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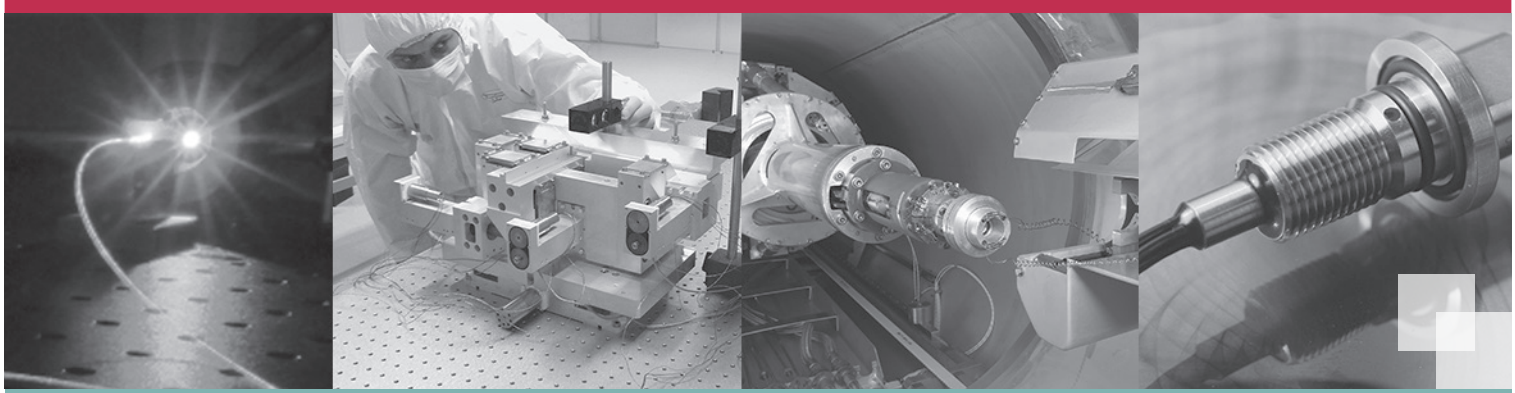

STUDY ON FRENCH PHOTONICS

Executive Summary

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This study aims at building a prospective review of Research, Economy and Industrial assets of Photonics in France, throughout its main civilian uses. This will be useful in order to put together French Photonics stakeholders to build collaborative projects based on new applications, technological breakthroughs, facilitate enterprises creation, growth and strategic diversification until 2020, according to international and national contexts. Industrial development can rely on true R&D strengths in France.

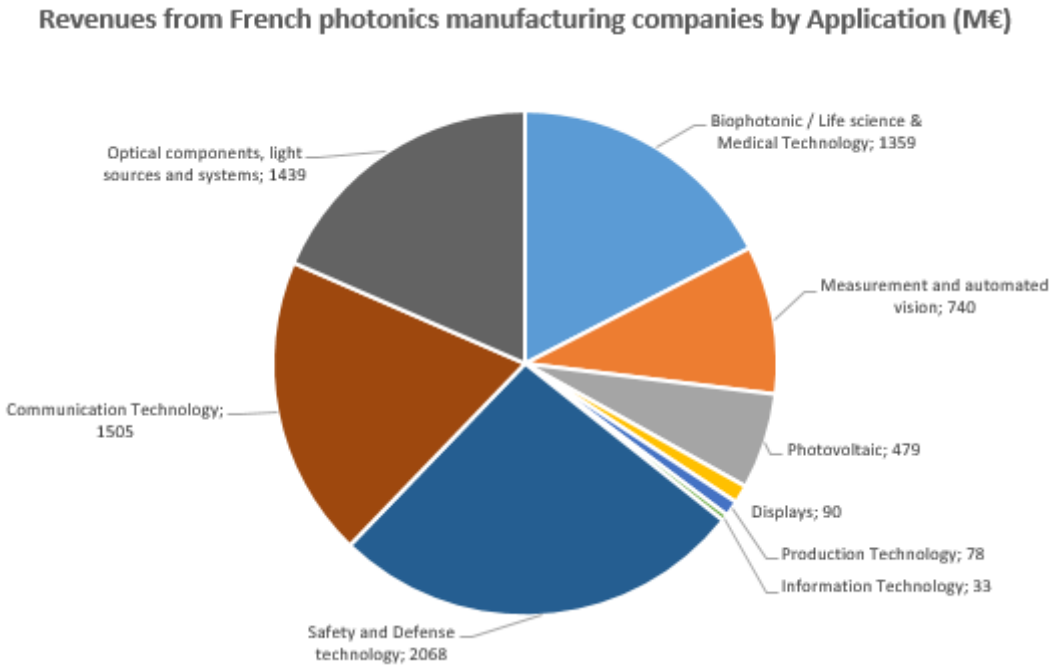
Therefore, the study's objectives are:

- Part 1: make a diagnosis on French Photonics Research and companies;
- Part 2: make an international benchmark of Photonics assets for 6 countries: US, Germany, Israel, Japan, Taiwan, South Korea;
- Part 3: identify and quantify main application markets for photonics technologies, especially for medium-term tendencies. The aim is to put in evidence the most promising applications and technologies for French stakeholders, according to their specific skills and market positions.

1. French Photonics mapping

The study was done in the first half of 2014. It resulted in an up-to-date mapping of French Photonics assets: 657 known industrial companies made a €10.8 billion global revenue. They count for 13.5% of European Photonics industry, as Germany counts for 35%. Besides industrial companies, we identified 109 services companies, 116 commercial companies and more than 200 integrators in this technological community.

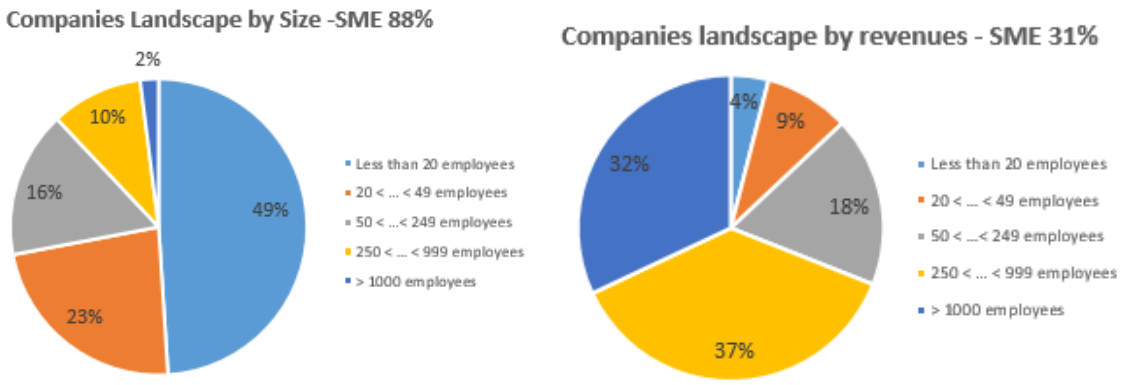
The most important production sectors in France are lighting, defence-security, communication technology, components & thin films, environment and health.



(source: TEMATYS)

Figure 1: Share of production sectors in French Photonics industry

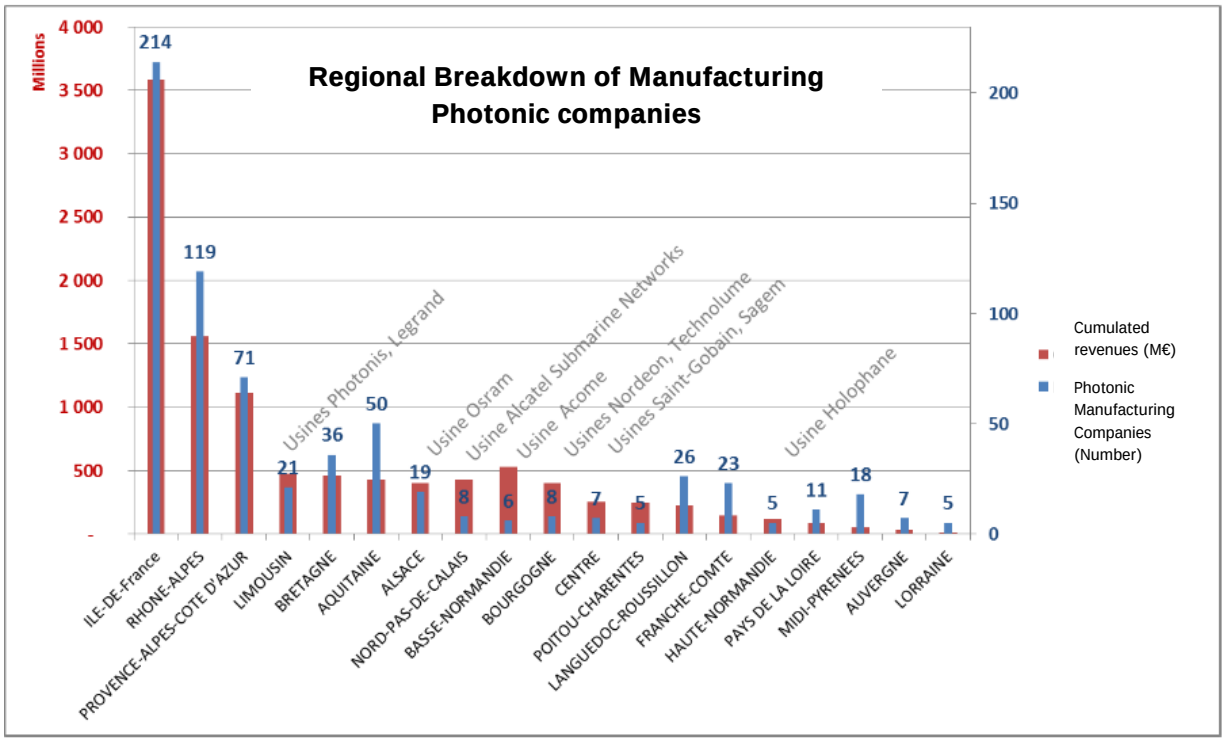
49% of the French photonics companies have less than 20 employees and count for 4% of the overall photonic-companies revenue. SMEs (less than 250 employees) count for 88% of all the photonic companies and generated 31% of the overall revenue.



(source TEMATYS)

Figure 2: Distribution of companies by size

These companies are scattered across the country, more specifically in 3 regions (Île-de-France, Rhône-Alpes, PACA-Languedoc Roussillon) which cover Defense and Infrared market segments. We can also mention Aquitaine and Bretagne as dynamic regions for company establishment and growth ; Franche-Comté, Limousin, Alsace and Midi-Pyrénées where photonic technologies support other technical fields and Normandie, Bourgogne and Nord-Pas-de-Calais as plant establishment regions. Although the overall revenue of companies in these regions is high, photonics is not considered as strategic because of the regions lack of decision-making centers and photonic research.



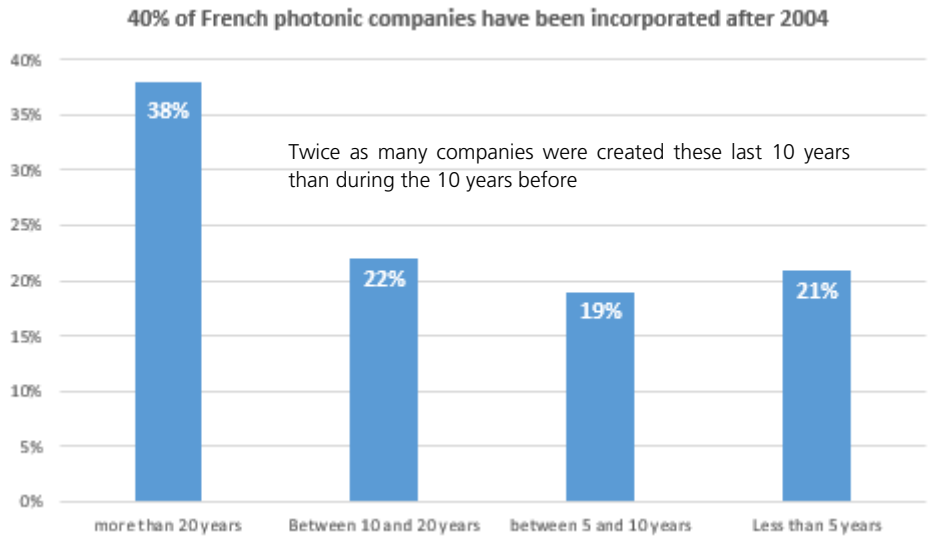
(source TEMATYS)

