LASSIE-FP7

Large Area Solid State Intelligent Efficient luminaires

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01

Introduction:

In 2009, in an effort to reduce global energy consumption, the EU Commission decided to move toward a complete ban of incandescent light sources by 2020. Their progressive replacement by highly efficient light sources is expected to reduce energy consumption for lighting by 30%

Among all existing technologies, solid-state lighting (SSL) represents the solution of the future, however, according to a recent study, many SSL products do not fulfill the claimed specifications and a deep market penetration of LED modules is at risk. The main problems are decreasing light intensity and varying light chromaticity due to aging and temperature, as well as poor uniformity of large-area luminaires and poor lighting quality.

02

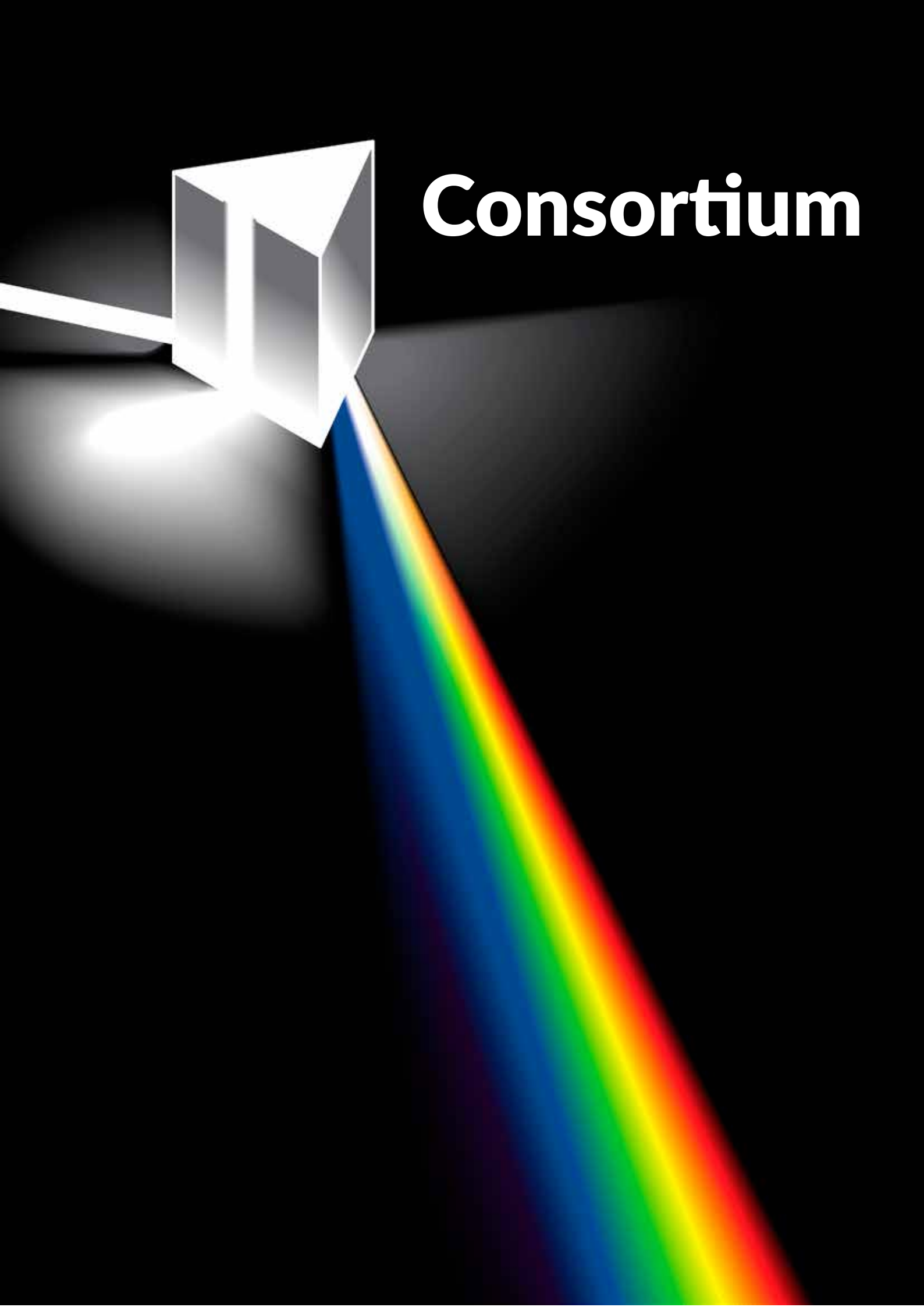
Project description:

