High-efficiency single etch step surface grating couplers engineered by subwavelength structured metamaterials

D Benedikovic, C Alonso-Ramos, L Vivien, P Cheben, J H Schmid, S Wang, D-X Xu, B Lamontagne, J Lapointe, S Janz, et al.

High-efficiency single etch step surface grating couplers engineered by subwavelength structured metamaterials

D. Benedikovic[1,*], C. Alonso-Ramos[1], L. Vivien[1]
P. Cheben[2], J. H. Schmid[2], S. Wang[2], D.-X. Xu[2], B. Lamontagne[2], J. Lapointe[2], S. Janz[2]
R. Halir[3], A. Ortega-Moñux[3], J.-G. Wangüemert-Pérez[3], I. Molina-Fernández[3]
J.-M. Fédéli[4]
M. Dado[5]
[1]Institut d'Electronique Fondamentale, Université Paris Sud, CNRS, UMR 8622, Université Paris-Saclay, Bat. 220, Orsay Cedex, France
[2]National Research Council Canada, Information and Communication Technologies, Canada
[3]Dpto. de Ingeniería Comunicaciones, ETSI Telecomunicación, Universidad de Málaga, Spain
[4]CEA-LETI, Minatec, CEA-Grenoble, France
[5]University of Žilina, Department of Telecommunications and Multimedia, Slovakia
[*]daniel.benedikovic@u-psud.fr

Abstract-We report our recent developments of high-efficiency fiber-chip surface grating couplers engineered by subwavelength grating structuration. The intriguing technological concept of subwavelength grating index engineering provides extraordinary degree of freedom in designing and fabricating high-performance 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 silicon photonics applications in the near-infrared spectral range (near 1.3 μm and 1.55 μm wavelengths) such as datacom and telecom optical interconnects.

Efficient optical coupling interfaces are one of the key building blocks in photonics integrated circuitry. Coupling of light to and from microphotonic waveguides has been recognized as a major practical challenge since the early years of integrated optics. The coupling is particularly difficult for silicon-on-insulator technology, since the cross-sectional area of silicon waveguides is more than two orders of magnitude smaller than that of a standard single-mode fiber. The surface grating couplers are an effective approach to circumvent this issue [1-5].

We have demonstrated by theory and experiments a series of subwavelength refractive index engineered surface grating couplers that require only a one fabrication step of lithography patterning and reactive ion etching, while providing the state-of-the-art coupling performance [2-5]. Specifically, we have reported various apodized grating couplers with an optimized directionality, with a coupling efficiency of up to -2.2 dB and -2.5 dB for wavelengths near 1.55 and 1.3 μm, respectively [2-4]. The grating couplers were implemented in a standard 220-nm-thick silicon-on-insulator substrates, as typically offered by silicon photonics foundries. In addition, a sub-decibel fiber-chip coupling efficiency of -0.7 dB has been experimentally realized for the first time in 220-nm silicon-on-insulator waveguides by utilizing the complementary metal-oxide-semiconductor-compatible manufacturing via backside processing [5].

