2D light emitting devices for silicon photonics

Presenting Author: Yue Wang[1]
Co-Authors: **Thomas Krauss[1], Hanlin Fang[2]** and **Juntao Li[2]**

[1] Department of Physics, University of York, Heslington, York, UK
[2] State Key Laboratory of Optoelectronic Materials and Technologies, Sun Yat-Sen University, Guangzhou, China
yue.wang@york.ac.uk

Abstract

The missing piece of the jigsaw that is silicon photonics is a light source that can be easily incorporated into the standard silicon fabrication process. Molybdenum ditelluride ($MoTe_2$) is one of the most promising gain materials for this purpose [1], with monolayer $MoTe_2$ having a direct bandgap of 1.13 eV (i.e. emission wavelength at around 1130 nm at room temperature).

Here, I discuss our work using few-layer $MoTe_2$ and sandwiched $MoTe_2$ heterostructures as gain materials with silicon photonic crystal nanocavities. Firstly, we have demonstrated an optically pumped $MoTe_2$-on-silicon laser-like emitter, by employing an L3 photonic crystal cavity. This device operates at 1305 nm at room temperature, i.e. at the center of the "O-band" of optical communications, with a threshold power density of 1.5 kW/cm^2 [2]. More recently, we have demonstrated narrow emission from a sandwiched $MoTe_2$ heterostructure, consisting of a layer of $MoTe_2$ sandwiched between thin films of hexagonal boron nitride (hBN), on a silicon topological resonator [3]. The topological photonic crystal nanocavity laser design allows us to have better control on the cavity mode; as such we have demonstrated single mode operation at 1319 nm with a wide free spectral range. We have achieved a Q-factor of 4,500 with the active 2D heterostructure on cavity. These results lend further support to the paradigm of 2D material-based integrated light sources for silicon photonics platform. Finally, it is worth noting that the carrier mobility of $MoTe_2$ is several times larger than that of doped silicon, which makes this material suitable for electrical injection devices as we move into the future [4].

References

[1] Y Li, J Zhang, D Huang, H Sun, F Fan, J Feng, Z Wang, C Z Ning, Nature Nanotechnology 12, (2017) 987;
[2] H Fang, J Liu, H Li, L Zhou, L Liu, J Li, X Wang, TF Krauss, Y Wang, Laser & Photonics Reviews 12, (2018) 1800015;
[3] H Fang, J Liu, Q Lin, R Su, Y Wei, TF Krauss, J Li, Y Wang, X Wang, Advanced Optical Materials 7, (2019) 1900538;
[4] Y Bie, G Grosso, M Heuck, MM Furchi, Y Cao, J Zheng, D Bunandar, E Navarro-Moratalla, L Zhou, DK Efetov, T Taniguchi, K Watanabe, J Kong, D Englund and P Jarillo-Herrero, Nature Nanotechology 12, (2017) 1124.