Notable markets (in addition to EU and US)		
Electricity supply	Japan, Korea, Mexico		
Computer programming	Canada, UK, Korea		
Manufacture of computer, electronic & optical products Korea, Mexico, Turkey			
Manufacture of motor vehicles	UK, Canada, Korea		
Professional, scientific and technical activities	UK, Australia, Korea		
Manufacture of rubber and plastic products	Korea, Mexico, Turkey		
Manufacture of electrical equipment	Mexico, Korea, Japan		
Manufacture of machinery and equipment	Korea, Mexico, Switz.		
Manufacture of fabricated metal products	Korea, UK, Mexico		
Human health and social work	Australia, UK, Korea		

Neuromorphic computing

Focussed, rapid growth. Total combined growth between 2023 and 2030 across the sectors relevant to this photonics activity \$1,212 billion

Example opportunities include: AI web applications; AI software development; Optical components; equipment for data centres; Experimental AI; AI adaptations for specialised & scientific applications

Industrial sectors	Notable markets (in addition to EU and US)
Information service activities	UK, Korea, Japan
Computer programming	UK, Korea, Canada
Manufacture of computer, electronic and optical products	Turkey, Mexico, Korea
Other professional, scientific and technical activities	UK, Korea, Australia
Human health and social work activities	UK, Korea, Australia

Data storage

Focussed, rapid growth. Total combined growth between 2023 and 2030 across the sectors relevant to this photonics activity \$994 billion

Example opportunities: Apps, data hosting, web portals; Research & experimental development; Scientific consulting & specialised design activities

Industrial sectors	Notable markets (in addition to EU and US)		
Information service activities	UK, Korea, Japan		
Other professional, scientific and technical activities	UK, Korea, Australia		
Manufacture of rubber and plastic products	Turkey, Mexico, Korea		
Manufacture of electrical equipment	Mexico, Korea, Japan		
Public administration and defence UK, Korea, Canada			
Civil Engineering and Specialised construction activities	New Zealand, Mexico, Canada		
Motion picture, video and television production	UK, Mexico, Canada		
Manufacture of machinery and equipment	Switzerland, Mexico, Korea		
Activities auxiliary to financial service	UK, Switzerland, Korea		
Repair and installation of machinery and equipment	UK, Switzerland, Korea		

Machine Vision

Dispersed opportunities. Total combined growth between 2023 and 2030 across the sectors relevant to this photonics activity \$823 billion

Example opportunities include: Optical visual components in precision instruments, computing and electronics; Networked and remote vision; Experimental R&D; Scientific consulting & specialised design activities

Industrial sectors	Notable markets (in addition to EU and US)		
Manufacture of computer, electronic and optical products	Turkey, Mexico, Korea		
Manufacture of motor vehicles, trailers and semi-trailers	Mexico, Korea, Japan		
Other professional, scientific and technical activities	UK, Korea, Australia		
Manufacture of rubber and plastic products	Turkey, Mexico, Korea		
Manufacture of other transport equipment	UK, Turkey, Korea		
Manufacture of electrical equipment	Mexico, Korea, Japan		
Manufacture of machinery and equipment	Switzerland, Mexico, Korea		
Manufacture of fabricated metal products	UK, Mexico, Korea		
Human health and social work activities	UK, Korea, Australia		

Directed energy

Dispersed opportunities. Total combined growth between 2023 and 2030 across the sectors relevant to this photonics activity \$763 billion

Example opportunities include: Remote/auto operated precision instruments and electronic devices; Networked remote operation of machinery; Experimental R&D; Scientific consulting & specialised design activities

Industrial sectors	Notable markets (in addition to EU and US)		
Manufacture of computer, electronic and optical products	Turkey, Mexico, Korea		
Telecommunications	UK, Korea, Canada		
Other professional, scientific and technical activities	UK, Korea, Australia		
Manufacture of other transport equipment	UK, Turkey, Korea		
Manufacture of electrical equipment	Mexico, Korea, Japan		
Civil Engineering and Specialised construction activities	New Zealand, Mexico, Canada		
Motion picture, video and television production	UK, Mexico, Canada		
Manufacture of machinery and equipment	Switzerland, Mexico, Korea		
Manufacture of fabricated metal products	UK, Mexico, Korea		
Human health and social work activities	UK, Korea, Australia		

Quantum Photonics

Narrow niches. Total combined growth between 2023 and 2030 across the sectors relevant to this photonics activity \$404 billion

Example opportunities include: Development of gaming & other entertainment software; Research & experimental development; Scientific consulting & specialised design activities

Industrial sectors	Notable markets
Computer programming, consultancy and related activities	UK, Korea, Canada
Other professional, scientific and technical activities	UK, Korea, Australia

Astrology/Telescopic/Earth Observation

Narrow niches. Total combined growth between 2023 and 2030 across the sectors relevant to this photonics activity \$142billion

Example opportunities include: Research & experimental development; Scientific consulting & specialised design activities; Robotics; optical and electrical instruments; Medical monitoring equipment

Industrial sectors	Notable markets
Other professional, scientific and technical activities	UK, Korea, Australia
Civil Engineering and Specialised construction activities	NZ, Mexico, Canada

Bio-photonics

Narrow niches. Total combined growth between 2023 and 2030 across the sectors relevant to this photonics activity \$121 billion

Example opportunities include: Research & experimental development; Scientific consulting & specialised design activities; Robotics; optical and electrical medical instruments; Prosthetics & in-body devices

Industrial sectors	Notable markets
Other professional, scientific and technical activities	UK, Korea, Australia
Human health and social work activities	UK, Korea, Australia

Spectroscopy / spectral

Narrow niches. Total combined growth between 2023 and 2030 across the sectors relevant to this photonics activity \$121 billion

Example opportunities include: Research & experimental development; Scientific consulting & specialised design activities; Utility projects for electricity & telecoms (satellites); Medical monitoring equipment

Industrial sectors	Notable markets
Other professional, scientific and technical activities	UK, Korea, Australia
Human health and social work activities	UK, Korea, Australia



7.0 Key Findings

7.1 Evaluating Opportunities

The economic assessments of global opportunities for photonics are an important component of the overall opportunity for Northern Ireland.

Based solely on the growth of industrial sectors across OECD nations, several areas (such as situational awareness, optical communications and advanced sensors observations) emerge as particularly strong economic opportunities for organisations within Northern Ireland.

