Emerging Trends in Photonics

A patent-landscape cartography of eight fast-growing domains

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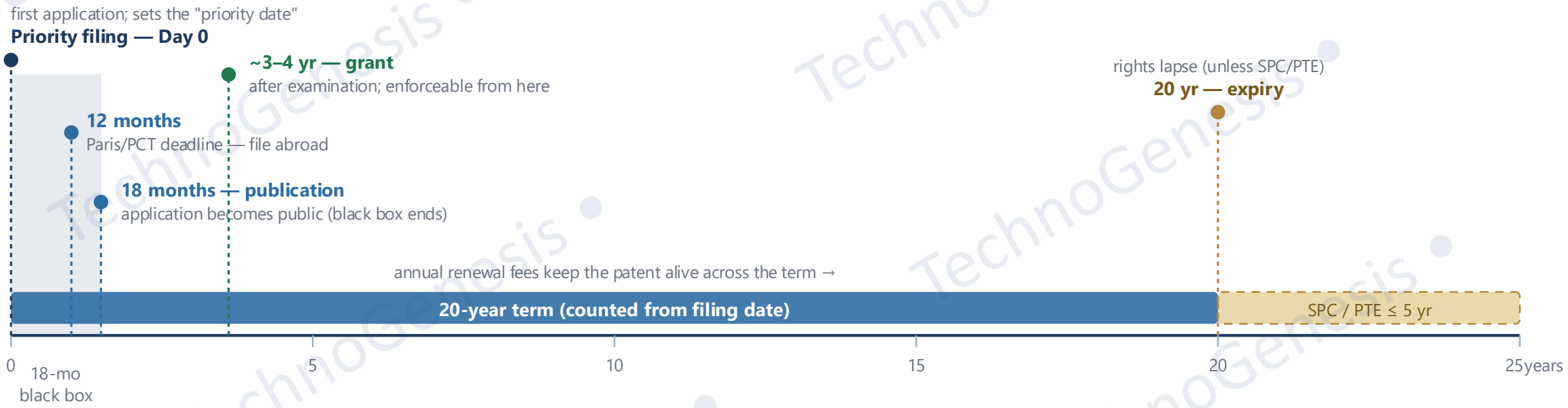
The lifetime of a patent

From priority filing to expiry — and why priority year ≠ publication year



Priority year -> when the invention was made · Publication/grant lag 1.5-4+ years · Time runs from the filing date, not grant.

Patent protection & earliest priority year

THREE ROUTEs TO PROTECTION

- **National** file office by office (US-USPTO, CN-CNIPA, KR-KIPO).
- **Regional** e.g EPO (EP) ~ covers 39 states, (UP) ~ covers 18 (last 2024)
- **International** PCT (WO); one filing reserves entry to ~ 150 countries for 30/31 months before national entry-> Is a route – no protection until national entry and grant!

RIGHTS & PROTECTION

- **Territorial** protects only where granted
- **Claims define the legal scope** scope of a granted patent can never be broader than the application as filled.
- **Publication** when provisional protection begins (depends on jurisdiction)
- **Grant** when enforceable protection begins.

PRIORITY YEAR = THE INVENTION MOMENT

- **Earliest priority year = when the invention was made**
- **Publication & Grant lag** 1.5-4+ years; long procedure which can be longer in some jurisdictions (e.g. postpone examination in Germany up to 7 years)