The main objective of the LASSIE-FP7 consortium is to implement large -area and low –cost intelligent SSL modules with high efficiency and high lighting quality, while assessing their environmental footprint. The project targets in particular the professional and architectural lighting sectors.

LED-based point source luminaires have been already investigated, but market requirements for intelligent, large - area solid -state light sources have not been met yet. In order to achieve luminaires with high intensity, good uniformity and high color rendering performance, significant intelligence has to be added to the LEDs.

The LASSIE-FP7 project aims to achieve progress beyond the state-of-the-art in terms of size, flexibility, efficiency, lighting quality and beam-shaping, lifetime, added intelligence for light out-put control, and production costs. It will do so by integrating light –management structures and new color-changing coatings with heat-management solutions by means of an innovative roll-to-roll production technology compatible with flexible substrates.

Outcome of the project will be a unique integrated SSL module that will represent a break-through in the professional and architectural lighting sectors and an alternative to the OLED technology.



Consortium

03

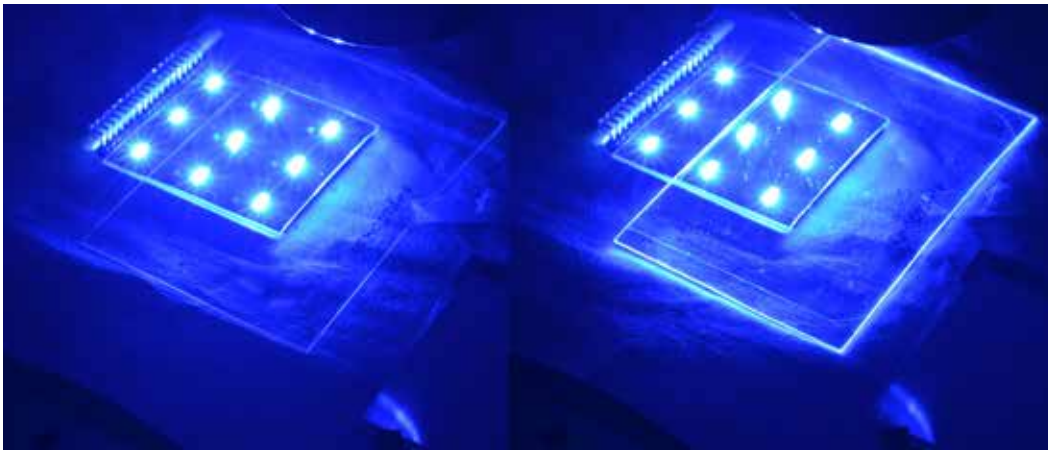
LASSIE-FP7 addresses all the limitations of today s SSL modules. The properties of a new product will create conditions favourable for the fast adoption of LED light applications and deployment of LED technology. The project will be targeting the standard sizes for the professional lighting segment. This compatibility will ensure a fast deployment of intelligent LED luminaires. The project is focusing on the planar lighting as a primary target. By 2011 analysis, this is expected to be 0.8 -1.2 mld. € market in 2017 (end of the project) and the developed know-how would be applicable to all of them, with the business focus on Professional and Architectural lighting sectors.

The secondary target would be expanding to other segments of planar lighting segments-Retail and Residential (additional 0.3 mld. €) and to flexible luminaires (originally reachable only for OLEDs). The flexible luminaires will find its way in designer lighting where aesthetic plays predominant role.