However, other factors should also be considered, including the intensity of competition and existing skills or capability within Northern Ireland. The analysis below is based on an evaluation of six criteria:

- 1. Extent of growth in related OECD sectors (\$) projected to 2030
- Speed of growth (%) projected to 2030

- Breadth of applications (number of sectors area is potentially relevant to)
- Relevance to UK Industrial Strategy sectors
- Intensity of competition (beyond UK/NI)
- Strength of existing NI capability

Criteria 1-4 are evaluated based on the results of the sector analysis and economic forecasting. The photonics areas are ranked based on the relative size or rate of growth, breadth of applications or relevance to the UK's industrial strategy.

Criteria 5-6 are evaluated qualitatively, with both Trajectory and the project Steering Panel providing assessments (using the results of the earlier stages of work as a guide). Scores are then equalised on a 1-10 scale to enable comparability across the criteria. The results are shown below.

	Extent of growth to 2030 (10=high)	Speed of growth to 2030 (10 = high)	Breadth of applications (10 = high)	UK Industrial strategy relevance (10=high)	Intensity of competition (10=low)	Strength of existing capability (10=high)
Situation awareness / autonomous sensing	9.2	5.8	9.2	6.7	2	6
Optical Communications	8.3	7.5	4.2	7.5	10	2
Advanced sensors observation	7.5	1.7	8.3	9.2	9	7
Photonic Materials	6.7	5.0	7.5	6.7	4.4	4
Neuromorphic computing	5.8	9.2	3.3	3.3	6.6	4
Data storage	5.0	8.3	5.8	9.2	1	10
Machine Vision	4.2	0.8	5.8	6.7	9.6	6
Directed energy	3.3	0.0	7.5	6.7	6	2
Quantum Photonics	2.5	6.7	2.5	2.5	7	4
Astronomy / Telescopic / Earth Observation	1.7	2.5	2.5	1.7	6	4
Bio-photonics	0.8	4.2	2.5	1.7	4	8
Spectroscopy / spectral	0.8	4.2	2.5	1.7	9	6

All photonics areas in our framework offer some degree of growth potential, but the speed and extent of growth, as well as the range of applications, varies widely.

The table above identifies both economic and non-economic components of opportunity. Adding the scores across the six factors together means that Advanced Sensors Observation, Optical Communications, Data Storage, Situational Awareness/Autonomous Sensing and Photonic Materials emerge as the greatest opportunities (based on combined

However, none is without drawbacks or challenge. For example, situational awareness and data storage offer reasonably strong growth opportunities, medium-wide applicability and medium-high existing capability. But the intensity of competition in these areas is very high. Contrastingly, the intensity of competition in optical communications or advanced sensors observation is much lower - but either existing competition or the speed of growth is lower.

In addition, bio-photonics must be considered a strong opportunity for Northern Ireland given the strength of existing capability in the country. Growth metrics are relatively weak but the fact that Northern Ireland has an established sector means that this area should also be taken forward as an opportunity.

7.2 Photonics in Northern Ireland: a preliminary SWOT analysis

Strengths

Northern Ireland's photonics sector benefits from an established foothold, with the presence of large firms that combine fabrication capacity with international recognition. These companies not only demonstrate global competitiveness but also provide a platform for supporting the growth of other applications and organisations within the region.

The sector is characterised by a broad history of engagement and innovation across a wide range of photonics subfields. This diversity has fostered an ability to be agile, allowing Northern Ireland to respond quickly to early opportunities and emerging areas of growth.

Although the knowledge base is relatively small, it is highly specialised and robust. The strength of expertise available provides a solid foundation for research, development, and future expansion.

A further strategic advantage lies in Northern Ireland's unique dual-market access to both the UK and the EU. This position creates opportunities for international trade, crossborder collaboration, and attracting inward investment.

Photonics also aligns closely with existing regional strengths in electronics, sensors, and medical technologies, as well as with the ambitions of the Smart Nano NI project. This alignment enables the sector to draw on adjacent skills, facilities, and collaborative networks, reinforcing its potential as a hub for advanced technology innovation.

Relatedly, Northern Ireland's strong and established bio-photonics presence and size of the sector in NI (and globally) mean that even though growth metrics are low there is still significant opportunity for bio-photonics.

Weaknesses

The skills and education pipelines in Northern Ireland are not currently aligned with the specific needs of the photonics sector. This gap limits the development of a workforce with the appropriate technical expertise, creating challenges for both industry growth and research capacity.

There are difficulties in communicating and promoting photonics to wider stakeholder groups, including the public, students, and universities. The perception of photonics as a "high science" discipline can act as a barrier to engagement, reducing the pool of potential talent and weakening broader support for the sector. It also raises the risk of other areas of research or technology being perceived as more urgent.

Awareness of the photonics sector itself remains low, both within Northern Ireland and beyond. This lack of visibility reduces opportunities for collaboration, investment, and the attraction of new entrants into the field.

Uncertainty around funding pathways also presents a challenge. The absence of clear, consistent pipelines for financial support makes it difficult for organisations to plan long-term projects and to build confidence in sustained sectoral growth.

Finally, the sector suffers from a lack of clear direction and leadership. Without a unified identity or strong coordination, the visibility of Northern Ireland's photonics sector is weakened, and its potential influence on wider industrial or policy agendas is diminished.

Opportunities

Northern Ireland has spare manufacturing capacity that could be leveraged to support growth in photonics. This provides a practical platform for scaling up production and attracting new investment without the need for significant upfront infrastructure development. Developing such capabilities also requires significant lead time.

There are emerging opportunities in testing and packaging niches, where Northern Ireland could establish a competitive position. By focusing on these specialised areas, the sector can create distinctive strengths and add value to global supply

A whole-of-Ireland approach also presents significant potential. Closer collaboration across the island could unlock synergies in research, skills, and industry development, creating a more integrated and competitive photonics ecosystem.

Photonics sits at the convergence point with wider technological priorities, including government investments in artificial intelligence and quantum technologies. This alignment creates opportunities to embed photonics into future innovation strategies and to benefit from adjacent funding and policy support.

There are both East-West and North-South opportunities created by Northern Ireland's unique position. Continued access to the EU market remains an important advantage, particularly as European programmes continue to invest in advanced technologies. At the same time, both the UK and EU are increasing defence spending, which could create further demand for photonics-based solutions.

