High Efficiency Nanofiber Reflectors for Lower Lighting Operational Costs

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ABSTRACT

Light fixtures or luminaires containing advanced lamp technologies such as LEDs suffer from an intrinsic flaw. The materials used to make the luminaire absorb a significant amount of light, reducing lighting system efficiency. RTI's NLITe™ technology overcomes this limitation by leveraging advanced nanofiber technology to provide a surface with a high diffuse reflectance. The NLITe technology has been tested in more than a dozen luminaires and efficiency improvements as high as 40% has been observed. These efficiency improvements translate into significant reduction in capital and operational cost of lighting systems incorporating NLITe.

Keywords: lighting, nanofiber, luminaire, reflector, efficiency

Lighting accounts for roughly 20% of all electricity consumption in the United States, so efficiency improvements in general lighting pays significant dividends in terms of reduced energy consumption and carbon dioxide emissions. New lamp technologies such as solid-state lighting (SSL) devices incorporating light emitting diodes (LED) continue to provide improving efficiencies at the lamp level. These advanced lamps can be combined with power supplies, optics, painted metal, and other reflectors to form luminaires that are used as part of a lighting system. However, a substantial portion of this efficiency gain is negated at the luminaire level due to a reliance on less efficient reflector materials that absorb a significant percentage of the light generated by high efficiency lamps. As a result, luminaire efficiency is often in the 0.60 to 0.70 range. To overcome the issue of parasitic absorption in luminaires, RTI developed a nanoscale material that exhibits high (> 0.97) diffuse reflectance and provides even color balancing across the visible spectrum. Incorporation of RTI's Nanofiber Lighting Improvement Technology (NLITe) into luminaires has been demonstrated to increase light output by as much as 40%, which can translate into higher luminous efficacy.

As shown in **Figure 1**, the NLITe technology is based on an advanced nanostructured material formed from the random assembly of polymer nanofibers with diameters between 150 to 500 nanometers (nm) and lengths on the scale of meters. Sheets of the NLITe material are made using roll-to-roll spinning processes, and NLITe reflectors can be inserted into luminaire surfaces to replace underperforming reflector materials. NLITe materials capitalize on the improved light scattering efficiency that arises when nanofiber features are comparable in size to the wavelength of visible light (i.e., 380 to 760 nm). The characteristically high reflectance of the NLITe material is analogous to the excellent reflectance properties of fresh snow that arise from the random structure and packing of snowflakes.

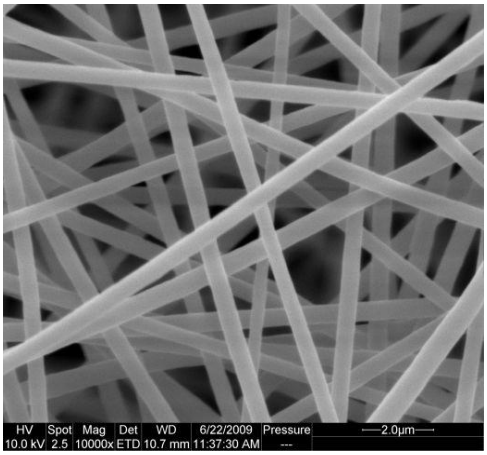

Figure 1: The NLITe™ material is a technical textile sheet that acts as a high efficiency reflector and provides performance that is superior to current technologies used in luminaires (paint, metallized plastics, etc.).

NLITe-modified luminaires provide a significant benefit to the lighting environment by reducing energy consumption, decreasing glare, and furnishing a more pleasing lighting environment. To validate the advantages of the NLITe technology in luminaires, RTI performed a head-to-head comparison on equivalent luminaires containing conventional reflector technologies and those incorporating NLITe reflectors. A comparison of the luminaire efficiency (defined as the ratio of the luminous flux emitted by the luminaire to the luminous flux of the lamp[s] alone) for a lensed 2-foot × 4-foot troffer and a fluorescent downlight is provided in **Table 1**. In both cases, the efficiency of the NLITe-modified luminaire was significantly higher than that of the standard luminaire [1]. This efficiency gain allows the NLITe-modified linear fluorescent troffer to produce luminous flux levels

