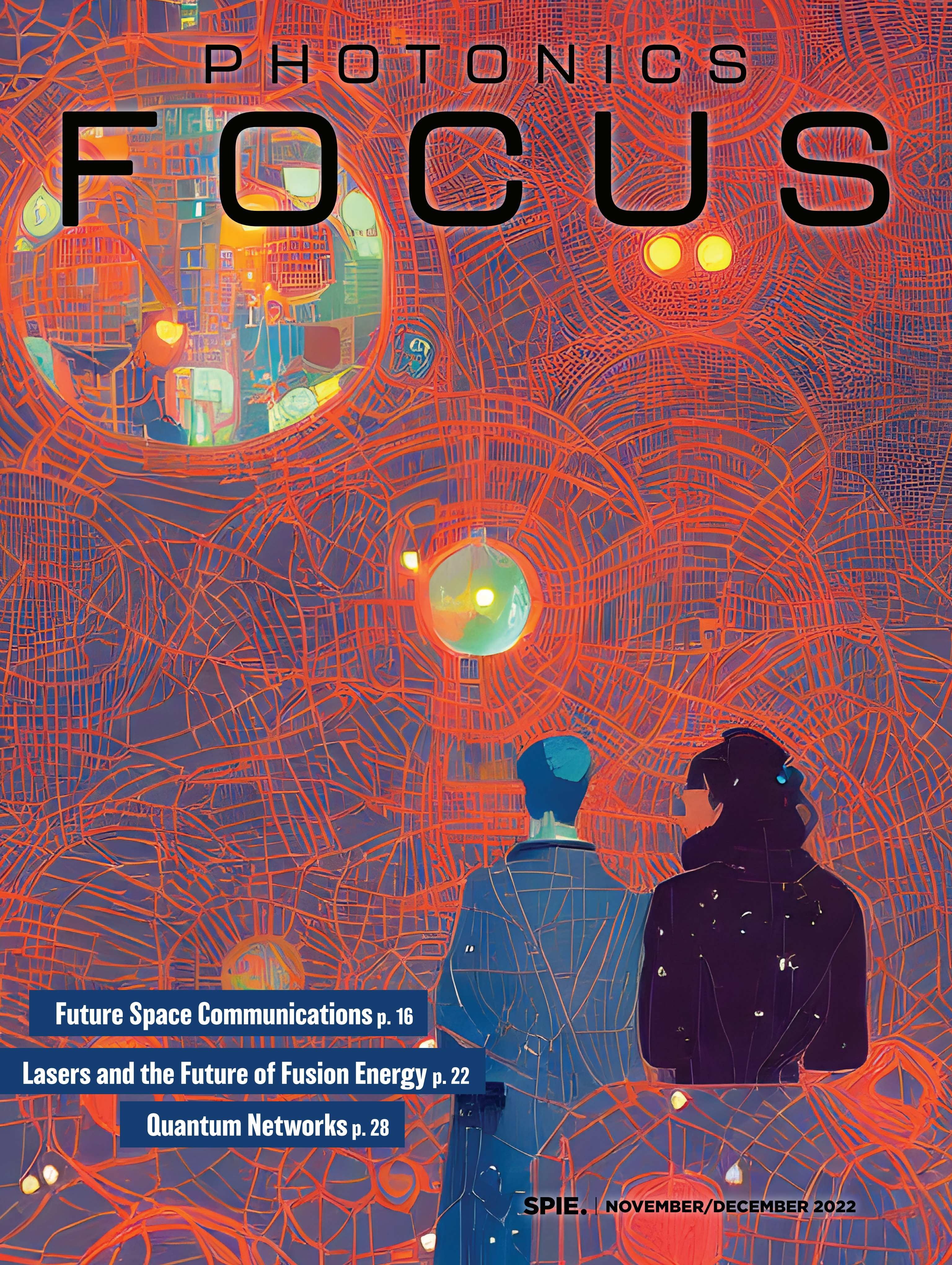

PHOTONICS FOCUS

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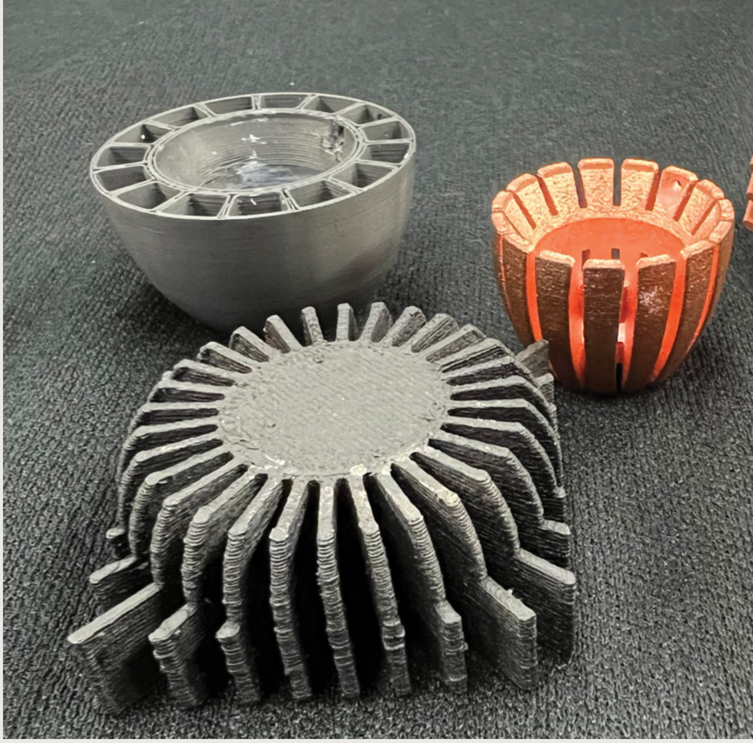
Lighting Up the Future of 3D Printing



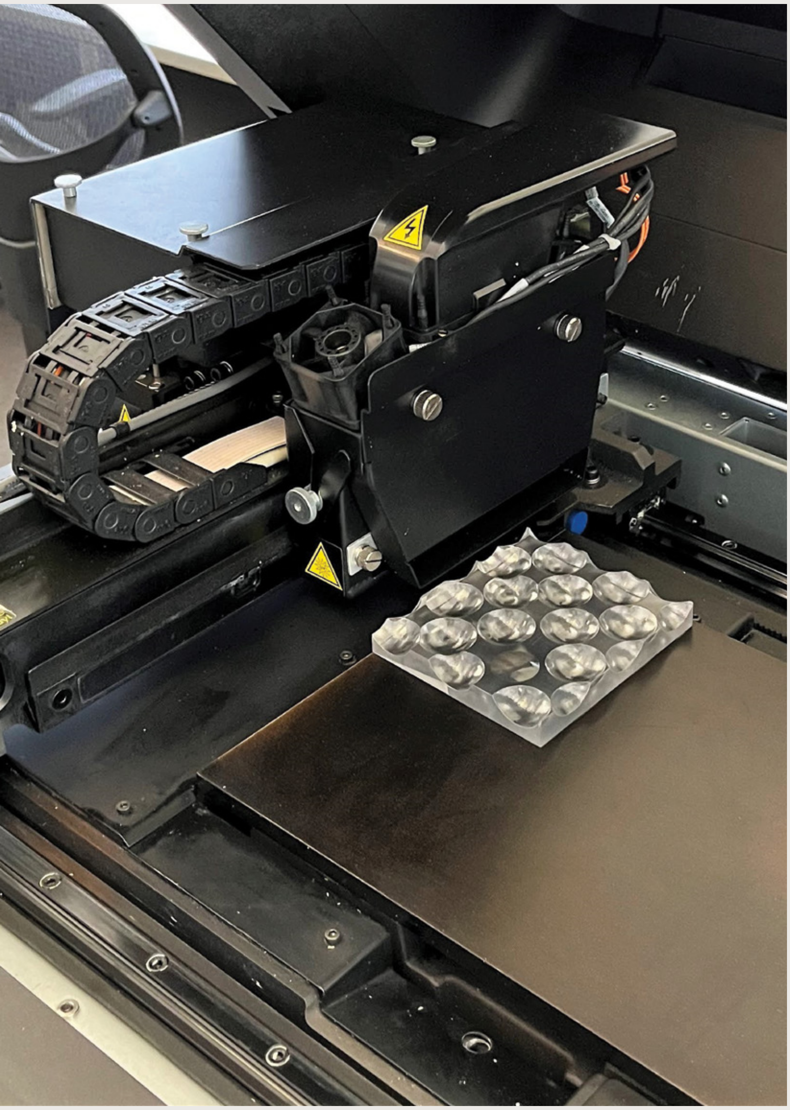
3D PRINTING has found a niche in prototyping and hobbies, both applications that require the ability to produce one-off complex designs quickly and cheaply. However, industry is looking toward additive manufacturing, too, and for the same reasons.