04

Swiss Center for Electronics and Microtechnology (CSEM)

In LASSIE-FP7, CSEM is responsible for the overall project coordination and, technically, for the development of large area light management (LM) solutions for efficient and homogenous illumination. For this latter technical task, CSEM can rely on its long-standing expertise in the conception, simulation and fabrication of micro- and nano-optical devices. In particular, industrially upscalable replication technologies are employed in order to guarantee a straightforward technology transfer for the mass production with roll-to-roll (R2R) techniques.



Within LASSIE-FP7, CSEM tackles one of the biggest challenges in the current development of solid-state lighting (SSL) systems. The point-like nature of the LEDs imposes the use of either inefficient and/or bulky light scattering sheets or costly short-pitch LED arrays to achieve acceptable spatial luminance uniformity in e.g. large-area luminaires. CSEM has proposed a new approach based on the direct-lit technology aiming at the development of thin-film efficient LED-based lighting modules. This approach overcomes the fundamental limitations of current technologies. In particular, LED backlights based on direct-lit LED technology presents several advantages over those using edge-lit. These include higher efficacy, higher spatial luminance uniformity, easier heat management, larger emitting areas and lower weight. In addition, the direct-lit technology is compatible with the use of flexible LEDs foils manufactured using cost-effective R2R processes.

Despite those advantages, the implementation of the direct-lit technology in ultra-thin modules is not straightforward as the distance between the LED sources and the outermost emitting surface (e.g. a diffusive thin-film or plate) must be similar to the LED pitch if highly uniform luminance over the complete emitting area is pursued.

An alternative solution is to widen the angular distribution of the LEDs, thus achieving a uniform illuminance on the outermost module surface. To this extent, CSEM is developing an innovative thin form-factor LM system comprising a highly engineered beam shaping thin-film. When implemented into a lighting module, our LM solution allows decreasing the LED pitch by a factor of 2-3, hence reducing the amount of LEDs (i.e. the module cost) for a given total emitting area and luminous flux. Moreover, the total thickness of the module can be reduced substantially below the LED pitch. Finally, the proposed solution is lightweight, cost effective, and highly efficient.

From the Coordinator perspective:

- **What is the LASSIE-FP7 project and its final goal?**

The main objective of the LASSIE-FP7 consortium is to implement large-area and low-cost intelligent SSL modules with high efficiency and high lighting quality, while assessing their environmental footprint. The project targets in particular the professional and architectural lighting sectors. LED-based point source luminaires have been already investigated, but market requirements for intelligent, large-area solid-state light sources have not been met yet. In order to achieve luminaires with high intensity, good uniformity and high color rendering performance, significant intelligence has to be added to the LEDs. The LASSIE-FP7 project aims to achieve progress beyond the state-of-the-art in terms of size, flexibility, efficiency, lighting quality and beam-shaping, lifetime, added intelligence for light out-put control, and production costs. It will do so by integrating light-management structures and new color-changing coatings with heat-management solutions by means of an innovative roll-to-roll production technology compatible with flexible substrates.

- **Why a new lighting system is so important in everyday life?**

In 2009, in an effort to reduce global energy consumption, the EU Commission decided to move toward a complete ban of incandescent light sources by 2020. Their progressive replacement by highly efficient light sources is expected to reduce energy consumption for lighting by 30%. Among all existing technologies, solid-state lighting (SSL) represents the solution of the future, however, according to a recent study, many SSL products do not fulfil the claimed specifications and a deep market penetration of LED modules is at risk. The main problems are decreasing light intensity and varying light chromaticity due to aging and temperature, as well as poor uniformity of large-area luminaires and poor lighting quality.

- **How the idea of this new lighting system was born?**

The original idea of combining large area light management solutions with color-changing films to obtain both highly efficient and high quality SSL systems was born in the period 2004-2011, when I was working at the EPFL in the laboratory of Prof. Libero Zuppiroli (LOMM), where I was responsible for a collaboration project with the company ILFORD Imaging GmbH for the development of hybrid organic-inorganic optical films. For more information on the early studies that few years later brought to LASSIE-FP7, one can refer to the following book: M. Schaer, P. Cotte, L.Zuppiroli (Lumières du Futur, PPUR, 2011).

