New shield blocks electromagnetic interference while allowing wireless optical signals

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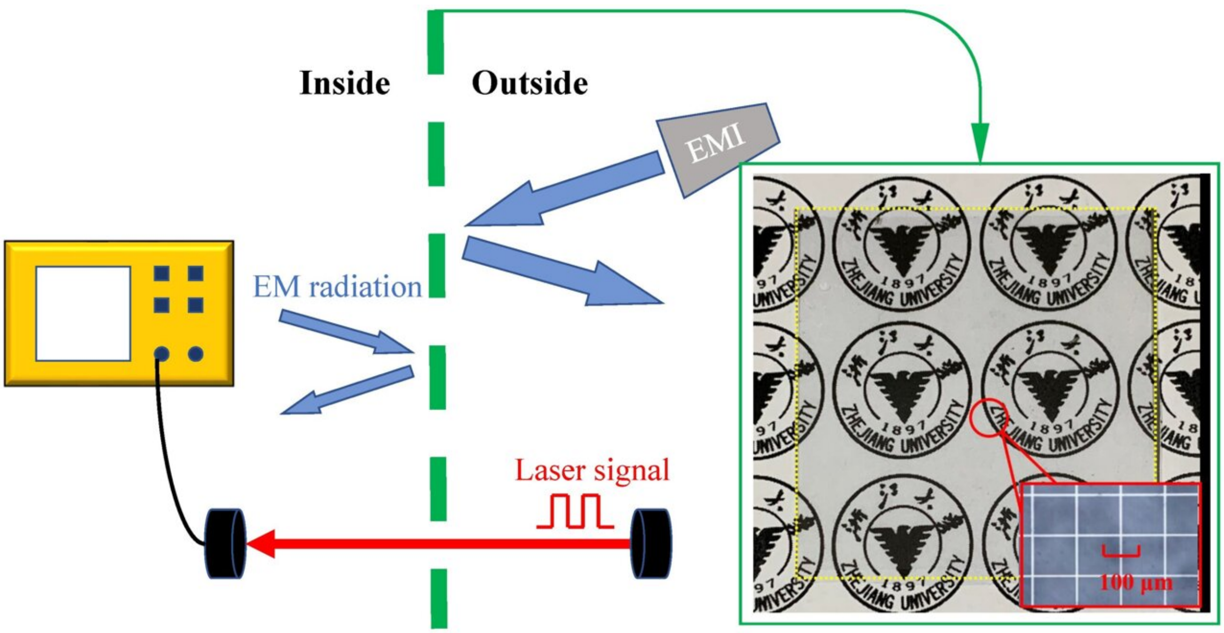

Researchers created a broadband transparent and flexible silver mesh that allows high-quality infrared wireless optical communication while also exhibiting efficient electromagnetic interference (EMI) shielding in the microwave radio region of the electromagnetic spectrum. The image on the right shows that the university logos are visible through the transparent grid (yellow outline), and the inset shows a microscopic image of the mesh's repeating grid pattern. Credit: *Optical Materials Express* (2022). DOI: 10.1364/OME.478830

Researchers have experimentally demonstrated, for the first time, a mechanically flexible silver mesh that is visibly transparent, allows high-quality infrared wireless optical communication and efficiently shields electromagnetic interference in the X band portion of the microwave radio region. Optical communication channels are important to the operation of many devices and are often used for remote sensing and detection.

Electronic devices are now found throughout our homes, on factory floors and in medical facilities. Electromagnetic interference shielding is often used to prevent electromagnetic radiation from these devices from interfering with each other and affecting device performance.

Electromagnetic shielding, which is also used in the military to keep equipment and vehicles hidden from the enemy, can also block the optical communication channels needed for remote sensing, detection or operation of the devices. A shield that can block interference but allow for optical communication channels could help to optimize device performance in a variety of civilian and military settings.

"Many conventional transparent electromagnetic interference shields allow only visible light signals through," said research team leader Liu Yang from Zhejiang University in China. "However, visible wavelengths are not well suited for optical communication, especially free-space—or wireless—optical communication, because of the huge amount of background noise."

In the journal *Optical Materials Express*, the researchers describe their new mesh. They show that when combined with transparent silicone and polyethylene, it can achieve a high average electromagnetic shielding effectiveness of 26.2 dB in the X band with good optical transmittance at a wide range of wavelengths, including those in the infrared.

"We take the advantage of the ultrabroad transparency and low haze of a metallic micromesh to demonstrate efficient electromagnetic shielding, visible transparency and high-quality free-space optical communication," said Yang. "Sandwiching the mesh between transparent materials improves the chemical stability and mechanical flexibility of the silver mesh while also imparting a self-cleaning quality. These properties will enable our silver mesh to be applied widely both indoors and outdoors, even on corrosive and free-form surfaces."

A flexible and transparent mesh

The researchers designed the new silver mesh with a very simple structure—a repeating square grid pattern applied to a transparent and flexible polyethylene substrate. The continuous grid structure makes the silver mesh very flexible by releasing stress during bending. Because the transparency of the silver mesh is primarily determined by the opening ratio, a measure of the size of the holes in the mesh, it is independent of the incident light wavelength.

"A large opening ratio, for example, is beneficial for a high, broadband transparency and low haze but is detrimental to high conductivity and thus electromagnetic shielding performance," said Yang. "Because the physical parameters for our mesh can be easily optimized by changing the grid period, line width and thickness, it is easier to achieve well-balanced optical, electrical and electromagnetic properties compared with what is possible with other kinds of transparent conductive films such as silver nanowire networks, ultrathin metallic films and carbon-based materials."

To demonstrate their new technology, the researchers fabricated a silver mesh onto a polyethylene substrate. The mesh had a grid period of approximately 150 μm, a grid line width of approximately 6 μm and a thickness that ranged from 59 to 220 nm. This was then covered with a layer of 60-μm thick polydimethylsiloxane. The resulting film showed high transmission for a broad wavelength range from 400 nm to 2000 nm and sheet resistance as low as 7.12 Ω/sq, allowing a high electromagnetic shield effectiveness up to 26.2 dB in the X band. The researchers also showed that the film could shield low-frequency mobile phone signals.

The researchers caution that this work is only a prototype demonstration, so there is much room for improvement. For example, using more conductive materials would improve the electromagnetic shielding effectiveness, and materials that are more transparent and have a lower haze could improve not only the visible transparency but also the free-space optical communication quality.

They are also exploring mid-infrared transparent conductive materials, which would extend the FSO communication to longer wavelengths where atmospheric interference is reduced and higher communication quality can be achieved. For commercialization, the mesh would also have to be more practical to install and less expensive.

More information: Qiyun Lei et al, Broadband transparent and flexible silver mesh for efficient electromagnetic interference shielding and high-quality free-space optical communication, *Optical Materials Express* (2022). DOI: 10.1364/OME.478830

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