Second Harmonic Generation Based on Surface Plasmon Polaritons

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Abstract— On-chip material platforms capable of efficient second harmonic generation (SHG) at the nanoscale is highly desired for optical sensing, subwavelength coherent light source and quantum photonic devices [1, 2]. Surface plasmon polaritons (SPPs) can break the optical diffraction limit and enter the realm of nanophotonics, spreading over a subwavelength mode size on each side of the interface and produce intense local field enhancement that is basic requirement of nonlinear optical processes [3, 4]. We focus on the nonlinear optic processes using SPPs in the plasmonic waveguides that in principle can be used in developing the compact nonlinear nanophotonic circuits [5]. The key factors to achieve the high conversion efficiency from the plasmonic waveguide include the large spatial overlap between the interacting modes and the nonlinear materials, and the momentum conservation that allows the coherent constructive superposition [6, 7]. Strategies toward this goal include shrinking the effective mode area through adjusting the geometry of the plasmonic waveguide, proper incorporation of the nonlinear susceptibilities with respect to the plasmonic near field, and the use of counter-propagating configuration or phase compensation techniques. The nonlinear efficiency in the hybrid plasmonic waveguides can be further increased by introducing a multiple hybrid cavity resonance approach [8]. By designing a nonlinear grating coupler based on the hybrid plasmonic waveguide, the flexible steering of the SHG beams can be achieved [9]. It allows the detection of the otherwise undetectable SHG from co-propagating waveguide modes in the high-loss waveguides. Our works are promising for the realization of efficient and tunable nonlinear coherent sources and opens new approaches for efficient integrated nonlinear nanophotonic devices.

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