Methodology & Limitations in patent analysis

Methodology

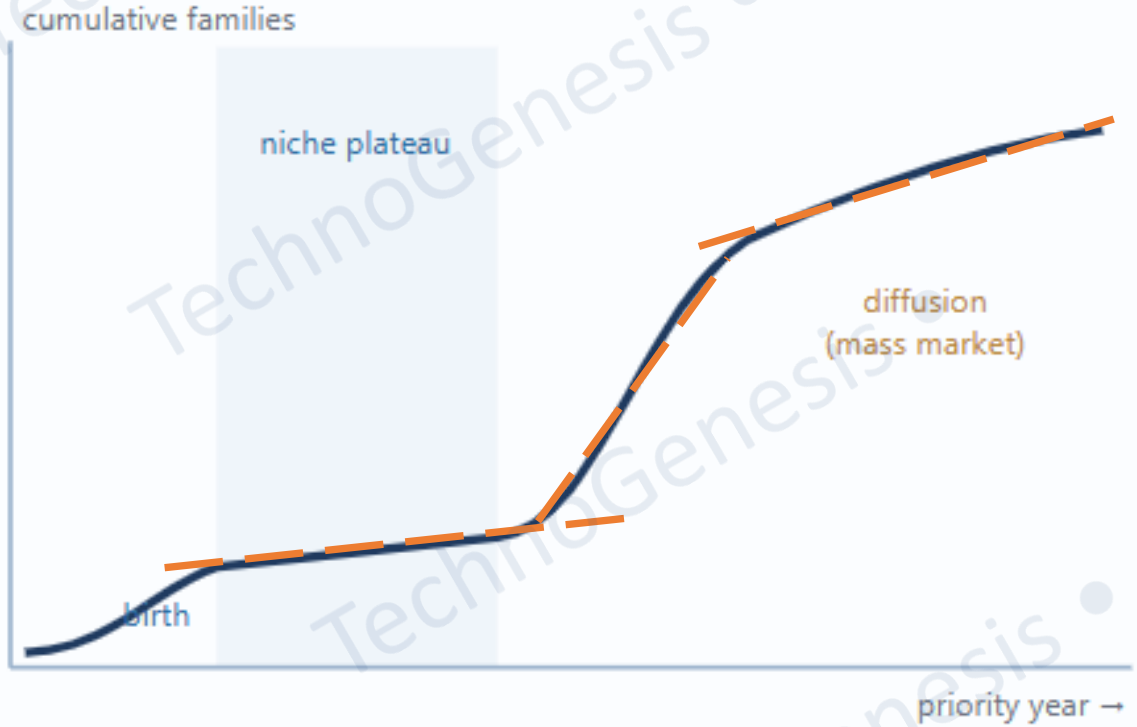
- **Patent families analysis** – Family as a unit, plot versus priority year.
- **Combination** of IPC/CPC classification codes (Technology) & Keywords. Codes bound the domain, keywords refine them and catch emerging technologies that classification misses. (e.g. hollow-core: G02B 6/02328, OCT: A61B5/0066). One patent application can carry several codes

The 18-month black box & even more!

- **Black box** Application stay secret ~18 months after earliest priority -> 18 last months can't be considered for an analysis
- **International routes** EP and WO (30/31 months to know)
- **Volume ≠ value like publication ≠ grant** Counts differ by source & scope.

To **take away:** a count measures activity, not rights or value.

The S-curve & Emergent technologies



THE LOGISTIC S-CURVE

- **Emergence ->** steep adoption (**invasion**) **-> saturation** (consolidation)
- **Natural law of how technology spreads** (Bejan & Lorent, 2011)*

*Bejan, A. & Lorente, S. (2011), "The constructal law origin of the logistics S curve," *Journal of Applied Physics*, 110, 024901.

THE TRAP

- A long flat middle can be a **niche/restricted phase**, not maturity.
- Read too early, can't give safe conclusions.

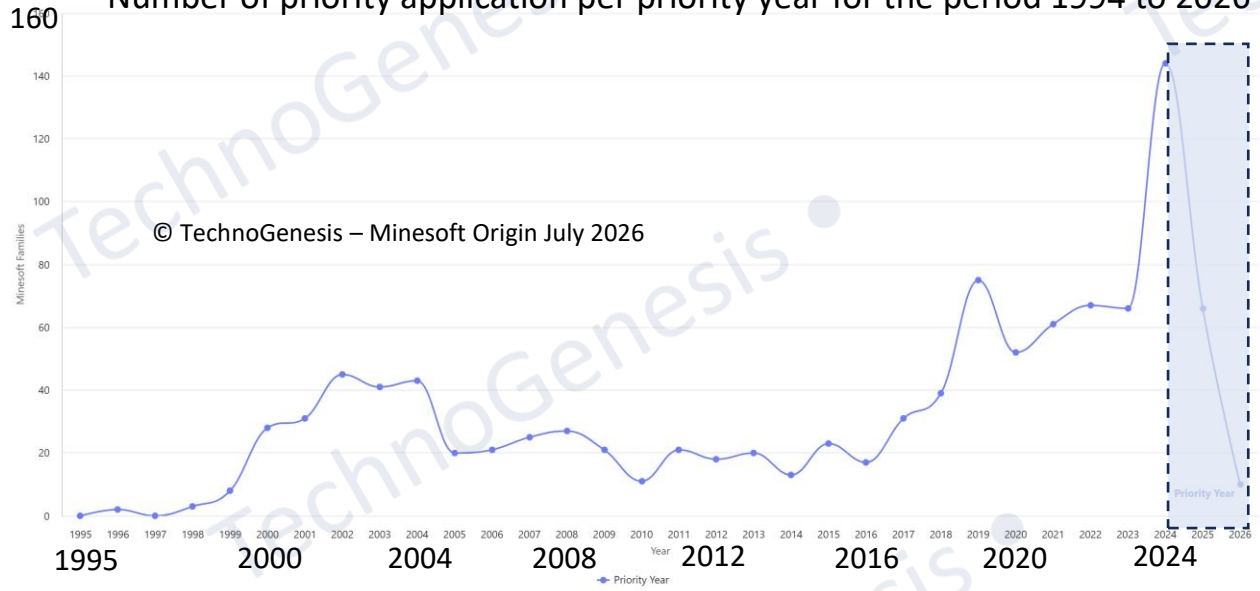
An S-curve is a hypothesis about diffusion and not a verdict on maturity