Luminaire	Configuration	Efficiency	Lumens	Energy Saved Per Fixture Per Year
Lensed Troffler	Std. White Reflector, 4 Lamps @ 32 W ea.	63%*	6829	—
	NLITe Reflector, 4 Lamps @ 32 W ea.	81%*	8780	—
	NLITe Reflector, 3 Lamps @ 32 W ea.	83%*	6748	96 kWhr/fixture***
Fluorescent Downlight	Std. Al Metal Reflector, 2 Lamps @ 26 W ea.	58.1%**	1987	—
	NLITe Reflector, 2 Lamps @ 26 W ea.	76.5%**	2754	—
	NLITe Reflector, 2 Lamps @ 18 W ea.	76.5%**	1836	24 kWhr/fixture***
Lensed Troffler	Std. White Reflector with LEDs	66%**	3456	—
	NLITe Reflector with LEDs	77%**	4001	—

* Estimated from light meter readings in field tests
** Radiometric test results.
*** Energy savings calculated assuming 3000 hours of annual operation.
Note: The lamps used in the luminaires were high-efficiency fluorescents.

Table 1. Comparison of the performance of conventional luminaires with the same luminaires modified with NLITe.

comparable to the original luminaire with three lamps instead of four, delivering an immediate 25% reduction in electricity consumption. According to the recent lighting market characterization study performed by the U.S. Department of Energy (DOE), linear fluorescents account for approximately 42% of the electricity consumed by lighting systems in the United States [2]. This information suggests that NLITe has the potential to reduce the total energy consumption of the office lighting systems by as much as 10.5%.

As an additional validation of the NLITe technology, the building-level impact of NLITe-modified luminaires was investigated. The chosen building floor plate contained approximately 17,000 square feet (ft^2), with a mix of open offices, private offices, and conference rooms, and the lighting system was designed using a lighting layout software. **Figure 2** shows the total power consumed by the lighting system across the floor plate, and the benefits of the reduced energy consumption in the NLITe-modified luminaires is readily apparent. In all building locations, the available lighting exceeded applicable guidelines set by local codes and the Illumination Engineering Society (IES).

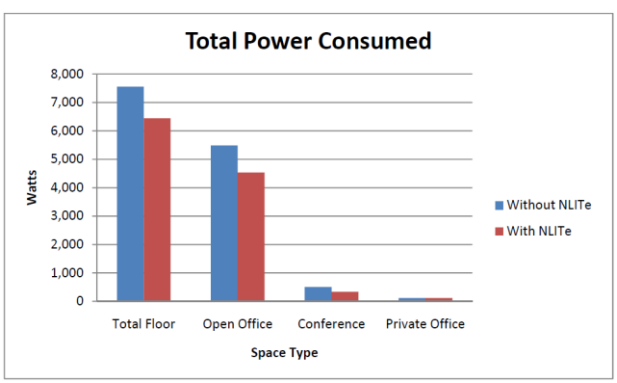

Figure 2. A comparison of the total power consumed in the model floor plate using a 2-foot x 4-foot lensed troffer and an equivalent luminaire made with NLITe. All light levels exceeded IES requirements.

This analysis demonstrated three ways that NLITe could provide an improved energy-efficient lighting systems. First, the higher light output levels of the NLITe-modified luminaires allowed fewer fixtures to be used in open areas of the floor plate (e.g., open offices, conference rooms), permitting a reduction in energy consumption because of the lower fixture count. Second, although it was not possible in small offices to reduce luminaire count and maintain acceptable lighting levels, the more efficient NLITe-modified luminaires produced significantly higher illuminance levels in these instances than the legacy luminaires, enabling new energy savings through use of dimming controls or a light management system. The third method demonstrated in this study to reduce energy consumption with NLITe was to use lower-powered lamps and ballasts in areas where illuminance is high.

In summary, NLITe is an innovative technology platform for the lighting industry that enables substantial energy savings and produces aesthetically pleasing light. The technology can be applied to any lighting fixture, from traditional fluorescents to energy-saving LEDs. NLITe reflectors dramatically improve light output and energy efficiency. This allows builders, architects, lighting engineers, and designers to change their lighting designs in order to reduce installation costs while lowering operating and maintenance costs. As a result, adding NLITe to most luminaires reduces the energy consumption and CO_2 emissions associated with lighting.

REFERENCES

[1] Davis, J.L., et al., "High Efficiency NLITe™ Reflectors for Increased Lighting Efficiency," Presented at Partners in Environmental Technology Technical Symposium and Workshop, Washington, DC. November 30, 2011.

[2] U.S. Department of Energy, "2010 U.S. Lighting Market Characterization," Page 34, January 2012. Available at http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf.