The transitions of ecological lighting

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PROCEEDINGS

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PROCEEDINGS

NEW SCIENCE, TECHNOLOGY AND CULTURE DEVELOPMENTS & APPLICATIONS

THE TRANSITIONS OF ECOLOGICAL LIGHTING

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The evolution from tungsten lighting to LED technology has led to experiments in which design is involved. New technological devices capture the energy produced by the light emitted by the luminaire and return it to the luminaire. In contrast, others exploit its high-frequency modulation and make it possible to "fill" a beam of LED light with information. This technology is called Light-Fidelity. The data is captured through an optical instrument and remains confined within the range of the light beam. In this case, the emitting device itself has a dual function: making light and transmitting data.

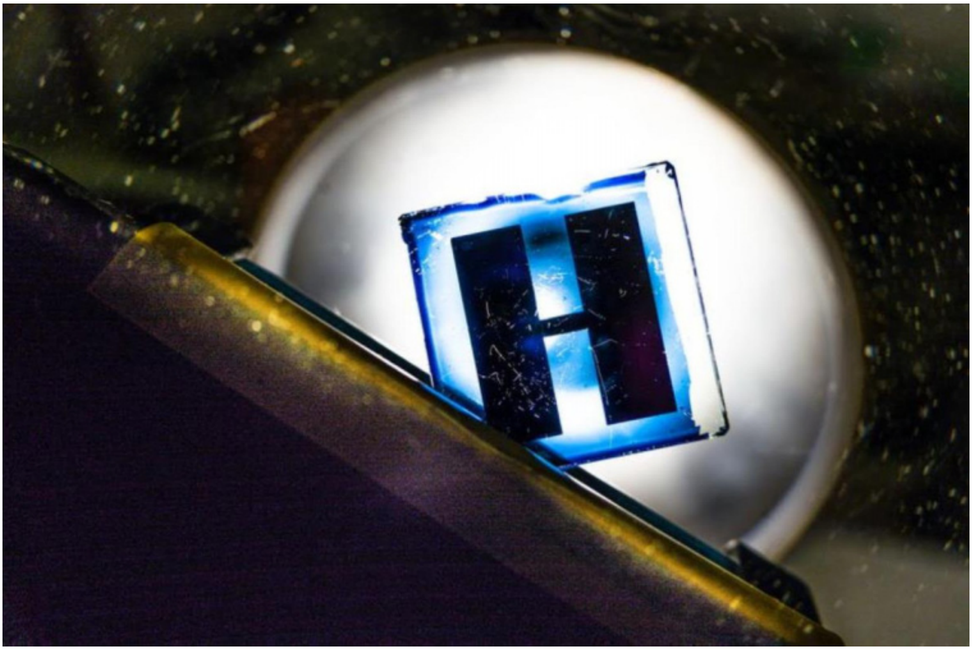
In addition to the technological transition already underway in terms of energy saving for artificial light, achieved by switching from tungsten lighting to LED technology, there are others still to experiment with and to which design is called upon to give substance. The experiments underway at the Smart Lighting Design - Sma.Li.De Lab of the University of Florence, I am the head, are already producing exciting results and launching concrete developments in this direction. Among the technologies tested by the Sma.Li.De Lab, three are mainly interesting for their potentialities and the already tested experimentation in progress, favouring the evidence of the theoretically hypothesised effects that the advancement of technological development is making more and more concrete. Photoluminescence, Organic Photovoltaic Cells (CFO) and Li-Fi (Light-Fidelity) offer valuable contributions to saving energy consumption in the lighting field.