International dynamics could also play in the region's favour. Cuts to R&D funding and immigration constraints in the US may redirect talent, partnerships, and investment opportunities towards other regions, creating a window for Northern Ireland to strengthen its position.

Finally, there are new funding avenues opening up at both national and international levels. The Enhanced Investment Zone and other untapped initiatives could provide significant financial support to scale photonics activity, provided the sector is positioned to capture them effectively.

Threats

Geopolitical and trade uncertainty continues to pose risks to photonics activity, with potential disruption to international supply chains. Such instability can undermine the reliability of inputs and increase costs for firms operating in the region.

The sector's reliance on a small number of large, lynchpin companies operating within Northern Ireland also creates a potential vulnerability. If engagement from these firms weakens, it could significantly reduce momentum and threaten the stability of the wider photonics ecosystem in the region.

Competition for funding and policy attention presents another challenge. More accessible or urgent-seeming areas, such as life sciences and healthcare, risk dominating the research and innovation agenda, leaving photonics underrepresented in future investment priorities.

Global dynamics also shape the threat environment. The US approach to funding and competition has had the effect of weakening development efforts elsewhere, with the exception of China, where strong investment continues. This risks leaving Northern Ireland squeezed between major international players.

The lack of clear leadership or coordinated representation of the photonics sector on national and international stages further compounds these risks. Without strong advocacy, Northern Ireland may struggle to secure its share of investment, recognition, and collaboration opportunities.

Finally, supply chain fragility remains a pressing concern, particularly given reliance on Chinese and wider East Asian components. Disruptions in these regions could directly impact the capacity of Northern Ireland firms to deliver and compete effectively in global markets.



8.0 Recommendations Summary

8.1 Recommendations Summary

As a result of our findings, we make several recommendations for further action. These recommendations are designed to ensure that Northern Ireland's photonics capabilities continue to develop and that the economic opportunity from global growth in photonics enabled industries is realised.

These recommendations are introduced briefly below and then explored in more detail.

- Future proof major areas of opportunity. There are several areas of photonics that offer the greatest opportunity for the region. This research has identified Optical Communications, Situational Awareness, Advanced Sensors Observation, Photonic Materials and Data Storage as the areas representing the strongest opportunities for Northern Ireland's photonics sectors. In addition, Bio-Photonics is a particular opportunity for Northern Ireland given the strength of existing capability in the region (despite weaker growth prospects). Industry and government should take steps to future proof these areas of opportunity and develop long term plans to ensure continued development.
- 2. Invest in partnerships across UK and Republic of Ireland. Northern Ireland should look East-West and North-South to develop partnerships that maximise photonics potential. Collaborative funding opportunities could also be pursued across Ireland and the UK, accessing EU and UK funding where possible, sharing facilities, and aligning intellectual property strategies to maximise competitiveness.

- Focus on promotion of photonics to wider stakeholders. The opportunity for photonics in Northern Ireland will be greater if more businesses and organisations currently not using the technologies can be encouraged to do so. NIPIC should focus on the promotion of photonics to wider stakeholders and identify more SMEs who could be important components of a broader photonics ecosystem. Industry should also play a matchmaking role - helping to identify where photonics solutions could be leveraged to solve business problems.
- Exploit existing fabrication capabilities. Industry can utilise existing capabilities to position Northern Ireland as a photonics testbed location, working with public-sector partners to trial new technologies in real-world settings such as healthcare, agri-food, or environmental monitoring.
- Invest in skills development. DfE and wider Northern Ireland government should work with industry and academia to invest in skills and education pipelines aligned to photonics. Importantly, this should focus on both technical skills development and wider capabilities that support the integration of photonics systems into devices - for example, design capabilities.

8.2 Recommendations in detail

1. Future proof major areas of opportunity

There are several areas of photonics that offer the greatest opportunity for the region. This research has identified Optical Communications. Situational Awareness. Advanced Sensors Observation, Photonic Materials and Data Storage as the areas representing the strongest opportunities for Northern Ireland's photonics sectors. In addition, Bio-Photonics is a particular opportunity for Northern Ireland given the strength of existing capability in the region (despite weaker growth prospects).

Industry and government can take steps to future proof these areas of opportunity and develop long term plans to ensure continued development.

Actions

- (a) Government and industry to conduct SWOT analysis to identify vulnerabilities in supply chains and ecosystems in order to identify and mitigate future threats.
- (b) Industry to form consortia around priority application areas such as data storage, situational awareness/autonomous sensing, photonic materials, optical communications, and machine vision. These groups should pursue collaborative projects and export-oriented pilots.
- (c) Industry can take a leadership role in shaping sector strategy, ensuring industry voices set priorities, measure progress, and maintain visibility of Northern Ireland photonics at UK, EU, and international levels.
- (d) DfE should work closely with industry stakeholders and photonics leadership groups to conduct deeper investigations into these areas, including analysis of export and trade opportunities and longer term futures studies to identify opportunities and vulnerabilities.

2. Invest in partnerships across UK and Republic of Ireland

Northern Ireland should look East-West and North-South to develop partnerships that maximise photonics potential.

Republic of Ireland based organisations have expressed enthusiasm for greater cross border collaboration. Such a partnership could be used to further research, identify (and scale) commercial opportunities and bridge skills gaps through cross-border training/ employment schemes and educational support programmes enabling lower percompany PhD support costs and building clearer career pipelines through the Whole of Ireland schemes.

East-West and North-South collaboration can be promoted by incentivising joint R&D projects, shared facilities access, and collaborative PhD/Masters training between NI, the Republic of Ireland, and wider UK regions with photonics strengths.

Collaborative funding opportunities could also be pursued across Ireland and the UK, accessing EU and UK funding where possible, sharing facilities, and aligning intellectual property strategies to maximise competitiveness.

Actions

- (a) DfE has an important role to clarify and coordinate funding pathways for photonics R&D and commercialisation, ensuring businesses and universities can access national and international programmes (including UKRI, Horizon Europe, and Enhanced Investment Zone resources).
- (b) The Northern Ireland Executive should proactively seek photonics partnerships and collaborations with relevant UK and ROI government stakeholders.
- (c) Through existing bodies, industry could expand connections and develop strong partnerships with photonics organisations and clusters in the Republic of Ireland and the UK.