Figure 3: Regional distribution of industrial photonic companies *(manufacturing companies)*

2. Stake #1: Improve the companies' financing capabilities and profitability

Many companies are created but are not able to grow fast enough and follow the market pace

40% of industrial photonic companies are less than 10 years old. The telecom bubble burst in the 2000s boosted the creation of many photonic-related companies but rapidly slew down. We noticed that twice as many companies were created these last 10 years (from 2003 to 2010) than during the 10 years before (from 1993 to 2003), essentially because recent companies remain SMEs, or even, Very-Small Companies. On the one hand, 30 photonic-related companies (4.6% of all the photonic community) generated half of the total national revenue whereas, on the other hand, companies with less than 20 employees, which represent 49% of the photonic community, generated 4% of the overall revenue.



(source TEMATYS)

Figure 4: Distribution of industrial photonic companies by age

This concentration can also be found in other studies such as French companies' involvement in the European Union Research Framework Program. Indeed 2 companies (Thales-TRT and III-V Lab) represented 16% of the companies' involvement whereas 10 German companies counted for the same percentage.

Reasons of this lack of growth:

- **A weak provision of private capital on photonic products.** More often used in niche applications and markets, they require a significant amount of time to grow and to be combined to several other expert assessments (micromechanics, fluids or signal processing). This maturation time is far too long for an investor. Besides, French companies valorizations are far lower than in North America. Photonics products are therefore not an attractive enough market segment for French venture capital.
- **A weak profitability of invested capital due to weakly-disposed companies to innovation**. To a point where we wonder if the "Made in France" label has a suspicious effect

on investors when it deals with innovative high-tech. Consequently, a lot of companies make their first sales on the American or the Asian market, which turn out to be more receptive. The cost of the first sales has a significant impact on the companies' initial Income Statements and therefore an impact on public or bank financing. This last point can be dealt with:

- either increasing the companies' capital stock to enable a rapid development abroad,
- or by improving local clients' solvency on photonic products (using investment aids such as Robot Start PME, http://www.robotstartpme.fr/)

- **The relationship between the purchasing companies and SMEs needs to progress toward collaborative work until production starts**. Companies often work with SMEs on prototypes but outsource the industrial production on another market. This tends to deteriorate the profitability of these SMEs which have to take on all the development expenditures, whereas competitors will have access to the products' production plans without having to worry about its cost.

- **An extremely slow technology transfers process and a low use of patents** whether in public research or industrial research. These patents can be key elements in the SMEs competitiveness. The international benchmark realized in this study shows us that foreign policies give priority to innovation accessibility rather than look for the patents' profitability by selling licenses.

- **Finally, and it is beyond the scope of this study, strictness of the right to work**. It is sometimes essential to be able to rapidly change market segment direction, specifically in a dynamic market as photonics. As a matter of fact, management turnaround in the telecommunication segment was easier to conduct in companies like Corning or Bookham as mobility was "forced" and "fast" than in French companies, which are still under permanent reorganization.

3. Stake #2: Reduce time-to-market which is the key element for photonics growth

Several market niches generate continuous product evolutions

Among the SMEs and start-ups we met, we noticed that several placed themselves on a specific niche market at the beginning of their project, strengthened their position on it but are now facing difficulties to diversify their applications. This is one of the reasons for the SMEs low growth and weakness.