PHOTOLUMINESCENCE

Using new generation pigments allows energy savings provided that the lighting is asked for a light of presence and not dazzling light. There are many cases in which adequate direct lighting is not needed, but a position light, a light that we can define as "presence" that gives the environment both inside and outside luminous evidence that defines the space with dim light, but enough to make people see in the dark. Photoluminescence, obtained from non-toxic natural minerals, absorbs daylight, and returns it to night with the science of energy consumption thanks to the minerals' properties in the pigments. This natural phenomenon contributes to saving energy and educating people to have a new relationship with the amount of lighting needed for adaptable vision in the dark. It is not always necessary to 'daylight' a driveway or garden overcome darkness. Consumption-free lighting such as that easily achieved with Photoluminescence provides sufficient soft perception to offer a degree of brightness that makes spaces and places visible in the dark. It should be borne in mind that any light emission emitted with energy is more powerful than the light emitted by Photoluminescence, but this does not prevent it from being sufficiently visible in a place subject to darkness. The effect can be obtained for about eight hours: the emitted light is visible in the first 15-20 minutes, then gradually decay. After the vividness of the first hour's maximum illumination, it loses brightness and stabilises for the rest of the seven hours while being visible. The ecological impact of this technology is evident from several key elements, both technical performance and type of use. The effect is direct, i.e., dependent on the system itself, and indirect due to the consequential impact triggered. Significant energy savings are achieved from the structures (lighting equipment) and places of use. In private and public outdoor spaces such as gardens, terraces, squares or pavements, swimming pools, fountains, or shop windows, it is possible to save up to 90% of traditional electricity consumption. Indirectly, however, the use of Photoluminescence impacts CO2 reduction because it does not require energy for its operation and helps save energy by acting as an alternative to other darkening systems. The eco-compatibility of the pigments, the unlimited duration, and the absence of power for operation place Photoluminescence at the disposal of a new culture of light against excessive consumption and light pollution and helps to make the culture of eco-sustainability practical to implement.

SELF-POWERED LAMPS (INDOOR PHOTOVOLTAIC CELLS)

Another technology tested by the Sma.Li.De Lab is based on self-powering lamps that take energy from themselves. Lights with energy gain are obtained by absorbing energy from LED sources and not solar energy. New films with organic components developed by researchers at Linköping University in Sweden, led by Feng Gao, and other researchers at Peking University, led by Jianhui Hou, have developed a combination of materials, carefully determined to be capable of yielding and accepting electrons, of absorbing exactly the wavelengths of light produced by artificial lighting sources. These panels can be called Indoor Photovoltaic cells - IP cells. This technology produces a voltage of more than 1V for more than 1000 hours from the capture of light produced by LEDs with a variation of 250 to 1000 lux (Hou & Guo, 2013). The potential of these films is enormous, considering that lamps often use lampshades to direct the light, which only absorbs the refraction of illuminance as an aesthetic effect. The prototypes developed by Sma.Li.De Lab have adopted the following principle: a source of light emitted by the lamp is partially intercepted by the IP cells incorporated in the same, which convert it into new electrical energy to feed the recharge of a battery that will give a new impulse to the LEDs to transform it back into the light. This is a lamp that will not be utterly self-powered since thinking of being able to close the cycle of consumption and recharging is utopian. The partial loss of energy as it passes through the circuits, but also because of the current efficiency of the devices, does not allow again more significant than the 24% of the energy used to illuminate that an LED source produces. It will be the progress of studies and experiments that, with the contribution of design, will provide the possibility of energy-saving and clean energy recovery and a new way of conceiving and using lighting equipment.