3. Focus on promotion of photonics to wider stakeholders

The opportunity for photonics in Northern Ireland will be greater if more businesses and organisations currently not using the technologies can be **encouraged to do so.** At the same time, an inherent weakness of photonics is its perception as high science - which makes it difficult to sell and difficult for wider stakeholders to grasp.

The promotion of photonics beyond established players should be a major priority for Northern Ireland in developing its photonics capabilities. NIPIC should focus on the promotion of photonics to wider stakeholders and identify more SMEs who could be important components of a broader photonics ecosystem. Industry should also play a matchmaking role - helping to identify where photonics solutions could be leveraged to solve business problems. PhotonDelta in the Netherlands offers an existing example of this kind of approach.

To support this function, DfE should commission a comprehensive business census and awareness survey to map existing photonics activity, identify gaps, and understand where companies in NI could adopt photonics solutions. This evidence base could guide targeted interventions and funding.

Actions

- (a) Invest NI should be encouraged to lead this role, supported by NI Executive
- (b) Government and industry collaborate to raise public and academic profile of the sector
- (c) Government to support identification of SMEs and potential collaborators through new business census
- (d) Industry stakeholders need to actively support and shape this promotions function to ensure its focus remains commercially relevant and internationally connected

4. Exploit existing fabrication capabilities

Existing fabrication capabilities in Northern Ireland are a huge asset but are not exhaustive.

Industry can utilise existing capabilities to position Northern Ireland as a photonics testbed location, working with public-sector partners to trial new technologies in real-world settings such as healthcare, agri-food, or environmental monitoring. There is also an opportunity to develop capabilities in areas away from fabrication and manufacturing (such as packaging and testing) that would provide some protection from supply chain uncertainty and would offer opportunities due to a relative lack of established international competition in the current photonics ecosystem.

Actions

- (a) Industry should focus on prototyping new applications for specific sectors - such as life sciences, agri-tech and food safety - that would require mid-scale volumes rather than mass market fabrication volumes.
- (b) DfE can support industry efforts to develop testing, packaging, and mid-scale manufacturing capability through shared facilities and targeted investment.

5. Invest in skills development

DfE and wider Northern Ireland government should work with industry and academia to invest in skills and education pipelines aligned to photonics.

Importantly, this should focus on both technical skills development and wider capabilities that support the integration of photonics systems into devices - for example, design capabilities. Industry should be closely involved in this process to ensure applicability and relevance. This should include curriculum development in universities and FE colleges, apprenticeships and professional upskilling programmes.

Actions:

- (a) Industry should support design of talent pipelines with universities and colleges, offering placements, apprenticeships, and joint curriculum development
- (b) Government should support the development of the relevant courses and teaching facilities, taking advantage of cross border funding initiatives where possible
- (c) Industry and government to collaborate to establish links with the Republic of Ireland and UK clusters to scale impact.



9.0 Appendix

9.1 Photonics organisations in Northern Ireland

Area	Key Organisations	
Advanced Sensors	Andor	https://andor.oxinst.com/
Observation	Causeway Sensors	https://www.causewaysensors.com/
	Raptor Photonics	https://www.raptorphotonics.com/
	Sengenia Limited	https://www.sengenia.com/
Astronomy / Telescope	IconicRF	http://www.iconicrf.com/
/ Earth Observation	Thales	https://www.thalesgroup.com
Bio-photonics	Ace45	https://ace45.co.uk/
	Almac	https://www.almacgroup.com/
	Andor	https://andor.oxinst.com/
	Bicolour	https://www.biocolor.co.uk/
	Bio Panda	https://www.biopanda.co.uk/
	Causeway Sensors	https://www.causewaysensors.com/
	Ciga Healthcare	https://www.cigahealthcare.com/
	Cirdan	https://cirdan.com/
	Clonallon	https://clonallon.com/
	Examen	https://examenlab.com/
	IceMos	https://www.icemostech.com/
	Klas Tx	https://klastherapeutics.com/
	Photonics	https://www.photonicmeasurements.com/
	Measurements	Tittps / WWW.priotoriiorriousurorriorits.com/
	Raidmed	https://raidmed.com/
		https://www.randox.com/
	Randox	https://stimoxygen.com/
	StimOxyGen	Titips.//stimoxygen.com/
Data Storage	Seagate	https://www.seagate.com/gb/en/
Directed Energy	Engineering Machinery and services	https://engineering-machinery.ie/
	Nijen Stainless	https://nijenstainless.com/
	Seagate	https://www.seagate.com/gb/en/
	Thales	https://www.thalesgroup.com
	Lister Machine Tools	http://www.listermachinetools.co.uk/
	Yelo	https://www.yelo.co.uk/
Machine Vision	Andor	https://andor.oxinst.com/
	Amon Electronics	https://amonelectronics.com/about-us/
	ATC Automation	https://atcautomation.com/
Neuromorphic	Academic research	https://www.ulster.ac.uk/research/topic/
computing	centre at Ulster	computer-science/intelligent-systems-
	University	research-centre/teams/computational-
	- J	neuroscience-and-neural-engineering
	Academic research	https://www.qub.ac.uk/schools/eeecs/
	,	Research/computing-systems/

	and the second s	
Optical Communications	Kinsetsu NuPrint Technologies Scanmatix	https://kinsetsu.co.uk/ https://nuprintuk.com/ https://www.scanmatix.com/
Photonic Materials	Seagate Academic research centre at Ulster University	https://www.seagate.com/gb/en/ https://www.ulster.ac.uk/research/topic
	Academic research centre at QUB	https://www.qub.ac.uk/research- centres/quantum-materials- technologies/about/
Quantum Photonics	Andor Brolis Photonics Seagate	https://andor.oxinst.com/ https://brolis-defence.com/ https://www.seagate.com/gb/en/
Situational Awareness / Autonomous Sensing	Amon Electronics ATC Automation Brolis Photonics Nelipak Healthcare Packaging	https://amonelectronics.com/about-us/ https://atcautomation.com/ https://brolis-defence.com/ https://www.nelipak.com/
	Smiley Monroe Terex Corp	https://smileymonroe.com/ https://www.terex.com/
Spectroscopy / Spectral	Andor Camlin GE Grid Lisburn	https://andor.oxinst.com/ https://camlingroup.com/ https://www.gevernova.com/grid- solutions/ourcompany
	Inov8 Particular Sciences	https://inov8s.com/ https://particular.ie/

9.2 Photonics in the wider world - detailed exploration

Outside of Northern Ireland, photonics is increasingly a priority for many governments and institutions, though approaches vary considerably. Some regions emphasise competitiveness in semiconductors and photonic chips, while others prioritise manufacturing capacity, research and collaboration, or innovation-led growth.

