Novel laser produces random mid-infrared light for improved imaging applications

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Most lasers produce coherent light, meaning that the light waves are perfectly synchronized with each other. Spatially coherent waves, however, can interfere with one another and produce speckles in an image. With this in mind, scientists are turning to so-called random lasers, which not only show promise for applications such as biological

and environmental imaging, but also mimic natural, disordered scattering from objects such as clouds.

Hou Kun Liang and co-workers at the A*STAR Singapore Institute of Manufacturing Technology and Nanyang Technological University, Singapore, have now developed a random laser that emits light in the mid-infrared range1. Moreover, the random laser is driven by electricity, making it more suitable for practical applications.

"Most random lasers are driven by optical pumping—this requires another laser to excite the random media," says Liang. "With electrical pumping we can make the laser smaller, less complex and cheaper."

The researchers modified a design known as a quantum cascade laser that contains several thin layers of compound semiconductors. When an external voltage is applied, electrons are driven across the layers and emit photons at every step. The frequency of the emitted light can be controlled by adjusting the thickness of the layers.

"A quantum cascade laser is like an electron reservoir," says Liang. "After an electron relaxes to a lower energy level, instead of becoming inactive, it flows to the subsequent active region where it is 're-used'. This is important for our laser, because loss in the mid-infrared region is high, and so we need a high gain to compensate for it."

Crucially, Liang and co-workers used plasma etching to create a random pattern of small holes—each only three micrometers in diameter—on the top surface of their laser. This design causes the laser light to be randomly scattered before it is emitted through the holes.

Currently, the random laser must be cooled to very low temperatures using liquid nitrogen to maximize the gain, but Liang and co-workers anticipate that their design can be improved to reduce the loss of mid-

infrared radiation at room temperature. Liang also points out that their design gives them great freedom to explore other laser frequencies.

"For example, terahertz lasers can penetrate thick plastics and papers and, unlike X-rays, are harmless to humans. These lasers could be used for applications, such as checking mail or airport security, where imaging quality is important—a random laser would remove speckling while maintaining brightness."

More information: Liang, H. K., Meng, B., Liang, G., Tao, J., Chong, Y. et al. "Electrically pumped mid-infrared random lasers." *Advanced Materials* 25, 6859–6863 (2013). DOI: 10.1002/adma.201303122

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