Indeed, the typical photonic entrepreneur is centered on engineering and its technical background with neither strategic, marketing nor financial knowledge. It will primarily seek to "know how to take actions" whereas diversification, and specifically in innovation, requires to "take actions if you want to know". The entrepreneur was able to provide all the expertise on the initial market in order to come up with an adequate product. But it is necessary to change its learning process to follow the dynamics in innovation and come up with new products.

Beyond all the financial aspects previously mentioned, it becomes necessary to raise awareness on "business knowledge" and to implement interaction processes with application markets. E.g. be able to foresee and get closer to new business openings in order to have a good place on growing markets of the moment:

- **By educating entrepreneurs in marketing and strategy** (the ability to detect and foresee opportunities on a new emerging market and therefore allowing the entrepreneur to properly decide on its investments). These actions can be launched as first-degree courses, as it is in the French Optical Institute Graduate School (IOGS) or Polytechnic School, but also as continuing education programs, for managers, directors or support functions. On that last point, the French *DEFI Photonique* Program can be considered as the small part of what could be deployed in the future, but needs to be applied thoroughly.

- **By increasing interaction between technical centers and pooled innovation platforms** which are already facing several industrial demands. This platforms are equipped with test means and 1/10 scale-control means that will allow, with incremental investments, to reduce the development risk (examples of French platforms: Alphanov in Aquitaine, Perfos in Bretagne, The Vision Institute in Paris, Carbohydrate Upgrading Center in Picardie, Cerimed – medical imaging in Marseille, Technical Preservation Center for Farm-produce Products in Vaucluse, etc.).

- **By increasing the attendance of the French photonics community on showrooms and conferences about applications and markets**. In addition to technical conference where French photonics usually participate (Photonics West, Laser Munich, Photonics Asia), it will be relevant if they strengthen their attendance on photonic-related markets and applications conferences (such as SIAL about agriculture mechanization, ForumLabo about lab equipment, Pollutec about environment, etc.). Having a promotion stand about photonics at the SIAL is, for us, much more productive than performing local animations which are not sufficiently displayed to attract decision-makers.

- **By taking over deep changes in their innovation policy**. Open innovation slowly brings strong industrial actors to open and share their strategic thinking. Each sector publishes its roadmap, specifically in Europe with the *Strategic Research Agenda:* ETRAC for automotive sector, IMI for pharmacology, CleanSky for aeronautics, EPIA for photovoltaic energy, etc. Due to

a lack of resources, it is difficult for SME and Very-Small Companies to seize all these initiatives, but it might be the responsibility of structures of animation to actively participate to those work groups and to have a role of information dissemination towards SME (programs to come) and customers (new technologies available at their members'). Some actors (Airbus Helicopters, Renault, PSA, etc.) also have an individual initiative of sourcing and sharing information of their road map. They are chances to improve the Time2market of photonic products.

4. Stake #3: Establish different support policies depending on markets

As explained in report #3, 4 different types of markets can be drawn, each having specific levers and stakes.

- **Highly technical markets:** Defense, Security, Space, Aeronautics, Major research infrastructure.
- **Growing markets:** Environment and agriculture, Life sciences and medical engineering, Process control, Building and infrastructure monitoring.
- **Opportunity markets:** Industrial processes, photovoltaic, laboratory instrumentation, telecommunications, rail and mobility.
- **Volume markets:** Automobile, Consumer electronics, Lighting.

Highly technical markets: enhance cooperation of actors

Defense, Security, Space, Aeronautics, Major research infrastructures

Key features

- Domestic market (French and European) and a leading national sector in Europe (> 25% of production in Europe).
- Small and medium series,
- Photonics = already integrated technology and at the heart of systems
- Complete value chain within the French industry, from the component to the system
- A national distribution of competencies and expertise in these segments: engineering systems from the Île-de-France region, major instruments from PACA and Aquitaine and sensors and imagers from Grenoble.

Defense, Security, Space, Aeronautics. Many of the technologies developed for these markets are also difficult to be used elsewhere, or with a long time lag (eg. Augmented reality of fighter aircraft cockpits vs. the one used in Peugeot 5008). The ripple effect for the rest of the photonics industry is low in a short term. These are also medium-to-low growth markets (less than 10% over time) that can involve skills but they create few jobs in the sector.

