Efficient Circularly Polarized Light Extraction in Photonic Integrated Platforms Using Intrinsic Chiral Metastructures

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Circularly polarized (CP) light plays a pivotal role in a wide range of applications, including advanced display technologies, optical data storage, quantum information processing, and chirality sensing in chemical and biological systems. Traditional methods for generating CP light typically rely on combinations of linear polarizers and quarter-wave plates, which inherently suffer from substantial energy losses – often exceeding 50%. Additionally, designing artificial structures with high circular dichroism (CD) to effectively discriminate between CP handedness remains a significant challenge in photonics. To overcome these limitations, we present a novel approach that leverages intrinsic chiral metastructures – specifically, asymmetric split-ring resonators (SRRs) integrated with slab photonic waveguides. The asymmetric design of the SRRs offers strong optical chirality, enabling selective coupling and extraction of the desired CP component (either left- or right-handed) from an incident linearly polarized mode. The intrinsic chirality enables propagation-insensitive extraction of circularly polarized (CP) light in photonic integrated waveguides. By precisely engineering the geometric parameters of the SRRs and their arrangement on top of the waveguide, we achieve tunable control over the polarization state and propagation direction of the extracted CP light. Rigorous electromagnetic simulations and experimental validations demonstrate that our design attains high efficiency with reduced energy losses, eliminating the need for bulky and lossy conventional polarizers. The ultracompact form factor and compatibility with existing photonic integration platforms make it a promising candidate for next-generation optical devices.