The lighting industry, for example, is now among the growing list of adopters. According to the US Department of Energy (DOE), additive manufacturing has the potential to solve many of the issues faced by the lighting industry, like reducing its manufacturing and transportation carbon footprint, helping to avoid supply chain disruptions, delivering better quality and reliability, and bringing back local manufacturing jobs.

But wait, there's more, says Indika U. Perera, a lighting researcher at Rensselaer Polytechnic Institute's (RPI) Lighting Research Center (LRC). 3D printing allows objects of almost any shape or geometry that might have been difficult or impossible economically to manufacture using traditional manufacturing methods, especially in smaller production runs, to be manufactured from digital model data. Custom lighting fixtures could be manufactured on-site for quick installation, and components like heat sinks could be designed as part of the fixture envelope rather than attached afterwards. This would reduce fixture bulk, size, and cost, and improve lighting aesthetics.

With those benefits in mind, Perera says, engineers and researchers at Eaton Corp., LRC, and Xerox Research Centre of Canada, with support from DOE, set out to fabricate and additively manufacture a solid-state luminaire—a parking lot lighting fixture—as a test-case study. One goal was to design a reflective secondary optic for the fixture's light engine and then 3D print and evaluate its performance in terms of light output, intensity distribution, application efficiency and efficacy, and illuminance uniformity.

The researchers selected a benchmark fixture with a mounting height of 20 feet. "Your target plane for this type of application based on lighting standards and recommended practices is two times that of the mounting height, so roughly 40 feet by 40 feet on either side with the light fixture at the center," Perera says. At 124 lumens per watt (lm/W) fixture efficacy, the benchmark fixture's application efficacy—the amount of useful light falling in the target area that was within the maximum and minimum illuminance values based on the application requirement—was 77 percent. Spillage is reducing the application efficacy, Perera explains: "It's putting out a lot of light but it's not going into that area where it's required."



Optics designed by RPI graduate student Akila Udage and printed using Stratasys Objet30 Pro Polyjet 3D printer.

Heat sinks were designed and 3D printed by LRC researchers and HP engineers using a variety of materials (left). Wall sconce designed and 3D printed by the LRC. (above).

For a 3D printed fixture, Perera says, the study team set a goal of 130 lm/W for application efficacy, and to achieve this project objective required a secondary optical component that would result in greater than 90 percent application efficiency. Application efficiency is the ratio between the flux on the target plane within the minimum and maximum illuminances and the total flux emitted by the light source.

With ray tracing software and information from LED source manufacturers, the team designed and fabricated three prototype reflectors: Two were 3D printed from a semiclear photo-curable resin and then nickel plated and polished by two different vendors. The third reflector was 3D printed in white nylon and finished with a specular reflective laminate adhered to the front surface of the reflector by Eaton Corp.

Testing revealed that the third reflector delivered the best overall performance with an application efficiency near 93 percent and minimum spillover while also maintaining the maximum-to-minimum illuminance ratio of approximately 10:1. The parameter-based design optimization was used to improve the optical performance of the reflector geometry and boost its application efficiency, among other important performance metrics, Perera says.

As a result of their efforts, Perera says the team now has laboratory characterization results of the reflector surface optical properties that were 3D printed and subsequently post-processed, as well as effects on the reflector performance due to 3D printing processes and 3D printing parameters. In August, four papers by LRC researchers, including Perera, were presented at the SPIE Optics and Photonics conference in San Diego regarding novel designs of 3D-printed lenses and optics for LED lighting systems.

Moving forward, LRC has established an alliance among researchers and manufacturers, called the ASSIST 3D Printing for Lighting consortium, to help overcome technical barriers and make 3D printing a viable resource for the solid-state lighting industry. These key stakeholders aim to develop a roadmap for transforming the industry to provide custom lighting fixtures, on-site and on-demand, that will elevate the appearance, value, and experience of the built environment, says SPIE Fellow and LRC Director of Research, Nadarajah Narendran. He notes that LRC also educates RPI students in the field of 3D printing for lighting, including PhD candidate Akila Udage, who presented several papers on 3D printed optics at the SPIE conference.

WILLIAM G. SCHULZ *is Managing Editor of* Photonics Focus.

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