Defense markets are currently decreasing in most occidental countries but are partly counterbalanced by export (for example SOFRADIR in infrared) and by diversification in large programmatic equipments (spatial and large instruments).

Because of their characteristics, those markets are mainly accessible to large groups. Indeed, there are few programs, public tenders are risky and programmes are often delayed.

However, the model of SOFRADIR, that has become in 20 years a global leader in infrared detection, is the proof that this industry has the capacity to generate industrials champions to serve as a model in other emerging subjects (hyperspectral, TeraHertz), which are essential for defense and spatial industries but also for short-term civil applications.

Major research infrastructures. For the state, the lever for action to improve is mainly his role as an ordering customer and coordinator of actors to form a competitive industry for France but also for international markets (for instance the ILE European program, European Extremely Large Telescope E-ELT).

Growing markets: develop shared technological resources

Environment and agriculture, Life sciences and medical engineering, Process control, Building and infrastructure monitoring.

Features

Significant domestic markets are linked to

- Local resources (agriculture, marine resources, population structure),
- Expert assessments available at laboratories and private companies (health, environment, agronomics),
- The presence of final users and well established in France (chemical and pharmaceutical industries, hospitals, building companies, infrastructures planner and/or manager such as airports, nuclear plants).

On those markets, photonics is still merging but is an occasion for many new products. However, the time-to-market is critical and not always well controlled.

Many industries (chemical, pharmaceutical, food-processing, oil) are looking for advanced sensors to control their process better. But existing products give optical measures that have to be processed to extract relevant information for process control such as: progress of firing or chemical reaction, presence of impurities, pollutants, bacteria.

For the market to take off, the photonics industry has to offer economic products that are able to process complex data in real time and return them into "industrial language", not scientific language. Those highly technical markets of small and medium-size series are nevertheless very accessible to French photonics companies with global leaders as ordering customers (Sanofi, Biomérieux, Danone, Rhodia) that can feed the smart sensor industry.

Those markets are customers of chips that are more complex, more various in terms of functionalities and customized for each application. To be able to produce those in a profitable way in small series strengthen the European value chain on those markets. It is also a way to recover larger series markets using those new capacities to reduce prototyping costs.

An upstream action in the chain for conception and production of integrated smart sensors would foster a significant part of the value chain (sources, fibers, passive components, signal). On this market of applications for smart sensor, the component has to be customized for each application. That is why bringing photonics industry closer to those markets is strategic and critical.

This theme and covered markets apply to all regional clusters.

Opportunity markets: accompanying entrepreneurs

Industrial processes, photovoltaics, scientific instruments, telecommunication, railway and mobility services

Those markets already use numerous photonics based products but the French photonic industry is not a leader or not anymore because of a lack of adapted strategic culture. The strategic approach is to position in niche markets to maintain skills and lie in wait for breaches where to enter when they appear to take the position of leadership. For instance, is it possible to reproduce in reverse the scenario of photovoltaic with the rise of organic technologies?

Those markets are too often structured by technological generations such as polycrystalline silicon, CO_2 laser for industrial processes or ADSL in telecommunications. Getting back to being competitive on those markets is about taking the right train, meaning detecting emerging technologies and placing them on the market at the right time. France has high quality photonic R&D in those fields (active materials, ultra-short lasers) but technology transfers are very slow, which explains the position of French companies.

The stake can be very high in case of major technological breakthrough, but it is difficult for the state to "predict" future breakthroughs. Moreover, France alone cannot force a market anymore like they did with nuclear energy.

Therefore, mobilizing main industrials players on a currently limited stake might be delicate. Building R&D programs that involve innovative SMEs on themes that will be promising (such as ALEDIA in future generation LEDs) is less risky.

For example in the field of industrial processes, commercial niches are yet to explore on materials that are not machined using laser or processes for emerging manufacturing such as organic or printed electronics, additive manufacturing but with the obligation to identify an international partner in mechanics and robotics.

As specified, on such markets, the state has to estimate the relevance of its supporting action. If the sector is not considered as strategic and if there is no local end-user able to attract developments, structural assistance is questionable and it would be better to put efforts in R&D and overall support to businessmen.