Hollow-core fibre

Studied in Minesoft Origin

Number of families per priority year & top assignees

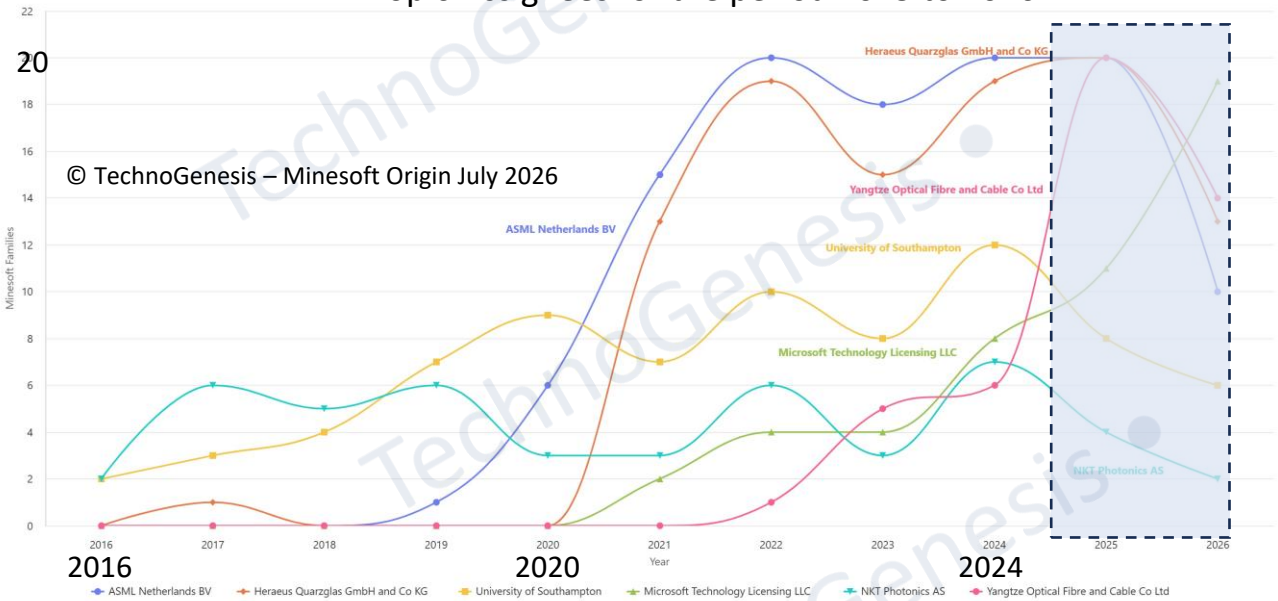
Number of priority application per priority year for the period 1994 to 2026



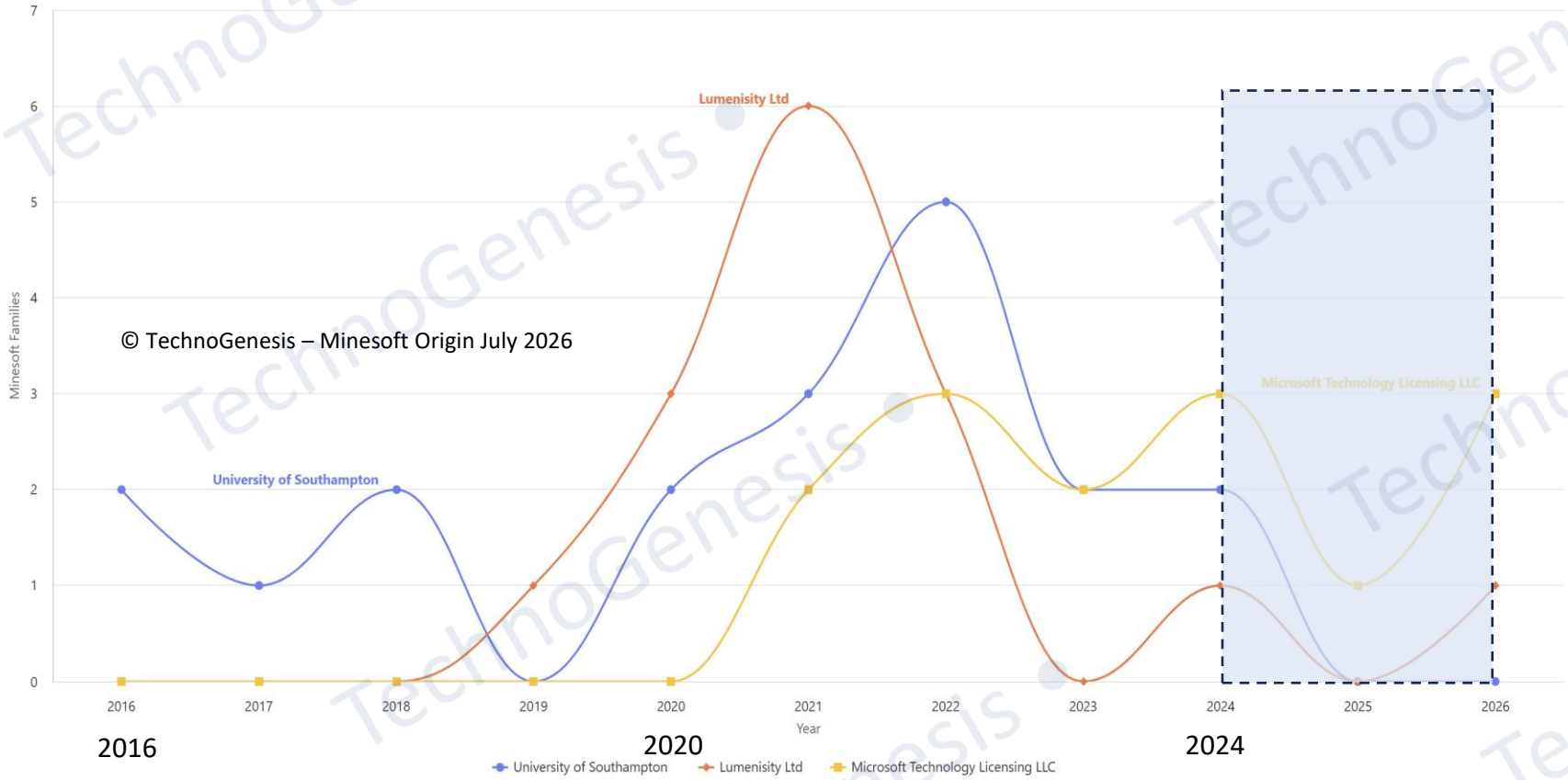
ASML: High-power beam delivery
Heraeus Quarzglas: Silica performer supplier
University of Southampton/Luminesity: Academic origin of NANF/DNANF
Microsoft Technology Licensing: Lumenisity acquisition
NKT Photonics: speciality fibre
Yangtze Optical Fibre & Cable: China's entry