- **Which is the main novelty of this new system and the main expected benefits?**

LASSIE-FP7 addresses all the limitations of today´s SSL modules. The properties of a new product will create conditions favourable for the fast adoption of LED light applications and deployment of LED technology. The project will be targeting the standard sizes for the professional lighting segment. This compatibility will ensure a fast deployment of intelligent LED luminaires. The project is focusing on the planar lighting as a primary target. By 2011 analysis, this is expected to be 0.8 - 1.2 mld. € market in 2017 (end of the project) and the developed know-how would be applicable to all of them, with the business focus on Professional and Architectural lighting sectors. The secondary target would be expanding to other segments of planar lighting segments - Retail and Residential (additional 0.3 mld. €) and to flexible luminaires (originally reachable only for OLEDs). The flexible luminaires will find its way in designer lighting where aesthetic plays predominant role.

- **Is it possible to measure the efficiency of this new lighting system, compared with what we have on the market today?**

The performance of the final lighting module will be assessed and validated against selected benchmarks from the market. In particular the following module parameters and performances will be targeted:

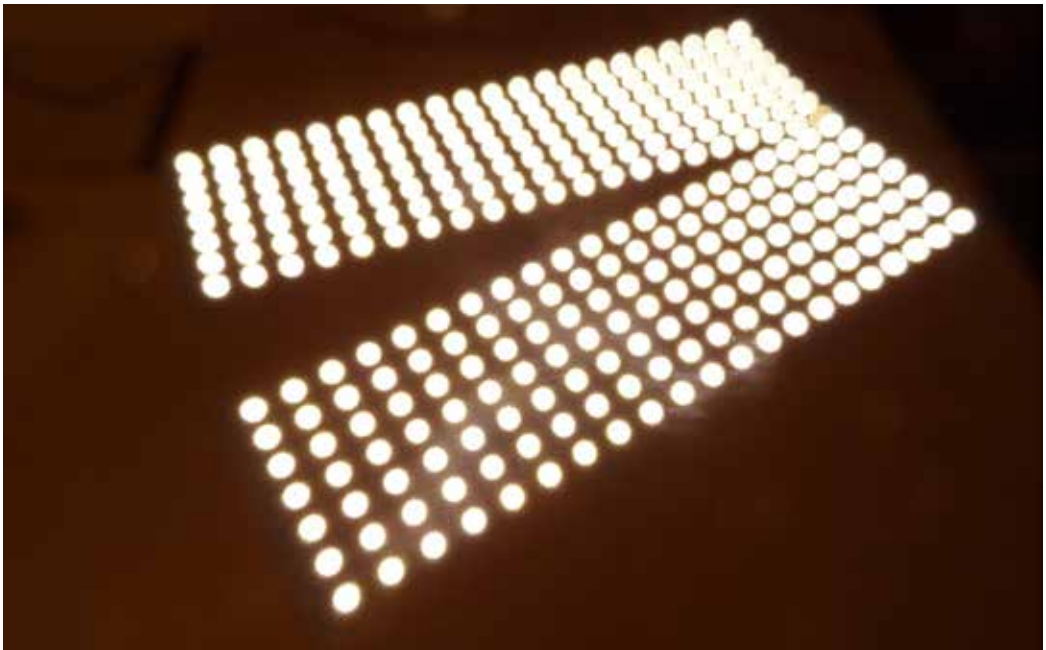
- Size of the lighting surface: 1172 x 312 mm
- Efficacy: 100 lm/W
- Luminous flux: 500 lm (for a 400cm^2 module)
- CCT: 3'000 K; 4'000 K
- CRI: > 90

- **Please, tell us about your overall experience as Project Leader working in a team of 8 different European companies from 6 different countries.**

Coordinating such an industrially oriented consortium combining competences along the whole value chain is a challenging but highly motivating experience. The professionalism and extreme commitment of partners has always allowed me to overcome the technology bottlenecks and to effectively adapt the project and its goals keeping the focus on the final development of a new lighting module with potential for exploitation and commercialization. From a personal point of view, having the chance of leading a group of partners from such a large number of European countries was a unique experience, which has definitely enlarged my horizons and enriched me as manager but, on top of all, as person.

