Silicon high performance devices using subwavelength structures

(Invited paper)

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ABSTRACT

Silicon photonics is poised to solve challenges in areas such as datacom, environmental monitoring and diagnostics, by leveraging the economies of scale afforded by CMOS manufacturing. This requires a wide variety of integrated silicon devices, including fiber-to-chip couplers, polarization splitters and waveguide couplers, operating both in the near-infrared and the mid-infrared wavelength range. However, the reduced set of materials available in this platform can often limit the performance of these devices. Subwavelength structures enable the synthesis of optical metamaterials, with properties than can be tuned to enhance device performance, by using fully etched silicon structures with a periodicity smaller than the wavelength of light. Here we review the basic operating principles of these structures, discuss how to efficiently model them, and report on the latest advances in this rapidly growing field.

Keywords: silicon photonics, subwavelength structures, dielectric metamaterials, high performance devices

SILICON SUBWAVELENGTH STRUCTURES

More than 130 years ago, Hertz used wires spaced at a subwavelength pitch to synthesize artificial materials which he used to study the polarization of electromagnetic waves [1]. The same principle of subwavelength engineering is currently used in silicon photonics: by segmenting silicon waveguides with a pitch below the wavelength of the propagating mode an equivalent medium is created, which exhibits both controllable refractive index and dispersion [2]. This has enabled polarization independent fiber-to-chip couplers with insertion losses below 1dB, waveguide couplers with bandwidths exceeding 300nm, as well as mid-infrared waveguides that can be fabricated in a single etch step and exhibit losses below 1dB/cm, to name a few examples [3]. Such devices are key enablers for systems such as ultra-broadband coherent receivers or integrated midinfrared sensors for environmental monitoring. Subwavelength structures typically exhibit feature sizes of the order of 100nm and larger, so that they can be fabricated using CMOS lines, paving the way for widespread adoption in silicon photonics. Recently reported strategies to furthermore gain control over the anisotropy of the metamaterial open exciting new possibilities for the subwavelength structures [4].

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