- **Not one S-curve but two waves:** Family as a unit, plot versus priority year -> 2000-2004 (Photonic bandgap era), long plateau until 2013 (niche phase) & 2014 pulled by AI data-centre latency.
- **No plateau reached until now:** The domain is still open and white spaces remains (manufacturing, splicing and cabling process).

Top 6 Assignees for the period 2015 to 2026



Lumenisity: A Technology transfer story



University of Southampton -> Spin out **Lumenisity** -> Acquired by **Microsoft** December 2022

When does it matter? – Niche-first, mass-market-later

A priority-year S-curve tells you **when** something was invented - not **when**, or **where**, it will matter.

Technology	Early restricted application	Later Growth & Diffusion
Aerospace insulation (Airbus)	Aircraft thermal control	Building envelopes *
Fibre Bragg Gratings	Motorsport (F1) & Aerospace measuring strain/temperature	SHM: bridges, dams, pipelines, wind turbines, medical equipment **
Hollow-core fibre	High power delivery, gas sensing, gyroscopes	AI data-centre & HFT low-latency links
Adaptive optics	Military / astronomy (telescopes)	Ophthalmology, microscopy, free-space optics
LiDAR	Space / Military	Automotive & consumer

* *(Accepted Invited talk at* 16th Constructal Law Conf, 12-15Oct 2026, Paris*)*
Project collaboration between TechnoGenesis & PSL University, Paris

** *(FBG medical application)* Ren, H. (2020). *Flexible Robotics in Medicine: A Design Journey of Motion Generation Mechanisms and Biorobotic System Development*. Academic Press. https://doi.org/10.1016/C2018-0-00607-6