- **Which are your expectations on this project for the next and final year?**

Outcome of the project will be a unique integrated SSL module that will represent a breakthrough in the professional and architectural lighting sectors and an alternative to the OLED technology.



05

Fraunhofer
IIS

Fraunhofer Institute for Integrated Circuits IIS (FhG IIS):

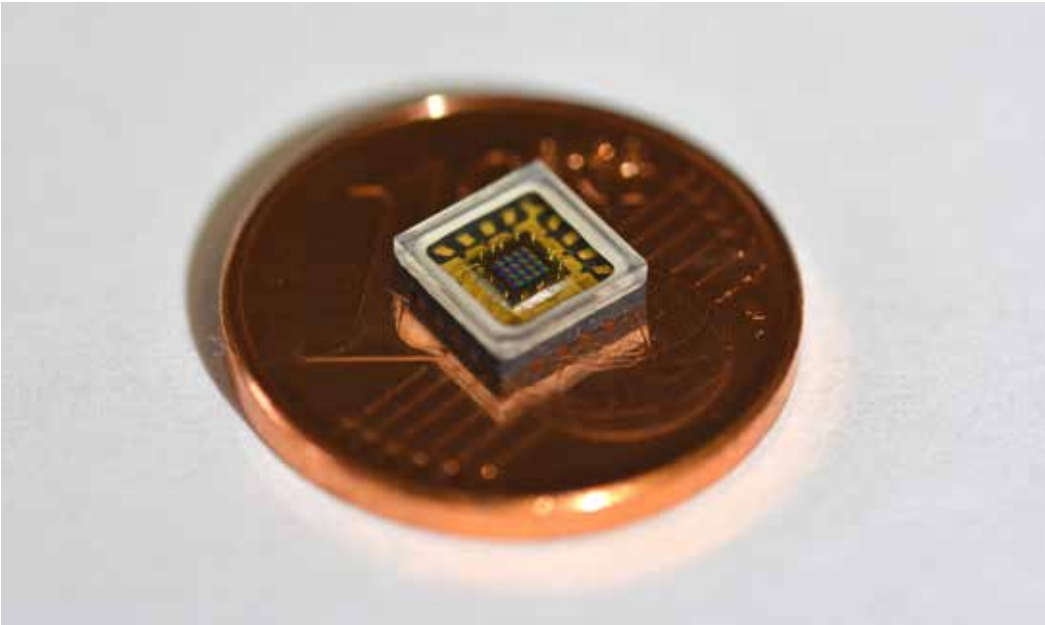
The main contribution of the Fraunhofer Institute for Integrated Circuits IIS to the LASSIE-FP7 project was the design and characterization of a multispectral sensor device that can be fabricated monolithically in CMOS technology. This sensor is able to detect the actual color (chromaticity point) emitted by lighting modules or luminaires, and this data is used as an input for a cost effective colour feedback system. The feedback system adjusts the driving currents of the LEDs with different wavelengths in a way that the color of the spectrally tuneable luminaire is kept constant over time and despite of temperature changes that cause wavelength and intensity drift of LEDs.
Fraunhofer IIS established nanostructured plasmonic filters that can be fabricated using modified metal layers of a CMOS process based on pre-existing know-how, but significant progress with respect to this new on-chip filter technology was achieved during the LASSIE-FP7 project, enabled by the advanced semiconductor technology of LFoundry and the close and excellent cooperation.
The outcome of the project is a small sensor chip (2 x 2 mm2) that features 12 spectral channels and consists of on-chip filters, photodiodes, integrated preamplifiers, and a serialized output of the sensor data. The sensor offers high dynamic range and high linearity with respect to incident light, and the filter technology can be used for other applications by tailoring the wavelengths of the nanostructured filters. As a next step, the sensor is integrated into the LASSIE-FP7 lighting module and the colour feedback system will be demonstrated.