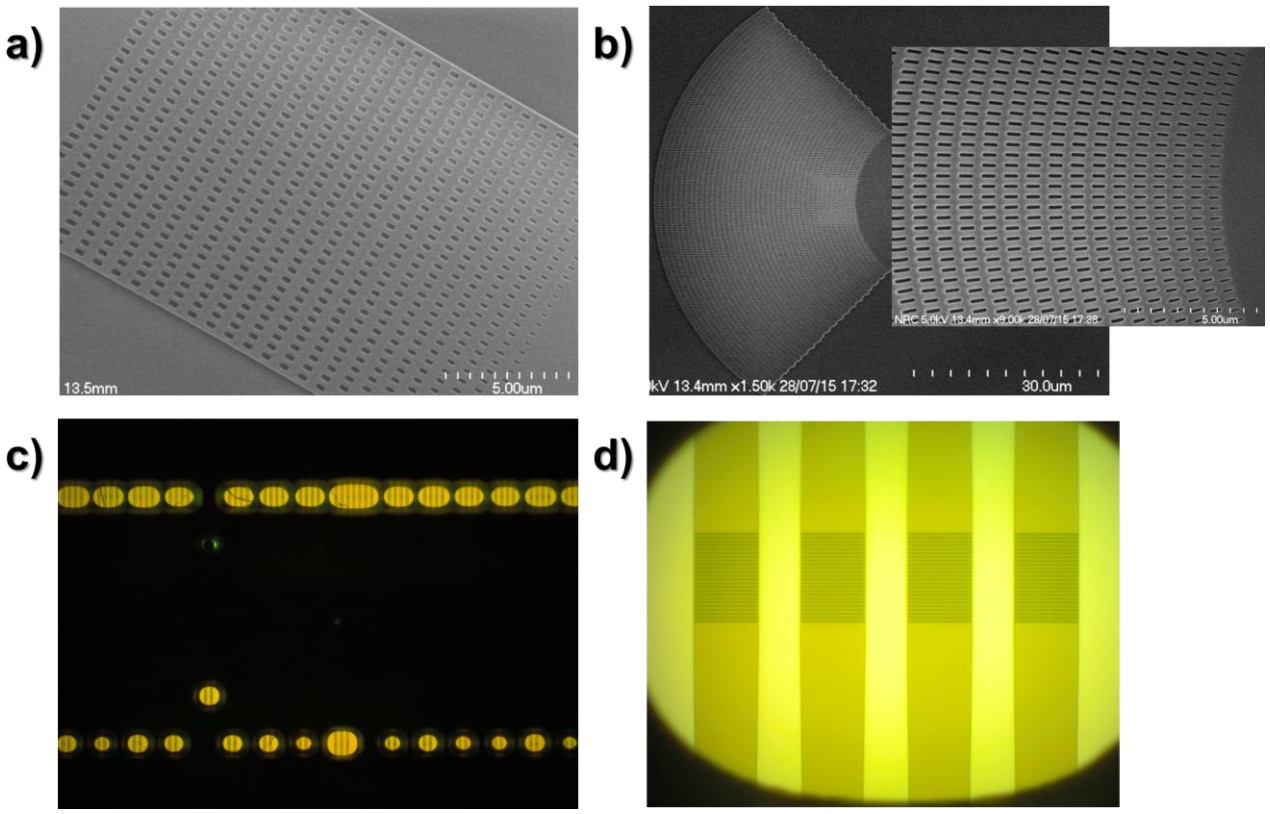

Figure: Single-etch apodized surface grating couplers in (a) linearly-tapered and (b) curved layout configurations, and subwavelength grating nanostructure inside the trenches. (c) Optical micrograph image of the surface grating couplers layout with metal reflector underneath. (d) Detail view of the surface grating coupler with metal reflector.

REFERENCES

1. Halir, R., et al., "Waveguide sub-wavelength structures: a review of principles and applications," *Laser Photon Rev*, Vol. 9, No. 1, 25–49, 2015.
2. Benedikovic, D., et al., "High-efficiency single etch step apodized surface grating coupler using subwavelength structure," *Laser Photon Rev*, Vol. 8, No. 6, 93–97, 2014.
3. Benedikovic, D., et al., "High-efficiency fully etched fiber-chip grating couplers with subwavelength structures for datacom and telecom applications," *Proc. of SPIE: OPTICS AND OPTOELECTRONICS*, Integrated Optics: Physics and Simulations II, Vol. 9516, 95160I–1 – 95160I-9, Prague, Czech Republic, 2015.
4. Benedikovic, D., et al., "Single-etch subwavelength engineered fiber-chip grating couplers for 1.3 μm datacom wavelength band," *Opt. Express*, (to be submitted), 2016.
5. Benedikovic, D., et al., "Subwavelength index engineered surface grating coupler with sub-decibel efficiency for 220-nm silicon-on-insulator waveguides," *Opt. Express*, Vol. 23, No. 17, 22628–22635, 2015.