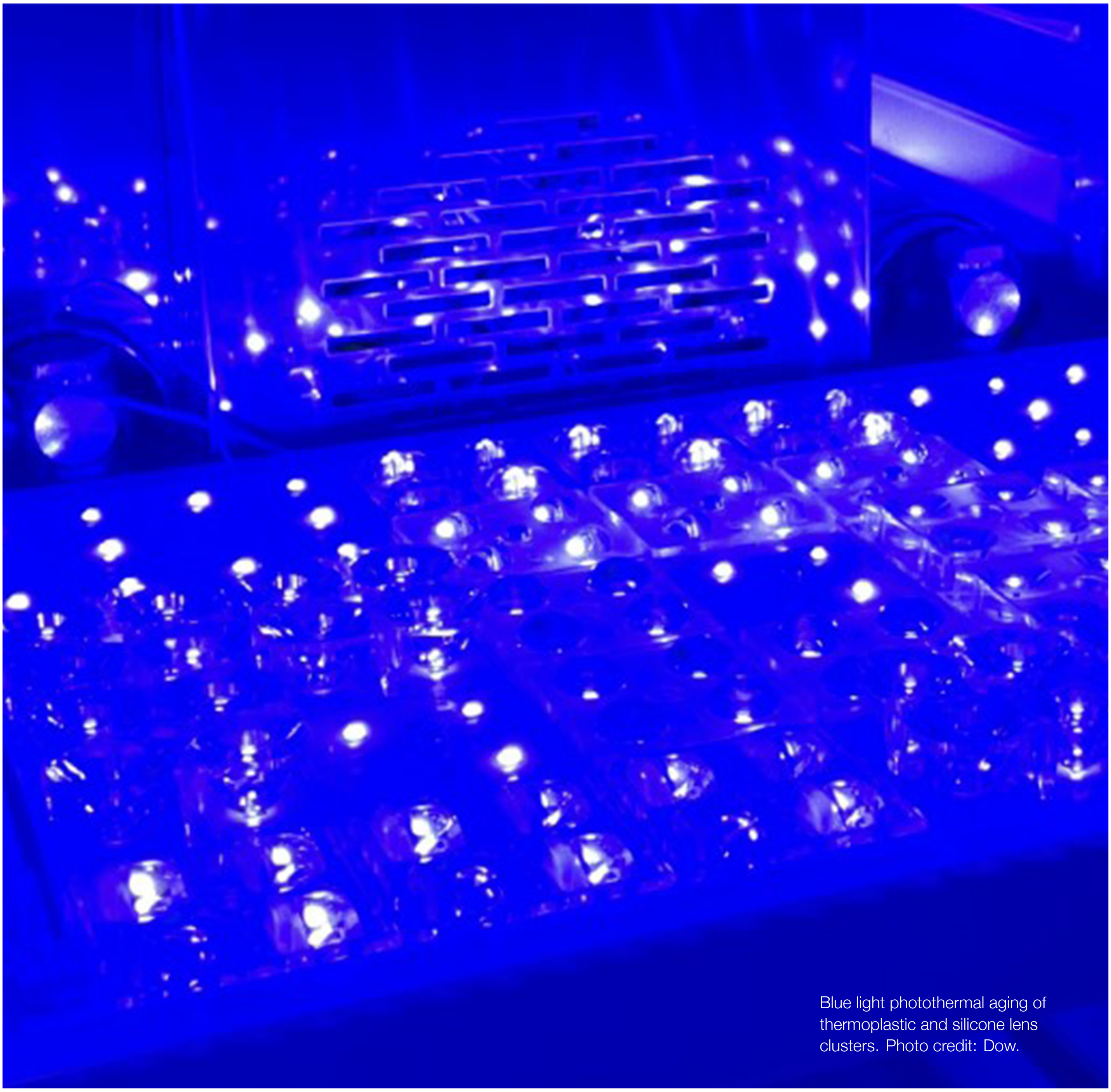
Materials as a Key Enabler for Next-Generation Lighting – Martijn A. Beukema, Technical Service & Development Scientist at Dow


Blue light photothermal aging of thermoplastic and silicone lens clusters. Photo credit: Dow.

As lighting technology reaches maturity, innovation is shifting toward materials, system integration, and long-term reliability. Deeper insights into material behavior—such as Dow's recent work on optical aging—are becoming increasingly critical to enabling next-generation lighting designs. In this exclusive interview Martijn A. Beukema draws on more than two decades of experience in LED optics, materials, and luminaire design to provide valuable perspectives on how deeper material understanding and long-term optical stability are becoming key drivers for future lighting innovation.

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LED professional: Martijn, let's start with your role—what do you do at Dow, and how does your work connect to the lighting industry?