06

Fraunhofer
IISB

Fraunhofer Institute for Integrated Systems and Device Technology IISB (FhG IISB):

Fraunhofer IISB was involved in three different tasks. The main activity was the optimization of the optical grating structures for the in-coupling of LED light into a waveguide foil. The challenging point for the optimization was to take into account the real spectral emission and radiation characteristic of the LEDs and several grating fabrication constraints. Therefore, a rigorous electromagnetic field solver in combination with a genetic algorithm based optimization was used. Both simulation tools are in-house developments of Fraunhofer IISB. The grating optimization could be performed successfully and the grating parameters for maximum efficiency and compatibility with manufacturability limits could be determined. The overall outcome is a grating structure with an in-coupling efficiency of 50%.



The second task was the development of a color feedback algorithm to realize a stable and tunable color temperature and brightness of the luminaire. The algorithm uses as input the signals of an arbitrary number of individual spectral sensors. Since the light of the luminaire is generated by a LED pumped color changing film the algorithm computes the required pumping LED intensity and additionally the required red, green and blue LED intensities for color tuning in order to reach the desired color temperature and brightness. The challenging point was the fact that the system to be tuned is under-determined. There are 3 target color coordinates to be used for the adjustment of 4 LEDs. The problem could be solved by additionally taking into account the CRI which has to be as high as possible. The algorithm is able to reach and to keep stable any color temperature within the specifications with a relatively small number of iteration steps and a definable accuracy.
In the third task Fraunhofer IISB has implemented a pulse-width modulation for a specific microcontroller used for the LED tuning.

07

LFOUNDRY
A SMIC COMPANY

LFoundry S.r.l.:

The main responsibility of LFoundry within LASSIE-FP7 project has been the fabrication of the CMOS multispectral sensor designed by Fraunhofer Institut (FhG IIS). This task required the development of a specific manufacturing flow for the realization of nanostructured filters, which was carried on using the most advanced photolithographic process available in LFoundry fab (ArF 193 nm).

This process module was integrated as an “add-on” on the standard 150 nm LFoundry technology (LF15A), guaranteeing an effective trade-off between the overall cost and the need of reduced dimensions (down to 100 nm) needed by the design of optical filters. The constraints for the material stack of metallic nanostructures - due to the constraints in terms of optical efficiency - represented a challenge for the process integration, which stands out of the standard methods used for fabricating metallic structures on a CMOS device. A series of process optimization steps has been performed by LFoundry to fix the main problem impacting the nanostructures, which consisted in an undesired diffusion of aluminum grains that deformed the smallest features. The large active area of photodiodes (300 um wide) also required an optimization of fabrication flow, which suffered at the beginning of the project for a severe non uniformity of silicon trench insulator polishing process.

The two silicon runs ended up demonstrating a good yield for the manufacturing of multispectral sensor, which since the end of 2015 can be considered as a finalized product ready for mass production.

LFoundry leveraged on the long experience matured by Avezzano Fab (working on CMOS technology since 1990) to make its contribution to the success of the project. The cooperation with the other members of LASSIE-FP7 consortium has always been very effective, in particular the excellent partnership with FhG IIS designer.

08

Technical Research Centre of Finland Ltd. (VTT)

In flexible LED luminaire revolution the heat management is one of the key challenges for successful industrialisation. VTT Ltd. has developed efficient heat management structures for LEDs assembled on plastic foils, such as PET, in LASSIE-FP7 project. Designed, processed and characterised structures include heat spreaders, thermal vias and thermal slugs. Thermal slugs have showed best performance as an intermediate result, and therefore, the manufacture process development of thermal slug structures towards R2R compatible processes was selected in order to meet final targets of the project. In addition, VTT has been main partner in development of lighting element integration processes towards luminaire industrial manufacturing.

09

REGENT LIGHTING

Regent Beleuchtungskörper AG

LASSIE-FP7 is working on creating a LED module that will be used in professional luminaires. Regent Lighting's role in the project is to connect the project to the real world. Ensuring that the lab- and research-generated LED module will be practically usable. Regent co-defined the end user specification and focusses that the module is compliant to the relevant international standards. In Regent's accredited lighting lab we can confirm that the outcome meets the pre-defined specification.

