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Semiconductor nanowire array for 1D and 2D topological lasers

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Topological photonics has recently expanded to include many fascinating areas of physics, for example, non-Hermitian systems such as topological lasers and parity-time symmetric topology, and non-Abelian topological charges. Among those, topological lasers have drawn attention because they provide a platform to study the interplay between light-matter interaction and topology of photonic bands. To demonstrate topological lasers, several different schemes have been employed, for example, a ring resonator array [1] and photonic crystal slabs [2]. In those, a top-down approach, which requires e-beam pattering and chemical etching, has been successful in fabricating such ring resonator arrays or air-hole type photonic crystals. However, the top-down approach suffers from large side wall roughness and is limited in achieving a high aspect ratio. As an alternative, selective area heteroepitaxy of highly ordered III-V nanowires on silicon-on-insulator (SOI) substrate provides a unique bottom-up platform to integrate on-chip light sources with silicon photonics.

In this talk, I will introduce some experimental efforts to make topological lasers using InGaAs semiconductor nanowire photonic crystals with deformed (expanded or compressed) honeycomb lattices. First, I will show the 1D Su-Schrieffer-Heeger lattice of nanowires lases with topological edge modes [3]. Then, I will show that room-temperature lasing is possible with quadrupolar modes in the expanded honeycomb structure [4], which could be associated with a bound state in the continuum. Finally, I will show emission with a very small beam divergence can be achieved with dipolar modes in the compressed honeycomb structure. We expect that the platform will be an excellent platform to demonstrate non-Hermitian topological photonics with spatially modulated pumping.

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[2] C. Han, M. Lee, S. Callard, C. Seassal, and H. Jeon, Light Sci. Appl., Vol. 8, p. 40 (2019).
[3] Y. Gong, L. Guo, S. Wong, A. J. Bennett, and S. S. Oh, Sci. Rep., Vol. 11, p. 1055 (2021).
[4] C. Messina, Y. Gong, O. Abouzaid, B.-P. Ratiu, T. Grieb, Z. Yan, A. Rosenauer, S. S. Oh, and Q. Li, Adv. Opt. Mater. Vol. 11, p. 2201809 (2023).