Martijn A. Beukema: I work at the intersection of application development and customer collaboration, partnering closely with lighting manufacturers and our internal R&D teams to develop material solutions tailored to lighting systems. My scope covers both new product innovations and the optimization of existing solutions—from optically clear silicones for secondary optics to protective materials used in electronics and housing assemblies.

With a background in light–matter interactions, I've always been fascinated by how materials influence optical performance. The LED revolution—accelerated by the invention of the blue LED by Shuji Nakamura[1]—fundamentally reshaped the lighting industry. Dow has been part of that journey for decades, and we continue to deepen our understanding of how materials can push performance further.

LED professional: Lighting has matured in many ways. From your perspective, how strategic is this segment for Dow today?

Martijn A. Beukema: Lighting remains a strategically important segment for Dow, even as the industry matures. The transition from conventional lighting to LED has fundamentally changed how luminaires are designed, manufactured and integrated into systems.

Modern luminaires require advanced materials across the system—from LEDs and drivers to PCBs, heat management components and secondary optics. At the same time, new assembly approaches and higher performance expectations are driving material innovation.

We see continued growth, particularly in demanding applications such as sports, horticultural, street, area and automotive lighting. These environments require materials that can withstand high thermal and photothermal loads while maintaining long-term reliability.

A key differentiator for Dow is our early engagement with customers. We collaborate at the design stage to guide material selection and system optimization, helping enable energy efficiency, durability and ultimately lower carbon footprints. We also work across the value chain to accelerate innovation at a system level.

LED professional: What are the biggest challenges lighting manufacturers are dealing with right now—and where do materials come into play?

Martijn A. Beukema: While the challenges facing lighting manufacturers are broad, one area where materials play a critical role is in preventing premature system failure.

Industry expectations for luminaire lifetimes[2] have increased significantly—often targeting 50,000 to 100,000 operating hours. This raises both performance expectations and warranty risks. Unlike legacy lighting technologies, where failure was largely confined to the filament, modern LED systems are more complex, and material performance increasingly becomes a limiting factor.

Long-term reliability now depends on how materials behave under combined stresses—thermal, optical, electrical and environmental—over extended periods. This makes deep expertise in material science, aging behavior and accelerated testing essential.

In addition, as LEDs approach their theoretical efficiency limits[3], further gains in system performance are increasingly enabled by materials. For example, thermal interface materials and protective silicones help manage heat and maintain optical performance, directly influencing system efficiency and lifetime.

LED professional: When it comes to LED systems, where do advanced materials—especially silicones—really make a difference?

Martijn A. Beukema: Silicones bring the greatest value in applications that demand long lifetime, optical stability and reliability under combined thermal and optical stress.

In LED optics, silicone lenses offer superior resistance to yellowing and maintain optical clarity over time. This enables higher drive currents, increased light output, and the development of more compact or high-density designs—such as slim luminaires or tightly packed LED arrays.

[1] www.nobelprize.org/uploads

[2] www.lightingeurope.org/images/guidelines

[3] Nature Energy | Volume 10 | May 2025 | 616–629.

Compared to thermoplastics, silicones are inherently more stable under harsh operating conditions. This translates into a lower risk of performance degradation, reduced warranty exposure and improved long-term system reliability.

While silicones may involve higher upfront material costs, they often deliver lower total system costs by enabling a longer service life and more stable performance.

LED professional: Dow has been a long-standing player in this space. What sets your solutions apart from other material suppliers?

Martijn A. Beukema: Dow's strength lies not only in materials, but in how we apply them.

We combine deep material science expertise with application-level understanding, supported by technical studies, optical validation and real-world testing. Our global team brings together competencies in chemistry, physics and multiple engineering disciplines to solve complex system challenges.

Importantly, we operate across the full secondary optics value chain—from optical design and molding to industrial processing. Our application laboratories cover every building block of the LED module, allowing us to evaluate materials in realistic system conditions.

This integrated approach enables us to co-create solutions with customers that are optimized not only at the material level, but at the system level.

LED professional: Dow recently published a study on blue light photothermal aging of LED optics[4]. What triggered this research, and what key gap were you aiming to address?

Martijn A. Beukema: There is a substantial body of research on photothermal aging of thermoplastics, but much of it is based on simplified test samples that do not fully represent real-world optical components, such as injection-molded lens clusters.

At the same time, while LED package reliability has been extensively studied, there has been less focus on the long-term behavior of secondary optics under realistic operating conditions.

Aerial drone view of a high-power pitch lighting system. Photo credit: Dow.

In discussions with customers, there was general awareness of the performance advantages of silicone optics, but a lack of comparative data against commercially available thermoplastic solutions. That gap motivated our study.

We leveraged our existing aging data on Dow's SILASTIC™ moldable optical silicones and expanded our investigation to assess how different thermoplastic lens clusters perform under more representative conditions. The goal was to better understand performance limits and identify scenarios where material choice can make a critical difference.