High-performance organic solar cells developed for indoor use

LI-FI TECHNOLOGY

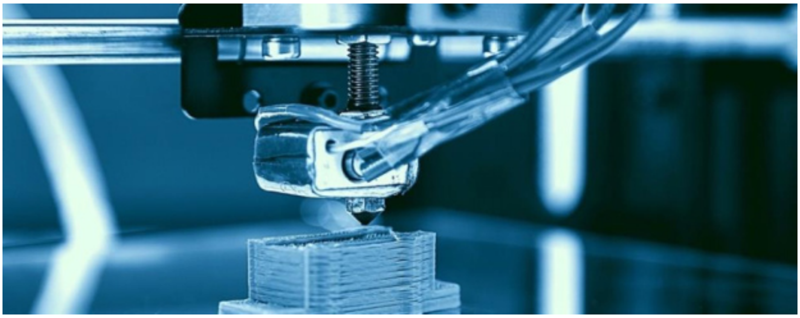
Still, another technology in lighting technology and resource-saving are waiting to contribute to the transition towards resilient principles and behaviour. The Smart Lighting Design Lab is testing, in synergy with the VisiCoRe Lab of the University of Florence and INO-CNR, several lamps that, in addition to their task of illuminating environments, have the dual function of transmitting data and thus offering a connection to the Internet simply by placing the receiving device under the beam of light. This new technology is called Li-Fi (Light-Fidelity) as an alternative to Wi-Fi. Using high-frequency light modulation, it is possible to 'fill' an LED light beam with information and transmit it as far as the light reaches. In this way, the data can be transmitted through an optical instrument and remain confined within the range of the light beam. If this works, the design has the task of incorporating the dual contribution that light can make: making light and transmitting data simultaneously.

Relux, a prototype of a self-powered lamp with IP cells technology created by the Smart Lighting Design Lab (UNIFI) with Esther Anguillesi

The determination of the project lies not only in combining the two performances in a single lamp but above all in making it available for recognition for the great advantage it brings. The award puts into the experiment the formal search for new types of lighting products that tell the story of their advantage. With this technology, the design contributes to the design of formally relevant objects. It has a proactive content, reacting to environmental impact by reducing the equipment used to operate them, the materials used, and the energy used to produce manage them. The energy consumption concerns the only light that is switched on, which performs two activities while powered. The double result with the same consumption. In all these technological perspectives, design intervening in the cultural offer of products can make a considerable synergic contribution not only to energy saving by finding appropriate applications for these innovations but also a new way of conceiving and using lighting equipment by educating people to a more conscious use of energy.

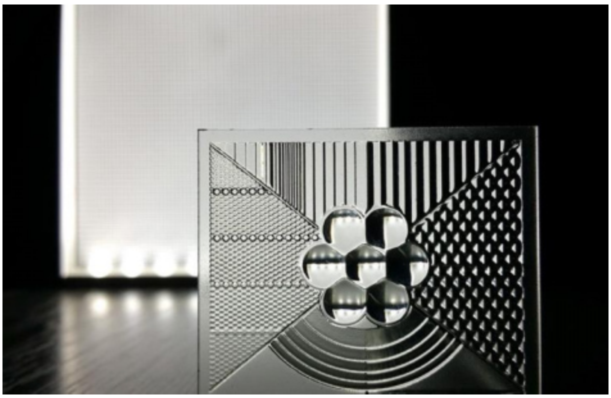
ADDITIVE MANUFACTURING INNOVATION

The Smart Lighting Design Lab at the DIDA Department of Architecture in Florence has been experimenting for some time with new developments in 3D modelling and Additive Manufacturing (AM), starting from CAD (Computer-Aided Design) models designed on the computer by adding several layers of material on top of each other, with specific application on lighting devices. The study prototypes developed are based on formal research into energy-saving structures and components at all design stages. Additive manufacturing systems work with various materials, allowing a single machine to produce parts suitable for different applications. One of the best examples of this versatility is polymer 3D printing processes using resin, such as stereolithography (SLA). Other unique 3D printing materials make it possible to digitise processes that until now were exclusively analogue. For example, high-temperature resins can be used to injection moulding low-pressure plastics and even melt soft metals such as pewter. Parts moulded by stereolithography, selective laser sintering (SLS) and fused filament fabrication (FFF), and fused deposition modelling (FDM) can be compounded and used to create device parts to be assembled into a single illuminating object/body.



Example of Additive Manufacturing (AM)

A Dutch company interestingly broadens its technical scope by proposing an innovative vision of additive technology and 3D printing using rapid prototyping to create LED optics, thus directly focusing on the technical characteristics of the luminous flux and not only on the decorative part of the finished object. After the creation and machine adjustment of the 3D design of the new optics studied, thin plates with a very high degree of definition are printed, avoiding the uncertainties associated with conventional processes, especially in the development phase. Furthermore, the printed optics are smooth and functional directly from the 3D printer without post-polishing.



