Press Release

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The Last Mile Towards Electrically Driven Perovskite Lasers

Ultracompact and low-cost perovskite laser with low energy consumption is an ultimate goal for monolithic all-optical integration. The cross-country group headed by Prof. Chien-Chih Lai (Department of Physics and Department of Opto-Electronic Engineering, National Dong Hwa University), which includes Prof. Yuan-Ron Ma (Department of Physics, National Dong Hwa University), Prof. Chia-Yao Lo (Department of Optoelectronics and Materials Technology, National Taiwan Ocean University), and Prof. Jia-Ming Liu (Department of Electrical and Computer Engineering, UCLA), confirmed that the key is the development of the crystal-fiber/nanoperovskite hybrid architecture. This excellent achievement was published in the top journal《Advanced Materials》in February 2021.

Recently, green energy and on-chip photonics have been two of the fastest growing fields in science and technology. Metal-halide perovskites and fiber-based devices are both integral to the development of next-generation energy materials and all-optical photonic circuits. A leading-edge 5 nm complementary metal oxide–semiconductor platform was demonstrated by Taiwan Semiconductor Manufacturing Company with a large production batch. This success is expected to be extended to all-fiber photonic integration, thus realizing continuous-wave perovskite lasers in a fiber configuration is imperative.

However, because of the well-recognized air and thermal instabilities of perovskites, laser action in a perovskite has mostly been limited to either pulsed or cryogenic-temperature operations. They have the shortcomings of significant complexity, high cost, and complicated setup, which do not meet the criteria of green

energy. Pulse pumping also implies that the system is larger than existing fiber devices, requires more hands-on maintenance, and is less reliable, thus increasing the complexity of integration with silicon microelectronics.

With the strong support from the Ministry of Science and Technology (MOST), the joint research team has successfully developed the first realization of a direct diode-pumped ultralow-threshold continuous-wave room-temperature perovskite laser, which can be easily fabricated by coating $MAPbI_3$ nanocrystallites onto a high-quality YAG crystal fiber. The atomically smooth crystal fiber not only serves as a perfect microcavity for ultralow-loss optical resonance but also facilitates heat dissipation toward robust laser devices, outperforming previously reported structures. Additionally, with the demonstration of this device on crystal fibers, the proposed and demonstrated approach relieves the constraints imposed by thermal instability and the pulsed pumping requirement. Moreover, this hybrid device is expected to be promising for color-tunable crystal-fiber-based perovskite lasers that are much simple and cost-competitive for monolithically on-chip silicon integration.

In light of this, the result thus foregrounds the prospect of electrically driven lasers for all-optical photonic integration. In the hope that by the breakthrough from this project, we can discover frontiers among the vigorous pace in fundamental science around the world; and further contribute to the energy materials and semiconductor communities in Taiwan.

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