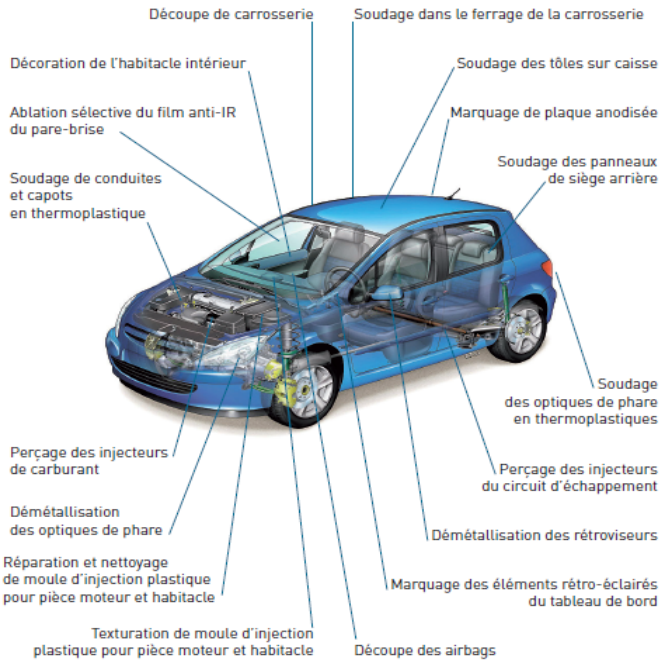
High-volume market, market models that are changing from mass to customized production

Automotive, consumer electronic devices, stationary lighting.

This section is about high-volume photonic products consumer markets. In most cases, cost is a dominating factor. On those markets, the upstream value chain in France is incomplete, especially in components (LEDs, plastic optical fibers, screens). However, this absence of basic components in France is not necessarily a drawback because most of the value is not due to components.

These markets are changing with the customization of end products thanks to 3D printed objects: smart lighting, color and light effects chosen in a car's passenger compartment. These functions that are closely linked to the user make most of the value.

Among those markets, the automotive industry (10% of jobs in industry in France) draws the development of technologies. During the interviews, several SMEs had witnessed a growth in activity further to partnerships with the automotive sector (in the fields of fibers, lighting). Significant potentials exist in the manufacturing field. Two French manufacturers are actively looking for components and systems on these subjects to face the following challenges:



- An increasing demand for cleaner vehicles, moving toward electrification, weight reduction, engine downsizing;
- A requirement that is still high for safe vehicles, more comfortable and easy to drive, leading to more and more advanced support functions with a strong and lasting trend toward connected and autonomous vehicles;
- Change of use that question traditional economic models (car-sharing, pay-per-use in insurance, urbanization);
- Collaboration between actors that exist horizontally for engines and platforms and vertically in the development of vehicle functions.

On the lighting market, the industry is in reconversion. Originally, those professions were at low technological level but they now have opportunities for significant growth to the system level with the current development of smart lighting that is entering in buildings, lighting in communities and that will add functions to allow objects and building to communicate by light.

Historic players on French territory mainly have foreign capitals such as OSRAM and Philips Lighting. Beyond light bulbs, they want to go down in the value chain to offer home automation and atmosphere controlling products. On these fields, they compete with electricity leaders such as Legrand and Schneider who also have identified lighting as a promising sector.

Several initiatives are set up to organize the development of the Smart Lighting sector, via local (Cluster Lumière in Rhône-Alpes region) or national initiatives (BPI). Public orders can also have a significant effect on sells, via street or train lighting buying.

5. Stake #4: Continue structuring the national sector

A fragmented community with an unclear strategy for national and European organisms, and industrial actors of application markets

As specified in the introduction, the sector of photonic is small in terms of total turnover (€11 billion in France) compared to other sector such as the energy or automotive industries. It is divided in many sub-sectors (lighting, security/defense, photovoltaic) and spread in several French regions (7 clusters) that are not very specialized. In return photonics are acknowledged to be a key enabling technology in France and even more in Europe. The skills of this technology can lead to opportunities for industrial recovery.