3D printed micro lens structures (www.luximprint.com)

Although conventional glass processing and injection moulding techniques produce higher quality parts with generally better feature resolution, 3D printing techniques offer the best route for prototyping or low volume work at a much lower cost (Hamadi et al., 2020). Additive manufacturing has also been identified as a viable and versatile process for fabricating plastic optical components for prototyping or low-volume research applications. Although many printing technologies use optically transparent materials, photopolymerization processes are preferred as they are more likely to produce parts with little or no void space, limiting scattering losses (Suresh Nair et al., 2019). In proposing innovative formal aspects, the use of generative computation software allows new worlds of design freedom and enables designers to create geometries, structures and final parts with incredible complexity (Zhang & Liou, 2021) and significantly reduce the amount of material in configuring an object with a corresponding economic benefit of not only material reduction but also the time is taken to make it. There is, therefore, a strong synergy between the designer and artificial intelligence: the designer's creativity is not suppressed, but rather it is stimulated thanks to the creation of a large number of possibilities and options to experiment and explore. In generative design, as in generative art, the objective is the process and not just the result. The designer's focus is on the design process, on controlling the process. In a phase of transformation and innovation, the designer will not lose his central role but will redesign it with new working methodologies (Faraone, 2021). The entry and experimentation in additive manufacturing of new materials that are stronger and more flexible with multiple performances make it possible to study, create and prototype parts and products with complex characteristics, which could not have been quickly produced through subtractive or other traditional production processes. With additive manufacturing, parts can be made immediately, as there is no longer a long lead time to produce the objects. The production of the tools needed for conventional mass production typically takes a few weeks to several months. This feature of additive manufacturing significantly impacts the time-to-market of new products and the ability to easily produce model changes throughout a product's life (Diegel, 2014).

Through additive manufacturing, classified as a standard terminology in the seven American Society for Testing and Materials (ASTM) F2792-12 categories, three-dimensional printing (3DP) components, manufactured by adding materials layer by layer, are considered ready-to-use finished products, and we have tested their feasibility in the laboratory for the manufacture of new energy-saving lamps. A basic model designed for a specific performance allowed accelerated production of the components with design and customisation capabilities. Thanks to computational calculation and the variability of the formal solutions obtained with generative modelling, the possibility of getting products with greater customisation, improved design, multi-functionality and high performance. Variations programmed with 3D modelling within the software, such as Autodesk Fusion 360°, Rhino-Grasshopper or SolidWorks, open up potentially efficient scenarios in terms of economy of scale in the production of new objects. In the specific case of the new generation of lamps, developed and prototyped by Sma.Li.De Lab, they have analysed and put into practical experience the double advantage of having much choice in identifying the optimal form concerning the performance and aesthetic indications inserted in the computational modelling and allowing, in the same design process, parametric control of the quantity of material used with the same formal content adhering to the aesthetic desired by the designer. The AM process also offers greater flexibility in product design and, in addition, can be used to incorporate sensors, or other electronic elements, into components to manufacture intelligent structures without compromising the geometries of the part. Using AM in any field is mainly due to cost reduction and the absence of limitations in product design freedom compared to traditional manufacturing processes. Complex functionality can be developed using AM to improve optimal product performance parameters. Designs for AM are considered off-the-shelf processes in which anything can be customised, regardless of functional complexity, material complexity and integration or assembly of parts (Krishna et al., 2021). Benefits and experimental exercises that are increasingly needed not only to train young designers during their education, as these kinds of practices take place in academia, but also to raise awareness of the contribution that new design processes, such as 3D generative modelling and 3D manufacturing, can make to the saving of both time, material and energy resources in the creation of new environmentally sustainable product configurations.

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