European Union

The European Union (EU) views photonics as a strategic technology underpinning industrial competitiveness, digital transformation, and scientific progress. However, despite strong research capabilities and a significant industrial base, recent analyses indicate that the EU is lagging behind global competitors such as the United States and China in the race to dominate emerging technologies. A 2024 study commissioned by the European Commission concluded that the EU is currently "weak in the emerging technologies that will drive future growth".12 In order to reignite growth, it stressed that the EU needs to close the innovation gap with the US and China, coordinate decarbonisation and competitiveness strategies, increase security and reduce strategic dependencies.

Strategy and policy

The 2020 Industrial Strategy for Europe identified photonics as a Key Enabling Technology critical to the region's industrial future.13 Photonics is already a sizeable sector: in 2022, Europe (including the UK) accounted for around 16% of the global photonics market, with more than 5,000 SMEs directly employing over 400,000 people.14

The European photonics industry sees market sectors such as lighting, medical photonics, and optical components and systems as key strengths.

Despite this, investment levels are substantially below those of China. EU investments are typically in the millions, whilst China invests billions, and EU regulations usually have a much longer approval process. A 2023 survey conducted by Photonics21 found that 53% of European companies reported dependency on China for key goods and materials, with 65% stating that certain critical materials required for manufacturing are unavailable within Europe.¹⁵ In July 2024, 110 European associations issued a joint declaration calling for significant new investment in photonics to close this competitive gap.¹⁶ China is now competing in the sectors traditionally dominated by Europe, and as Photonics21 President Dr. Lutz Aschke argues, "Without significant investment, Europe faces the threat of losing ground in this crucial technology sector, which could undermine its economic competitiveness and technological independence".

While photonic chips are included within the scope of the European Chips Act (adopted in September 2023 to strengthen Europe's semiconductor ecosystem) there is currently no dedicated European photonics strategy.¹⁷ This has prompted calls for greater EU engagement in the future of photonics from the European photonics industry, highlighting the contrast with other technology sectors (such as electronic chips, batteries and photovoltaics), where the European Commission has conducted dependency reviews.18

In addition, the EU's funding approach to photonics has shifted over the past decade. It was previously technology-driven but today it uses a more market-based approach, aligning funding with EU societal priorities such as health, ageing, and the environment.19

- 12 https://commission.europa.eu/document/download/97e481fd-2dc3-412d-be4c-f152a8232961_ en?filename=The%20future%20of%20European%20competitiveness%20_%20A%20competitiveness%20 strategy%20for%20Europe.pdf
- 13 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0102
- 14 https://www.photonics21.org/download/ppp-services/photonics-downloads/Market_Research_Study_ Photonics_2024.pdf
- 15 https://www.photonics21.org/download/ppp-services/photonics-downloads/230421_Supply_Chain_Report_Final_ C3.pdf?m=1682499310&
- 16 https://www.photonics21.org/2024/experts-urge-eu-to-increase-investment-in-photonics-or-risk-falling-behindchina
- 17 https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-chipsact_en
- 18 https://www.photonics-france.org/250106_Joint%20Statement_C3.pdf
- 19 https://www.optica-opn.org/home/industry/2024/may/photonics21_surveys_a_changing_landscape/

Still. several initiatives demonstrate the EU's photonics focus. In April 2025, PhotonHub Europe launched its PHACTORY investment scheme, a €15 million programme running until 2028 to provide SMEs and mid-sized photonics companies with expert support, access to laboratories, and subsidies of up to 85% of project costs.²⁰ Under the European Chips Act, the EU has also allocated substantial funding to photonic semiconductors, including a €133 million investment in Dutch pilot production facilities in November 2024, as part of a wider €380 million fund under the Chips Joint Undertaking, a public-private partnership designed to strengthen Europe's semiconductor industry.²¹ Photonics could become a greater focus in the future, with the European Commission currently considering whether photonics should be classified as one of the key strategic digital technologies for EU research and innovation funding from 2027.²²

Industry and partnerships

The Photonics21 Technology Platform, representing more than 3,800 stakeholders across industry and academia, is a crucial centre of EU-level coordination.²³ In 2021, the EU relaunched a public-private partnership (PPP) with Photonics21 under Horizon Europe, running until 2027. This PPP aims to strengthen industrial leadership by stimulating privatesector R&D, promoting business-driven research and innovation and accelerating the development of photonic technologies.²⁴ Photonics21's 2023 Strategic Roadmap (2025-2030) identified nine strategic value chains, including health, renewable energy, automotive and mobility, and defence, where photonics is central to securing Europe's strategic autonomy.²⁵

The EU photonics network includes a range of other institutions and organisations, including the European Photonics Industry Consortium (EPIC). With over 800 member companies, EPIC researches and reports market intelligence, organises technical workshops, funding proposals and advocates and lobbies for photonics organisations.26 PhotonHub Europe, launched in 2021, functions as a onestop-shop to accelerate photonics adoption among SMEs through test-before-invest services, training, and business support.27 The EU has a strong research base, including educational institutions such as ICFO (Institute of Photonic Sciences, Spain), FEMTO-ST (France), and Fraunhofer institutes (Germany), as well as national initiatives, with the Dutch PhotonDelta standing out as a key example, providing end-to-end value chain support for photonic chips. Supported by the Dutch National Growth fund, it provides funding and subsidies to support startups, creation of new photonic chip applications, and development of infrastructure and talent.28

Europe also hosts a number of leading industrial players in photonics. These include Smart Photonics (Netherlands), a specialist in indium phosphide photonic integrated circuits; Jenoptik (Germany), active in photonic systems for healthcare, semiconductors, and smart mobility; TOPTICA Photonics (Germany), a leading manufacturer of lasers for quantum and scientific applications; and XFAB (Germany), a foundry group for semiconductor technologies, including silicon photonics.