*** (image *taken from*) Mexis, M. (2004). *Fiber Bragg Grating Sensing Systems,* MSc Thesis, Aston University.

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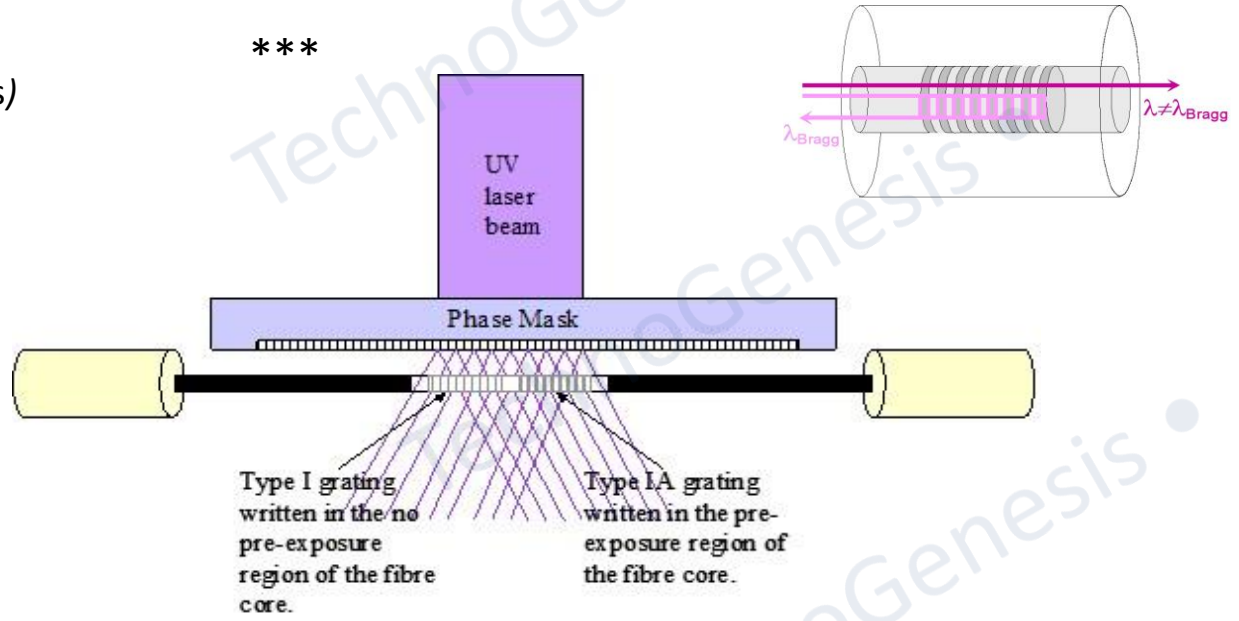
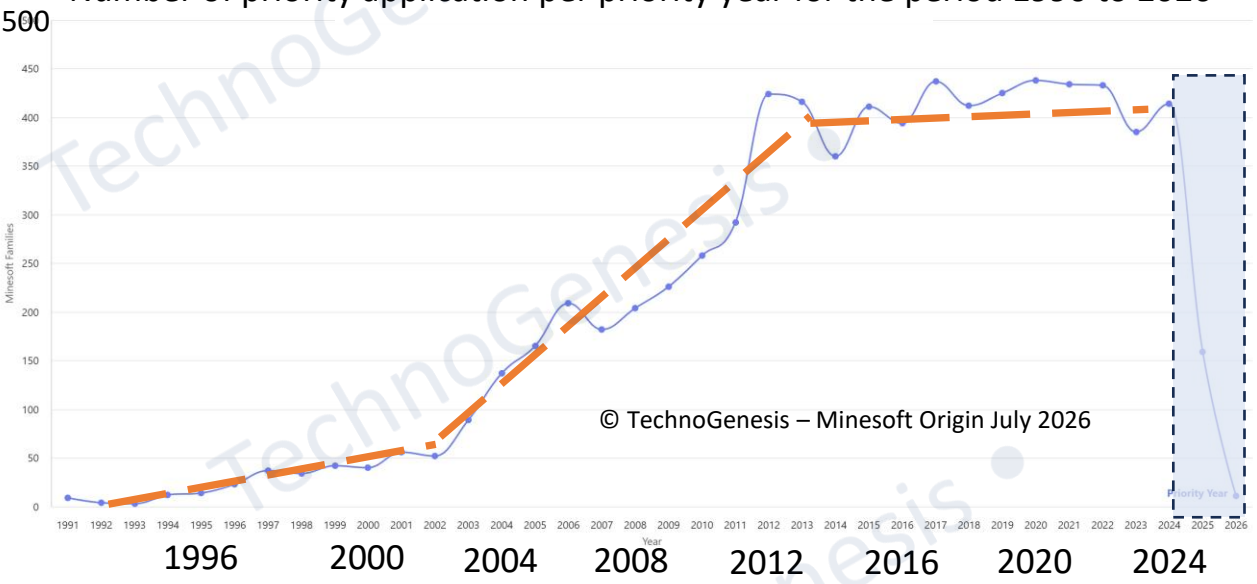