French photonics has to become able to:

- Show its ability to stand out in France and in Europe
- Clearly express its needs and get organized to strengthen and meet the expectations that photonics raise in terms of competiveness and employment.

The sector has to continue the structuring initiated by the creation of CNOP and meet the following objectives:

- Representation, standing and influence
    - Represent industrial and academic actors of the sector to French public power thanks to correspondents in the three principal ministries (Industry, Defense, and Research) that will allow to quickly get a representation of the nature and amount of support to the whole community;
    - Represent industrial and academic actors to their European equivalent (Photonics 21);
    - Have influence and lobby capacities to these organizations (H2020, ANR, ministries, communities, standard committee);
    - Represent and promote French photonics to applicative markets (important ordering customers, clusters, professional unions).
- Rationalization and orientation of means of support for companies in photonics
    - Host local, regional, and national companies cooperations between suppliers and customers (public and private), between companies and academics (research and innovation)
    - Group means and tools at the country level to rationalize available resources brought by members of CNOP (eg 50 FTE): technological watch, exhibitions and conferences, international representation, professional training, market research in the application sectors, platforms of technological maturation

This requirement of structuring is strategic especially since this industry cannot mobilize funds because of its size (see above). The majority of the 50 FTE mentioned are financed by public assistance (except for AFOP). This observation was already true at the country level and is even truer at the region level.

Current obstacles to structuring

The French photonic industry quickly resulted in a consensus on this diagnosis and needs of structuring the sector. But the action that came from this consensus only took place recently with the launch of the

DEFI program. Moreover the benefits of this program have more symbolic than economic impacts; it did show that the players can work together but also showed the complexity and how it only depends on people's good will and efforts to support this program.

Interviews and workshops conducted by ERDYN and TEMATYS during their mission for DGCIS have confirmed and specified obstacles to efficiently structure the sector.

1. **Disequilibrium of resources.** The CNOP does not have its own resources. Its actions are supported by the members' good will, especially by AFOP. This dependence weakens the CNOP which cannot assure an ongoing effort on their own.
2. **Financing and defining missions for clusters**. Most of the supporting resources are from employees of clusters and competitiveness clusters. But these organizations are mostly financed by regions and departments. Clusters are particularly affected by this situation because they don't have the statute of competitiveness clusters (4 out of 7 among which Opticsvalley and ORA that represent more than 50% of the sector in terms of number of companies or turnover).

   Moreover, the state has showed its intent to reduce its participation in these packages. The consequence of this situation is that the mission of clusters and poles has to follow the will of the most significant financing organizations which are Regions. That is to say that the first "client" of poles project managers is the local community, and then companies and academics. Yet though all the players show a shared desire of local economic development, their individual objectives are not so alike:

   - ⇨ **Regions often consider poles as economic development agencies more than as organizations for promoting sectors**. So poles have institutional obligations especially representation that take a considerable part of their time. They are also contacted for associated missions that are not always related to their principal activity.
   - ⇨ **External and interregional cooperation is not considered enough by regions as a profitable component for the development of their companies.** Economic development is often seen from the perspective of local strategies:
     - o Participation of project managers to national or regional actions are not considered as a priority
     - o A start-up created from a university has to set up locally
     - o Technical and scientific platforms have to support local companies first
     - o The large regional group has to participate to local institutional initiatives even if its suppliers and markets are established elsewhere
     - o Local clusters have to locally set up tools that would be more efficient and less expensive if they were grouped, such as technological watch, hiring assistance or professional training. Therefore local tools are less ambitious and often with a sub-critical size.

But photonics regions are often not big enough to have all the skills needed for product development. Photonics are a very international and diffusing sector. Markets are global, most research projects in photonics are interdisciplinary and it is not sure that a region will have all the skills locally. And if it has them, the obligation to keep them at a regional level prevents it from seeking for European support and establishing initial contacts with potential future commercial partners.

DTP : Bureau de la communication et sous-direction de la Prospective, des Études et de l'Évaluation économiques de la DGE / mars 2015.

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