- 20 https://www.photonhub.eu/general/eu-invests-15m-to-help-companies-supercharge-their-products-
- 21 https://www.reuters.com/world/europe/eu-invests-142-mln-dutch-photonic-chip-plants-2024-11-11/
- 22 https://digital-strategy.ec.europa.eu/en/activities/study-identify-digital-technologies-next-eu-researchand-innovation-fund
- 23 https://www.photonics21.org/about-us/photonics-ppp/
- 24 https://digital-strategy.ec.europa.eu/en/node/9810/printable/pdf
- 25 https://www.photonics21.org/download/ppp-services/photonics-downloads/Photonics21_Multi-annual_ Strategic_Roadmap_2023-2030.pdf
- 26 https://epic-photonics.com/the-association/
- 27 https://www.photonhub.eu/
- 28 https://www.photondelta.com/about/

Outlook

The EU's strengths lie in its strong research base, well-established photonics network, and globally recognised companies across lasers, integrated photonics, and fibre optics. Yet the region faces critical challenges: investment levels remain far below those of China, supply chains are vulnerable due to dependencies on non-European sources for key raw materials, and the lack of an EUwide photonics strategy means the region may struggle to compete on a global scale. With targeted investment and dedicated policies, photonics could strengthen Europe's economic competitiveness and technological autonomy in the years ahead, but without significant action, there is a risk of further decline in its global standing.

United States

In the United States, photonics is closely tied to national priorities of economic competitiveness, technological dominance, and defence. Policymakers and industry leaders have framed photonics as both a driver of economic growth and a critical technology in the geopolitical competition with China. Yet the current administration has brought uncertainty around funding and international collaboration that mean some are concerned about the future of photonics.

Strategy and Policy

Under the Biden Administration, R&D investment significantly increased, with total national expenditure reaching \$792 billion in 2021, representing 3.4% of GDP compared to the OECD average of 2.7%.²⁹ Of this, around three-quarters came from the private sector. Photonics has directly benefitted from these funding increases, receiving an estimated \$1.7 billion from federal and regional grants in 2023, with significant further funding allocated for military and aerospace uses.

The Defense Advanced Research Projects Agency (DARPA), for example, more than doubled its photonics budget between 2021 and 2023, from \$72 million to \$168.7 million.

Outside of defence, the US photonics landscape is shaped by several other federal funding strategies.

The Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act, signed into law in 2022, authorised \$52.7 billion in federal incentives for domestic semiconductor production and research over a 5-year period. The act also prohibits funding recipients from expanding semiconductor manufacturing in China and countries defined by US law as posing a national security threat to the US. The 2024 National Strategy on Microelectronics Research explicitly highlights photonics in relation to quantum technology, heterogeneous integration, and advanced packaging. Programmes such as the Small Business Innovation Research (SBIR) initiative also provide vital support, with around 15% of NASA and Department of Energy SBIR budgets between 2021 and 2023 directed toward photonics projects.³⁰ However, while these initiatives remain important, the Trump administration has criticised some as wasteful, calling for new funding models.

A defining feature of US policy is competition with China, especially in silicon photonics, with recent calls from state representatives urging the Department of Congress to investigate Chinese photonics companies and support domestic innovation within the field by expanding export controls to include Chinese photonics chips and photonics technologies.31

²⁹ https://www.photonics21.org/download/news/2024/Analysis_of_US_grants_for_Photonics_RD__funding_Final_0.

³⁰ https://www.photonics21.org/download/news/2024/Analysis_of_US_grants_for_Photonics_RD__funding_Final_0.

³¹ https://selectcommitteeontheccp.house.gov/sites/evo-subsites/selectcommitteeontheccp.house.gov/files/evomedia-document/10.27.24 SCC Letter on Photonics.pdf

Challenges and Uncertainties

Despite the historically strong focus, US photonics research now faces uncertainty. Under the current administration, federal research budgets have been cut, while tariffs have increased the cost of optical components by around 20%.³² Some projects have been delayed or downsized, raising concerns about a "brain drain" as researchers move to Europe and Asia in search of more secure funding.33 Industry voices, including the National Education Association and SPIE, the International Society for Optics and Photonics, warn that if policy makers do not act, this will cost the US its role as a global leader in photonics and innovation more broadly. In May 2025, SPIE launched a campaign urging urgent community action to fight against the cuts.34

Industry and Commercial Interests

US industry is heavily engaged in photonics, particularly in semiconductors, defence, and quantum technologies. Silicon photonics is a major focus for companies such as Intel, Nvidia, Broadcom, and AMD, while GlobalFoundries recently announced a \$16 billion expansion of US semiconductor production, including silicon photonics.³⁵ Defence and aerospace are also strong markets, illustrated by Gooch & Housego's expansion in the US through the recent acquisition of Global Photonics, and PsiQuantum's \$10.8 million Air Force Research Laboratory contract for quantum photonics.³⁶ ³⁷ Major firms include Lumentum, Thorlabs, Coherent, and IPG Photonics, supported by consortiums such as AmeriCOM that seek to expand US optoelectronics manufacturing.

Research and Academia

The United States has a strong network of photonics institutes that link academia, industry, and government. AIM Photonics, one of the Department of Defense's Manufacturing Innovation Institutes, receives around \$130 million annually to support silicon photonics development.38 Similar collaboration is seen from the National Photonics Initiative, which has worked to strengthen coordination between industry, government, and academia, and the Joint Directed Energy Transition Office (JDETO), which provides funding for basic and applied optics and photonics research with both domestic and international partners.3940 Other federal centres include Sandia National Laboratories' National Security Photonics Center and Lawrence Livermore National Laboratory's National Ignition Facility and Photon Science Directorate, both of which integrate photonics into defence, energy, and industrial competitiveness goals.41 42 Leading academic centres include Stanford's Photonics Research Center, the University of California Santa Barbara, and the University of Central Florida's College of Optics and Photonics.

Outlook

In the US, photonics plays a major role in national security, semiconductor competitiveness, and quantum technology development. The country benefits from enormous private-sector investment, worldleading academic institutions, and defencedriven R&D. However, recent funding cuts, rising costs, and international competition - particularly from China - pose major risks. If these challenges are not addressed, they could erode the US' position as a global leader in photonics.