Biophotonics: Optical Coherence Tomography (OCT) & Wearable Optical Biosensing

Studied in Minesoft Origin

Number of families per priority year & top assignees

Number of priority application per priority year for the period 1990 to 2026



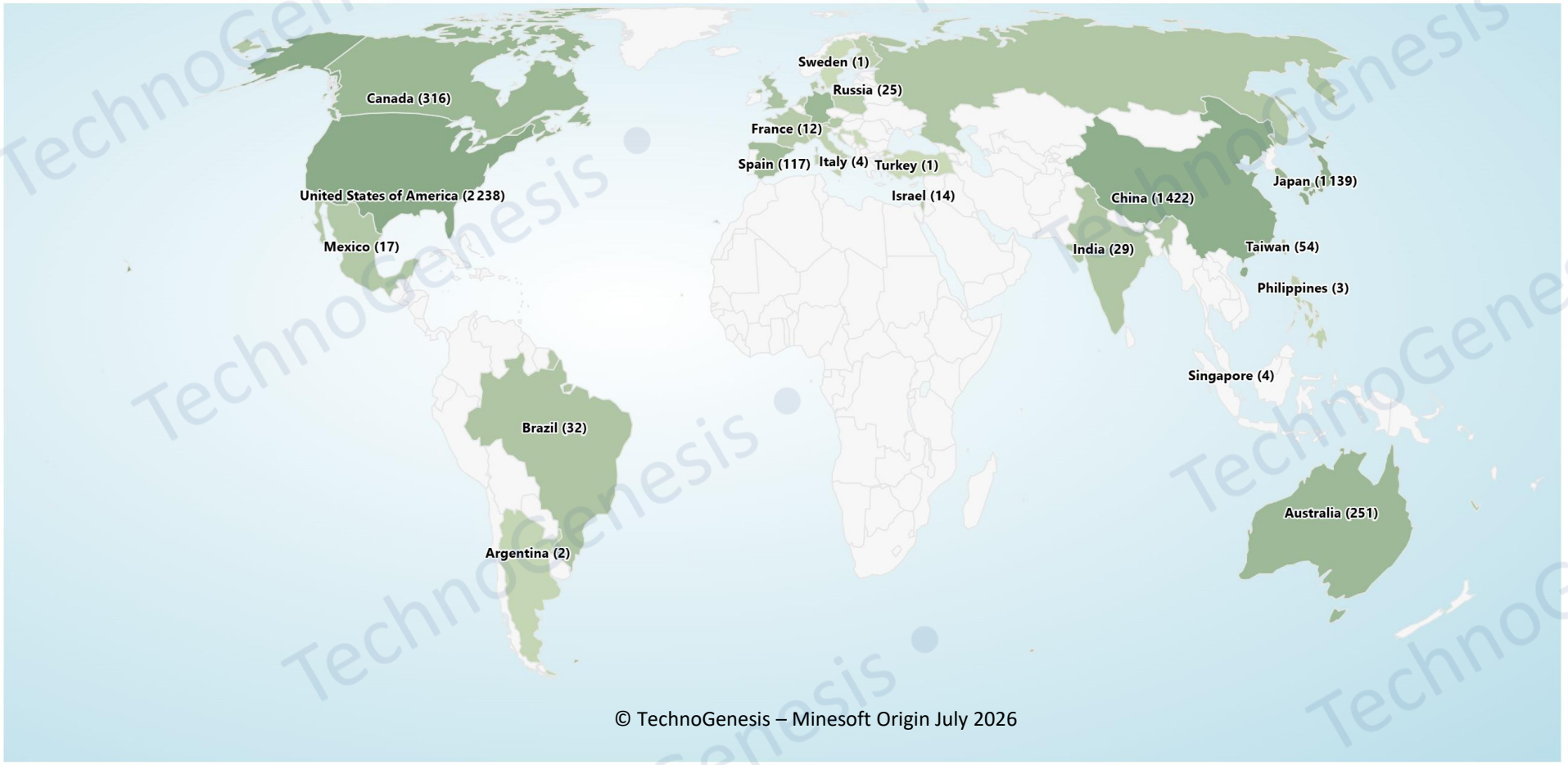
Top 5 Assignees for the period 2001 to 2026

A **mature** domain: steep growth up to ~2012, then a flat plateau of ~400 families/yr - saturation.

Carl Zeiss: Early & sustained leader
Topcon & Alcon : Current front-runners
Canon: Optopol-driven wave (peak 2014, then retreat)
Nidek: Steady ophthalmic specialist

Geographical cover

Top 33 Jurisdictions by Minesoft Families



The US dominates, over the 2nd China by more than 60%, followed closely by 3rd Japan.