LED professional: The study points to degradation—and even catastrophic failure—of thermoplastic optics under real operating conditions. How relevant is this risk for today's high-power lighting applications?

Martijn A. Beukema: The relevance depends on operating conditions—particularly the photothermal load and the specific material formulation.

Our results confirmed that PMMA is generally more stable than other thermoplastics, which aligns with industry knowledge. However, it still requires careful thermal management to avoid deformation when operating limits are exceeded.

Performance can also vary depending on raw material sourcing, stabilizer formulations and processing conditions at the molder.

A key observation is that once stabilizing additives are depleted, degradation can accelerate rapidly. Under high irradiance conditions, this can lead to thermal runaway—resulting in severe discoloration, deformation or even material failure.

By contrast, silicones exhibit intrinsic stability under typical luminaire operating conditions, even beyond the thermal limits of many thermoplastics, which significantly reduces these risks.

LED professional: Based on your findings, how should luminaire manufacturers rethink material selection for long-term reliability?

Martijn A. Beukema: Manufacturers already manage known limitations—for example, by increasing the distance between LEDs and optics or adjusting drive currents.

However, our findings highlight the importance of evaluating material behavior over the full system lifetime, not just initial performance.

[4] https://www.dow.com/en-us/market/mkt-electronics/sub-elec-lighting/app-elec-light-optics.html

Thermoplastic optics rely on stabilizing additives, which degrade over time. Once depleted, material performance can deteriorate quickly under combined thermal and optical stress.

Silicones, in contrast, are inherently stable across UV, visible, and near-infrared wavelengths and do not rely on such additives. This makes them particularly well suited for high-intensity or UV-related applications.

Ultimately, selecting the right material is about balancing performance, reliability and system-level design—especially in demanding operating environments.

LED professional: **Beyond this study, can you highlight recent innovations from Dow that are relevant for lighting?**

Martijn A. Beukema: Dow continues to innovate across several key material areas for lighting.

Our portfolio includes moldable optical silicones for high-power LED lenses, optical potting solutions for linear lighting, thermal interface materials and pottants for heat management, as well as high-durability adhesives and sealants.

We are also advancing carbon nanotube-based thermal technologies to improve heat spreading in compact, high-power modules.

These developments address critical industry challenges—thermal management, optical stability, environmental resistance and long-term reliability. As always, we continue to co-develop new solutions with customers to meet evolving system requirements.

LED professional: **The industry is evolving fast—what key trends are shaping the next phase of lighting?**

Martijn A. Beukema: Several trends are shaping the future of lighting.

We see continued advancement in smart and connected systems, increasing adoption of solar and off-grid lighting, and growing interest in modular and additive manufacturing approaches such as 3D printing.

At the same time, luminaires are becoming more integrated with sensors, controls and building systems. There is also rising demand for tunable and adaptive lighting solutions.

Across all these trends, sustainability, system efficiency and long-term performance remain central—and materials play a key enabling role.

LED professional: **Smart and connected lighting continues to gain traction. How does this shift impact material requirements?**

Martijn A. Beukema: As systems become more integrated and complex, material requirements increase accordingly.

Materials must support higher performance, improved reliability, and compatibility with advanced electronics and sensing technologies. This further reinforces the importance of early-stage collaboration between material suppliers and system designers.

At Dow, we continue to work closely with customers to support these evolving requirements from the outset.

LED professional: **Looking ahead, what role will materials play in the next generation of lighting?**

Martijn A. Beukema: Even as LEDs approach their theoretical efficiency limits, materials remain a key lever for improving system performance.

Material selection directly impacts thermal management, optical efficiency, durability and overall system reliability. This is where meaningful gains can still be achieved.

Dow is committed to supporting customers across the value chain with high-performance silicone-based materials that enable more efficient, durable and sustainable lighting systems—particularly in demanding, high-power applications.

LED professional: **Thank you for providing these valuable insights into the future of lighting materials and system reliability.**

Martijn A. Beukema: My pleasure. ■

Martijn A. Beukema is a Technical Service & Development (TS&D) Scientist at Dow, based in Seneffe, Belgium, where he focuses on material solutions for LED lighting applications. In addition, he serves as Application Technology Leader for the lighting segment, supporting the development and implementation of material technologies across global applications.

He earned a Master's in Applied Physics from the University of Twente, Netherlands (1996), and has worked in research, development, and customer roles throughout Europe. With expertise in optical physics and engineering, his focus for the past 20 years has been LED light engines and luminaire design.

In his current role, Martijn works at the interface between material development and lighting system design, collaborating closely with both internal teams and customers. He supports applications ranging from secondary optics to the protection of electronic components and luminaire assembly, with a particular focus on silicone-based materials.

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