- 32 https://budgetlab.yale.edu/research/state-us-tariffs-july-30-2025
- 33 https://www.electrooptics.com/article/photonics-peril-how-us-funding-cuts-will-set-groundbreakingscientific-research-long-term?check_logged_in=1
- 34 https://spie.org/community-support/advocacy-and-public-policy/federal-science-funding?
- 35 https://www.reuters.com/world/asia-pacific/globalfoundries-boosts-investment-plans-16-billion-withresearch-focus-2025-06-04/
- 36 https://optics.org/news/16/5/24
- 37 https://www.datacenterdynamics.com/en/news/psiquantum-signs-108m-contract-with-us-air-forcefor-quantum-photonics-research/
- 38 https://www.aimphotonics.com/
- 39 https://www.lightourfuture.org/
- 40 https://www.trmc.osd.mil/JDETO_Central.html
- 41 https://www.sandia.gov/mesa/nspc/
- 42 https://lasers.llnl.gov/about

China

China has placed photonics at the centre of its long-term technological and industrial strategy, linking it directly to national objectives of selfsufficiency and global leadership in emerging technologies. Photonics features in multiple national plans, most notably Made in China 2025 and the 14th Five-Year Plan (2021-2025) and is strongly tied to broader competitive aims around semiconductor and quantum technologies.

Strategy and policy

China's policy emphasises reducing reliance on foreign technology, building domestic value chains, and achieving leadership in critical and emerging technologies. First announced in 2015, Made in China 2025 set a target of 70% self-sufficiency in core components and materials by 2025, including photonics-related technologies.⁴³ The 14th Five-Year Plan has since reinforced this by prioritising stronger innovation, and reduced external reliance, including photonics as a part of the country's development plan.44 Additionally, the National Integrated Circuit Industry Investment Fund, also referred to as the "Big Fund," plays a major role in scaling China's photonics capacity. Its third phase (2024-2029) allocates an estimated £33 billion of funding with specific emphasis on integrated photonics.⁴⁵ The National Science and Technology Plan seeks to solve bottleneck problems by investing in basic research while accelerating commercialisation. Initiatives such as these provide multi-billion-pound financing to build out photonics ecosystems across China. In 2024, there were an estimated 1,000 photonics projects across the country.46

Whilst China is aiming to strengthen its competitiveness across technologies, it is particularly focused on silicon photonics and photonic chips, with the sector viewed as a potential "leapfrog" technology that could enable the country to overtake the United States in semiconductors.

Restrictions imposed by the US on traditional silicon chipmaking have accelerated Chinese investment into alternative pathways, including compound semiconductors, photonics, and quantum computing.

Industry

Much of China's photonics industry is geographically clustered, with major clusters located in eight different cities, with most having their own regional strategies and focus. Local governments and industry play a central role, with clusters typically combining research institutes, start-ups, and large companies with state-backed infrastructure and investment. Wuhan's "Optics Valley of China" is the largest, with significant photonics growth concentrated here. It hosts more than 200 laser equipment manufacturers and the Jiufengshan Laboratory, which recently demonstrated a silicon photonics breakthrough by integrating a laser light source into a silicon chip.⁴⁷ Shanghai is also emerging as a major hub, with approximately €130 million invested annually in silicon photonics and optical communication chips, while simultaneously building what it aims to become the world's largest photonics and quantum technology cluster. Additional clusters are based in Xi'an, Chengdu, Shenzhen, Changchun, Beijing, and Suzhou and Wuxi. Each is developing their own industrial specialisations, from advanced laser manufacturing to full-chain optical communications. Across these regions, local governments are expected to spend approximately €5 billion on photonics cluster development in the coming years. 20

China's photonic industry reflects the close integration of state, research institutions, and private enterprise. Huawei remains one of the country's most influential players, with substantial investment in optical communications and photonics research. Huagong Tech, partially stateowned and located in Wuhan's Optics Valley, is a leader in industrial laser equipment, investing a minimum of 5% of annual sales into R&D and maintaining multiple national-level research centres.48

- 43 https://cset.georgetown.edu/wp-content/uploads/t0432_made_in_china_2025_EN.pdf
- 44 https://en.ndrc.gov.cn/policies/202203/P020220315511326748336.pdf
- 45 https://www.photonics21.org/download/ppp-services/photonics-downloads/Presentation_EAC_Daniela_ Bartscher-Herold_Annual_Meeting_2024.pdf?m=1716477659&
- 46 https://www.photonics21.org/download/ppp-services/photonics-downloads/EAC_Photonics21_Political_Steering_ Processes_in_China_Final_Report_C3.pdf
- 47 https://www.digitimes.com/news/a20241008PD221/silicon-photonics-growth-technology-subsidy-laser.html
- 48 https://hgintl.hgtech.com.cn/AboutUs/index.htm

Han's Laser, headquartered in Shenzhen, has become one of the largest laser equipment manufacturers worldwide. 495051 Additionally. companies such as Hesai Technology, FocusLight Technologies, and HiSilicon (Huawei's semiconductor arm) are increasingly prominent in specialised markets ranging from LiDAR for autonomous vehicles to high-power laser optics and optical communication chips.52

Whilst extensive, China's photonic industry has been described as "strong in applications, weak in technologies, huge in markets, and low in profits".21

Research and innovation

Chinese universities and research institutes have also achieved a strong global research performance. Between 2019 and 2023, 46% of the world's highly cited publications on photonic sensors originated from China, illustrating both the scale and influence of its scientific base.53 National institutes like the Changchun Institute of Optics, Fine Mechanics and Physics (CIOMP) and the Institute of Optics and Electronics (Chinese Academy of Sciences, Chengdu) remain major research hubs, working closely with regional industrial parks and companies.5455

Outlook

China's photonics strategy is characterised by scale, speed, and clear government objectives. Considerable national and regional funding, integration with national semiconductor and quantum strategies and a vast research network see China pushing toward global leadership in the field. At the same time, there are challenges.

The industry's dependence on state subsidies and the rapid push towards commercial products raises questions about long-term success of this approach, whilst external pressures, particularly from US export controls and geopolitical scrutiny, may constrain global partnerships and access to key technologies.

Overall, China is positioning photonics as both a strategic substitute for restricted semiconductor pathways and as a crucial component of next-generation technologies. It is therefore likely to remain highly relevant to international competition with the European Union, the United States, and other advanced economies throughout the next decade.