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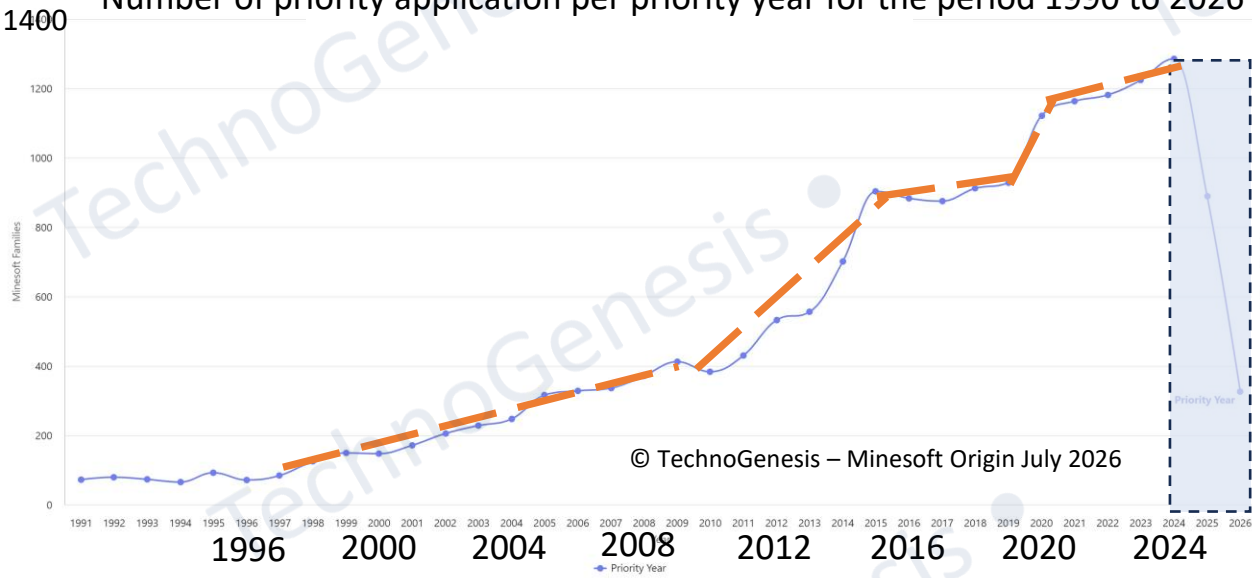

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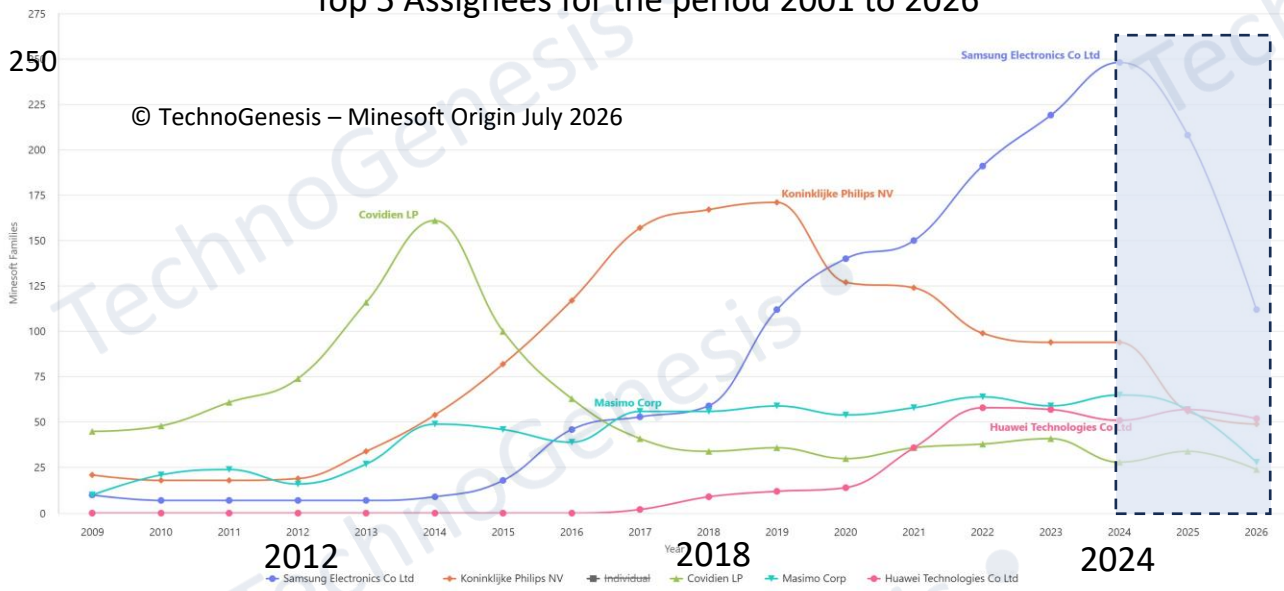


Double S-curve: a first wave with the smartwatch / fitness-tracker (~2014–15) & then a second acceleration from 2020 (health monitoring) which is attributed to the COVID era.

