



low protein yield—making the process inefficient—and low molecular weight, weakening the resulting product. It seems that while spiders are well suited to efficiently express these large proteins critical to their survival, other species are not.

Scientists at Utah State University turned to silkworms as an alternative, engineering them to create a hybrid spider-silkworm protein. “This was a great idea, as most expression systems aren’t well suited to making proteins of the size of the main silk proteins,” said Federico Rosei, a researcher at INRS University in Quebec, Canada, and another contributor to the review.

Once the proteins are expressed, the resulting slurry must be spun into a thread. Spiders have specialized

equipment for this task: glands in the abdomen release a molten protein mixture, which flows through ducts that reorder the proteins into a fiber before releasing it through spinnerets. For humans, it has proven to be more of a challenge. One promising solution uses microfluidics, where fiber assembly takes place at the interface of a fluid protein stream and a water-insoluble liquid like oil.

It’s too soon to call spider silk the next miracle material—many of the technologies being developed, though promising, are still in their nascent stages, and the exact properties of a given spider silk depend on the complex interplay between its molecular makeup and the fiber structure. Nevertheless, opportunities for its eventual use abound.

Randy Lewis, a Utah State University researcher who was not involved in the review article but has been studying spider silk for 25 years, points out that the potential for the material goes beyond the strong, lightweight fabrics one might expect. “We have found that we can make a variety of things other than fibers from spider silk,” he says, like adhesives, coatings, and highly absorbent sponges.

The authors of the review agree. “We think some of the most exciting applications aren’t the ones that follow the obvious properties of spider silk—applications in biophotonics and sensing, for example,” said Brown.

**Laurel Hamers**

#### Nano Focus

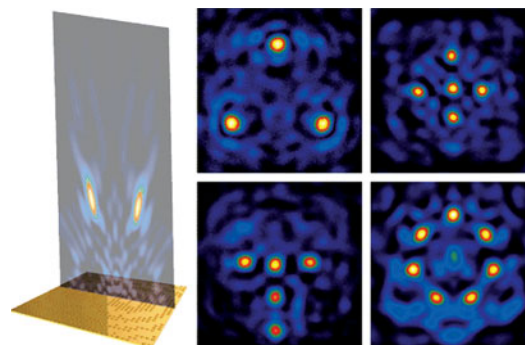
#### New optical materials manipulate light into 3D profiles

The discovery of new materials is being rapidly accelerated through the use of computational methods that can screen the constituent elements for a desired application. While simple materials systems and structures can be easily predicted using these methods, more complex systems can prove challenging due to the increased number of potential configurations. Evolutionary algorithms, a sort of “survival of the fittest” methodology that sequentially generates and weeds out potential solutions to converge on an optimized result, offer the possibility to accurately predict complex systems while reducing computation time. These design methods have been used in the past to predict metamaterial structures that can operate at terahertz frequencies but encounter problems at optical frequencies that require a finer computational grid to account for losses, leading to prohibitively longer computation times.

Teri W. Odom and colleagues at Northwestern University now report a bottom-up strategy that uses a custom-built evolutionary design algorithm to predict a new class of optical materials. These new “lattice opto-materials” are detailed in the

November 7, 2014, issue of *Nano Letters* (DOI: 10.1021/nl5040573; p. 7195). Lattice opto-materials can be used to concentrate light into discrete focal points in the optical far-field and produce arbitrary three-dimensional (3D) light profiles. They function based on the discretization of a plasmonic film into a two-dimensional (2D) subwavelength grid of holes with diameters in the range of 100–200 nm. The researchers were able to design lattice opto-materials for a specific design criterion with vastly reduced computation time.

A number of optical systems were simulated based on this new design algorithm before being experimentally validated in the laboratory. The researchers used a focused ion beam to mill a 2D grid of holes and they measured 3D optical profiles using confocal scanning optical microscopy. They found that experiments matched simulations accurately in a number of configurations. The researchers were able to generate a variety of 3D far-field light



Lattice opto-materials can manipulate visible light to produce a variety of three-dimensional profiles from two-dimensional grids of nano-sized holes milled into a substrate. Reproduced with permission from *Nano Lett.* **14** (12) (2014), DOI: 10.1021/nl5040573; p. 7195. © 2014 American Chemical Society.

profiles with focal points varying in  $x$ ,  $y$ , and  $z$  positions. These lattice opto-materials grant exceptional control over visible light, surpassing the capabilities of current microlenses, metalenses, and plasmonic lenses. With the inclusion of polarization-sensitive hole shapes, the possibility of dynamic control without physical alteration of the substrate is also possible. This new class of materials holds incredible potential for current and future applications, paving the way for enhanced flat optics for new imaging modalities.

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