Brazil

Brazil is an emerging player in photonics. with the government viewing photonics as an enabling technology that catalyses economic progress in sectors such as industry, agriculture and telecommunications. While the domestic industry is still in its infancy, the country has a strong research base, a growing network of companies, and recent large-scale investments in semiconductors and optical communications that demonstrate its capacity to expand.

National Policy and Strategic Priorities

Photonics has been included under Brazil's General Coordination of Enabling Technologies (CGTH) since 2017.56 Its central programme, the Brazilian Photonics Initiative (IPFóton), was launched in 2021 by the Ministry of Science, Technology and Innovations (MCTI). It aims to stimulate research and innovation, strengthen partnerships with industry, internationalise programmes, and develop human capital.⁵⁷

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- 54 http://english.ciomp.cas.cn/about/Brief/
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- 56 https://crei.skoltech.ru/app/data/uploads/sites/33/2020/11/10_2020-WG-BRICS-Photonic-English.pdf
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At the core of this strategy is the Brazilian Photonics Laboratories System (Sisfóton), a network of eleven labs, supported by the new Photonics Advisory Board (CCFOTO), established in 2023. Beyond this, the government has linked photonics and wider industrial policy- in 2024, Mission 4 of New Industry Brazil (NIB) announced £25 billion of funding from both the public and private sectors, while the Brazil Semicon Act committed £1 billion annually to the semiconductor and ICT sectors, including photonics applications.⁵⁸

Research and Academia

Brazil's photonics research ecosystem is broad and internationally connected. The National Institute of Photonics (INFO), comprising 21 institutions, focuses on nonlinear photonics, biophotonics, and device applications, while collaborating with partners abroad.⁵⁹ The Optics and Photonics Research Center (CePOF) develops both basic and applied science and engages closely with industry. Other notable centres include the Photonics Group at the Instituto de Física de São Carlos, the Photonics Laboratory (LAFOT) in Rio de Janeiro, and the University of Campinas' (UNICAMP) Photovoltaic Research Laboratory, linking photonics with energy technologies.

Industry

Although relatively young, Brazil's photonics industry is expanding, especially in lasers and optical communications.⁶⁰ A 2020 study identified over 300 manufacturers and 6,500 service providers, supported by nearly 700 research groups.⁶¹ Padtec, a multinational producer of optical communication systems, now competes with Nokia and Ciena in Latin America and is expanding into North America. 62 BR Labs Fotônica, a spin-off of UNICAMP and CePOF, develops optical devices and systems, while the Photonics Innovation Institute (iTech) supports technology transfer and industrial partnerships.⁶³ These firms reflect a gradual move from academia to industry.

This move is also supported by societies such as the Brazilian Optics and Photonics Society (SBFoton), which connects researchers. universities, and companies. It aims to increase research and innovation in optics and photonics, hosting annual international conferences as part of this effort.

Outlook

Brazil's photonics sector remains at an early stage of industrialisation, but strong public policies, international collaborations, and emerging firms are driving momentum. The government's integration of photonics into national industrial programmes demonstrates strategic intent, while the success of companies such as Padtec illustrate commercial potential. The sector still faces challenges, including a lack of advanced manufacturing facilities and as yet no wellestablished ecosystem of photonics firms, but Brazil's combination of research excellence and growing industrial policy commitment positions it as a significant emerging player in global photonics.

India

India's photonics sector is still relatively small but expected to grow quickly, driven by national strategies that link photonics to semiconductor manufacturing, quantum technologies, and selfsufficiency goals. The sector has a major focus on manufacturing, largely on developing silicon chips and Photonic Integrated Circuits (PICs).

National Policy and Strategic Priorities

Photonics in India is closely tied to the Atmanirbhar Bharat ("self-sufficient India") government mission, which aims for India to become more efficient, competitive, and resilient, while expanding its role in the global economy by developing India into a "global supply chain hub".64

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The Ministry of Electronics and Information Technology (MeitY) funds research into PICS across multiple materials-including silicon, lithium niobate, diamond, and polymers- while the National Quantum Mission, approved in 2023 with a budget of \$720 million, supports photonics applications in computing, secure communications, and quantum devices.65 The India Semiconductor Mission (ISM), launched with around \$1 billion in investments, further embeds photonics into the strategy for developing advanced semiconductor and display manufacturing.66

Industry and Manufacturing

The Indian photonics industry was valued at around \$3.5 billion in 2021, with expected annual growth of 12-15%.67 Although small on a global scale, the sector is gaining momentum, especially in optical communications and chip manufacturing. Sterlite Technologies, headquartered in Pune, is India's most established optical and digital technology company, with a Centre of Excellence in Aurangabad.⁶⁸ Newer firms such as Cloud Photonix are targeting high-speed transceivers and integrated photonics solutions, while international players such as Jabil are investing in new Indian facilities, including a planned silicon photonics site in Gujarat.⁶⁹ For the most part, industrial activity remains concentrated around southern universities and research hubs, reflecting close ties between academia and early-stage companies.

Research and Academia

Photonics in India has a strong academic base, with multiple research institutes across the country. The Centre for Programmable Photonic Integrated Circuits and Systems (CPPICS) at IIT Madras, established in 2021, is a flagship centre aiming to deliver selfsufficiency in PIC design and manufacturing within five years, with collaborations ranging from local startups to international foundries.7071 Additionally, the Photonics Research Laboratory at CeNSE, Bangalore, focuses on nonlinear optics, PICs, and plasmonic materials with active industry collaborations. Centres such as these play a crucial role in India's photonics sector, providing the necessary expertise and innovation for India's industrial ambitions.

The Optical Society of India (OSI), founded in 1965 and based at Calcutta University, provides a national forum for optics and photonics researchers and organises annual conferences.⁷² While smaller than its counterparts in Europe or North America, OSI supports networking and professional development across India's emerging photonics ecosystem.

Outlook

India's photonics sector is at a formative stage, marked by strong policy support, high research activity, and early industrial growth. Government strategy such as Atmanirbhar Bharat, the National Quantum Mission, and the India Semiconductor Mission highlight photonics as a strategic enabler of future technologies. While challenges remain in scaling up domestic manufacturing and building a globally competitive industrial base, rapid expansion seems likely in the coming decade.

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- 66 https://ism.gov.in/
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