Samsung Electronics: Dominant and still rising to ~248 in 2024

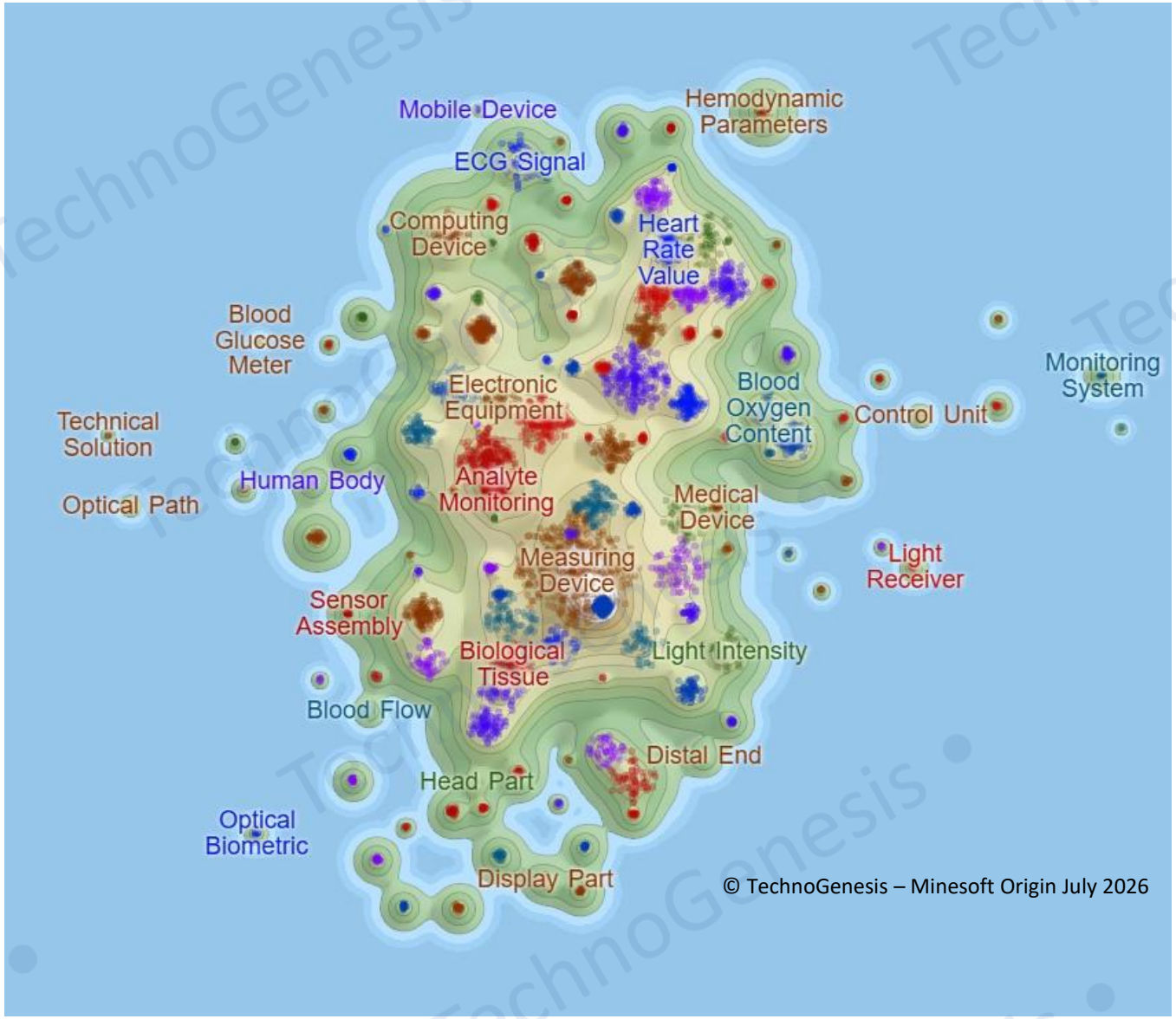
Koninklijke Philips: peaked in 2019

Covidien LP: Early leader peaked in 2014

Masimo Corp: Pulse-oximetry pure player

Huawei: China entry in 2016

Technology map for fences & white spaces



Fences (crowded, FTO risk) -> the vital-signs core - heart rate, ECG, blood-oxygen, hemodynamic parameters - plus the generic hardware massif (measuring device, sensor assembly, analyte monitoring).

White spaces (thin, at the edges): the optical-component periphery - optical path, light receiver, light intensity, optical biometric, blood flow - and the valleys between the consumer's device clusters (e.g. mobile/computing device, display part) and the clinical clusters.

Caution: empty doesn't mean valuable - a blank region can be infeasible rather than open.

Summary

S-curves, white spaces studies

Methodology: Patent families by earliest priority year, bounded by IPC/CPC codes and refined with keywords.
Two domains studied in-house with Minesoft Origin (hollow-core fibre; OCT & wearable biosensing); six read from published landscapes.
S-curves place a technology on its diffusion path -emergence, invasion, saturation- and the **theme map** locates the fences and the white spaces. Limits kept in view throughout: the **18-month black box**, and **publication ≠ granted rights**.

Results: Three cross-cutting signals

China leads filing counts; the US and Europe still hold the international families.

AI is the tide. Co-packaged optics, photonic computing and hollow-core fibre are one story - the physical layer of AI compute.

The domains are converging. Metasurfaces feed LiDAR and AR; silicon photonics underpins quantum and computing. Whitespace is found at the interfaces.

Next

What this analysis does *not* yet tell us: whether the fences are still alive, how broad the claims are, and how the patents cite and litigate.

Building on assignee harmonization already applied here. The next step is adding legal-status filtering and claim-level whitespace mapping which can turn a landscape into a filing strategy.