A further aspect of Regent's role in the project is building demonstrators that are in fact small luminaires. Thus Regent can prove that the module is in fact usable in luminaires.

As Switzerland's biggest luminaire maker, Regent is keeping a market overview of LED modules and benchmarks LASSIE-FP7 with other LED modules on the market. Regent is also building the bridge to LED module standardization (Zhaga) and ensuring that the most current applicable standards will be met by the LASSIE-FP7 module.

10

BASF Schweiz AG

BASF main role together with its project partners is to gather all relevant information to steer the project. This consists in defining the end user specification of the luminaire, assessing the critical success factors (technology boundary conditions (within the consortium)) and providing a frame and the relevant inputs to realize an eco-efficiency analysis of the demonstrator.
BASF is also responsible for providing adjusted color conversion films based on it's Chemistry platform in combination with an optimized polymer matrix to achieve an optimal light down-conversion for a high quality color white light illumination.
As the world-leading chemical company BASF is also using its know-how to deliver and produce Color Converting Films on an industrial scale.

11

GAIKER
ik4 research alliance

Fundacion GAIKER:

LASSIE-FP7 also looks for the sustainability of the research results. For this reason, GAIKER is working in the environmental and economic analysis of the different alternative designs developed within the project.

The environmental evaluation is being carried out applying the Life Cycle Assessment method, which enables to quantify the impacts related to the complete life of the product, from the extraction of the resources for its production to its disposal, including also the use phase. According to the results obtained at this stage of the project, the use phase accounts for around 95% of the environmental impacts associated to the product. This is characteristic for lighting products, especially in long life technologies. In this context efficiency is a key aspect, and therefore the requirements set within LASSIE-FP7 aim to develop a lighting module with the highest efficiency class. But even more, LASSIE-FP7 has identified other key aspects. The project has identified the materials and processes with the highest contribution to the environmental impact during the production phase, leading to specific material changes. The project is also determining the most suitable recycling alternatives for the products developed, once they reach their end of life.

Carrying out the economic and environmental assessment at this early stage of the product development enables identifying limitations and influencing the design. However, it also implies to deal with high uncertainty (materials, processing, scaling up issues, etc.). The implication and collaboration of the experts within the consortium, and also within LASSIE-FP7 External Advisory Board has enabled to overcome this limitation.

12

AMIRES

AMIRES s.r.o.

A challenging medium-size project like LASSIE-FP7 requires an effective, efficient and well-defined management structure. Within the project, AMIRES s.r.o. is responsible for project management and dissemination activities. It supports the technical coordinator and Work Package Leaders in their administrative, financial, dissemination and communication role. After project proposal approval by the Commission, AMIRES ensured prompt negotiation and supported consortium agreement preparation. AMIRES project manager focuses on monitoring and timing of technical deliverables and milestones, ensures timely and quality reporting check, partner's budget follow-up and supervises the project to be compliant with Framework Programme rules.

Moreover, the project manager is responsible for coordination of the project meetings and teleconferences, and monitoring dissemination (e.g. development and running of project webpage, press releases, leaflets, newsletters) and exploitation planning.

In the last year of the project, AMIRES will supervise a design competition organisation and will be part of the final meeting preparation team.

AMIRES main vision of its added value to the project is to ensure that the project would be running smoothly and would deliver an output which exceeds the state of the art in the domain and contributes to more innovative Europe.

SAVE THE DATE: LASSIE-FP7 Final Workshop on SSL

LASSIE-FP7 consortium co-organizes with Swiss National Lab for Solid State Lighting SSSL and CSEM a Workshop on Solid State Lighting (SSL) in Pantheon, Muttenz - Basel in Switzerland on 12 December 2016. It will be the third workshop in a series when the first was held in 2014. As the project finishes at the end of the year 2016, final results will be introduced and demonstrators showcased at the workshop. Other SSL topics will be covered by invited speakers. You can also look forward to the announcement of the winner of the LASSIE-FP7 Design Competition. The details about the event will be continuously updated on www.swissphotonics.net among upcoming events and at the project website www.lassie-fp7.eu. Don't miss it!

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Project EU funding€ 3.15M

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