Controlling photonic topology and non-Hermiticity using functional materials

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In recent years, research on photonic systems utilizing concepts from condensed matter physics and quantum physics, such as topological and non-Hermitian systems, has been actively pursued. This has led to the emergence of new fields in nanophotonics, namely topological photonics [1] and non-Hermitian photonics [2]. In these areas, not only have fundamental investigations into the underlying physics been conducted, but novel optical functionalities based on these principles have also been reported. Examples include highly transmissive waveguides with sharp bends in topological systems and asymmetric optical phenomena in non-Hermitian systems. In this presentation, we introduce our recent experimental achievements in realizing topological and non-Hermitian nanophotonic systems utilizing functional materials such as phase-change materials [3-6].

To develop advanced optical devices, research has been conducted on integrating dynamically tunable materials, such as phase-change materials, into nanophotonic systems. We have demonstrated that phase-change materials enable control over the topological properties of optical systems [3]. This experiment was made possible by advanced microfabrication techniques that allow patterning and integration of phase-change materials into silicon photonic crystals. For the realization of non-Hermitian optical systems, the patterned integration of such materials plays an even more crucial role. This is because the arrangement of absorptive materials in non-Hermitian systems determines their properties. Utilizing this technique, we have selectively integrated absorptive materials such as graphene and Cr, and have reported experimental observations of non-Hermitian chirality and the non-Hermitian point gap [4, 5]. Furthermore, we recently proposed generation of optical angular momentum by using non-Hermitian skin effect in metastructures with anisotropic absorption [6].

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