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Fiber-chip surface grating couplers engineered by nanophotonic sub-wavelength grating metamaterials

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Abstract-We present our recent advances in the development of high-efficiency fiber-chip surface grating couplers engineered by sub-wavelength grating nano-structuration. The intriguing technological concept of sub-wavelength grating refractive index engineering affords an additional design freedom in the development of high-quality optical coupling interfaces for sub-micrometric silicon-on-insulator technology. We present an overview of various demonstrations of high-efficiency surface grating couplers, particularly develop for applications in silicon photonics across the near-infrared wavelengths.

We have demonstrated by both designs and experiments a set of different fiber-chip surface grating couplers engineered by sub-wavelength grating metamaterials, requiring only a one step of lithography patterning and reactive ion etching, while providing the state-of-the-art fiber-chip coupling performance [1-7]. In particular, we have reported on apodized single-etch grating couplers with optimized thin film interference pattern. Those grating couplers are implemented in a conventional 220-nm-thick silicon photonics platform, with a coupling efficiency of up to -2.2 dB and -2.5 dB for wavelengths near 1.55 and 1.3 μm , respectively [3-5]. In addition, a sub-decibel fiber-chip coupling efficiency of -0.70 dB has been experimentally realized by utilizing the CMOS-compatible manufacturing via backside metallization [5].

We have also developed a flexible grating coupler concept with an ultra-high intrinsic directionality. The grating couplers can be fabricated by using only two, deep and shallow, etching levels, typically used in silicon photonic foundries [6, 7]. This coupling structure obviates the need of using typically complex fabrication processes such as high-index overlays, customized etch depths, and bottom mirrors. In particular, we have shown that the blazing effect can directly be implemented in any conventionally used silicon-on-insulator substrates, with a negligible dependence on the thickness of the BOX layer. We reported an experimental coupling efficiency of -1.3 dB near 1.55 μm in a standard 220-nm-thick silicon platform [7].

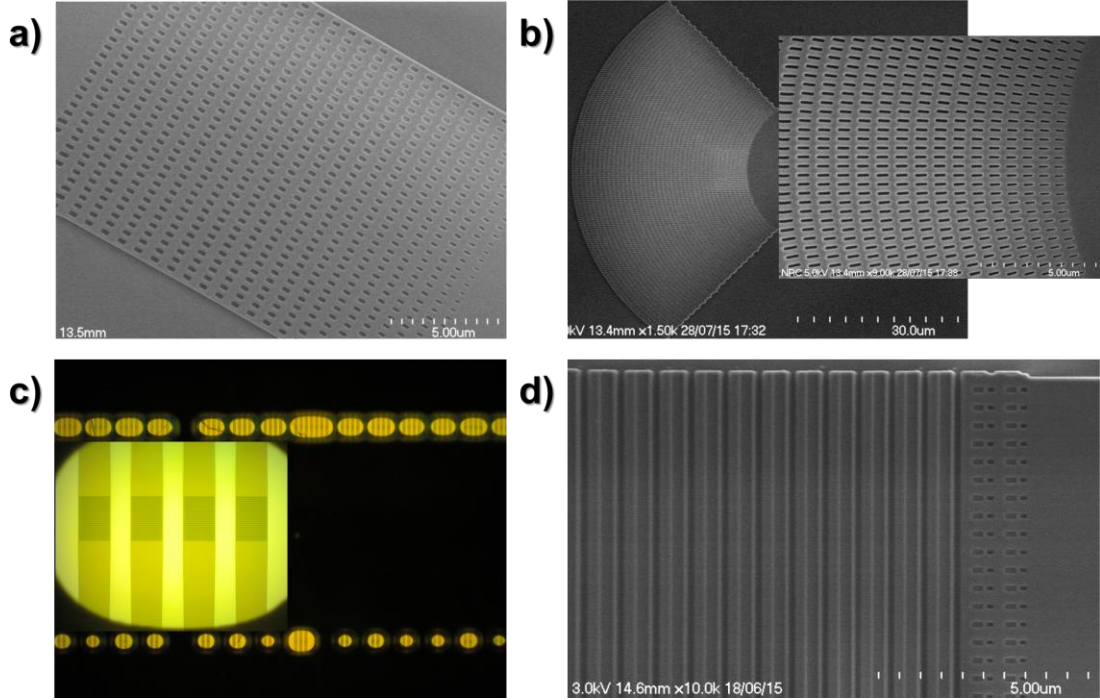


Figure: Single-etch step apodized surface grating couplers in (a) linearly-tapered and (b) curved layout configurations, and subwavelength grating nanostructure inside the trenches. (c) Optical micrograph image of the surface grating couplers layout with metal reflector underneath. (d) Dual-etch surface grating coupler with interleaved deep and shallow etched trenches and subwavelength grating index-matching region.

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