Fabrication of High Resolution Digital Spectrometers-on-Chip

S. Babin[a], C. Peroz[a], S. Cabrini[b], S. Dhuey[b], A. Goltsov[c], I. Ivonin[c], A. Koshelev[c], V. Yankov[c]

[a)]aBeam Technologies, 5286 Dunnigan Ct., Castro Valley, CA 94546, USA
[b)]The Molecular Foundry, Lawrence Berkeley National Laboratory, Berkeley, CA-94702, USA
[c)]Nano-Optic Devices , 3333 Bowers Ave., Santa Clara, CA-95054, USA

Digital planar holography (DPH) is a new approach to designing devices with the desired properties to control light [1]. The DPH is a computer designed grating which involves millions of lines specifically located and oriented in order to encode the desired transfer function of the device. This concept was used to design a new class of miniature spectrometers-on-chips [2], which direct the output light into designed focal points according to the wavelength. The principle is demonstrated in Figure 1.

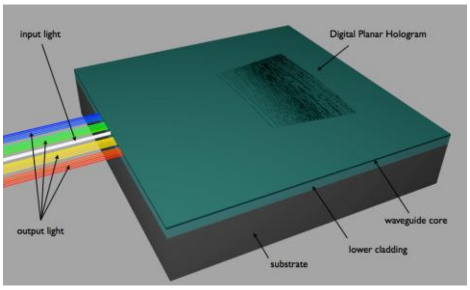
A novel type of digital optical spectrometer-on-chips that display the ultra-high spectral resolution ($\lambda/\Delta\lambda$) is reported here. Spectrometers of one type were made using substrates of $Si/SiO_2/SiO_2Ge^x$. Optical measurements confirmed the spectral resolution down to 0.0375 nm, which is in good agreement with the design. For another type of spectrometers, the target was to achieve the broadband capability. Si_3N_4 films were used as a core waveguide. A 300 channel spectrometer with a spectral spacing of 0.3 nm was utilizing the dispersion region of 475nm - 567 nm. A four bands, 240 channel spectrometer chip was also fabricated.

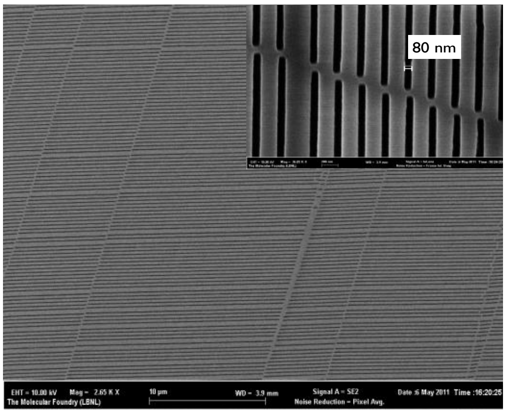
The fabrication technology of spectrometers-on-chip is described. The chips were made using electron beam lithography (EBL) and dry etch. A 100 KeV electron beam lithography system was used for patterning; proximity effect correction was applied to improve the uniformity of the linewidth across the device. Inductively coupled plasma (ICP) etching and ion milling were used for the pattern transfer into waveguide cores. An example of the hologram with a silicon germanium core is shown in Figure 2a, and its performance is shown in Figure 2b. The device utilizing a silicon nitride core and its optical performance are displayed in Figure 3a and 3b respectively.

1. V. Yankov et al, IEEE Photonics Techn. Lett. 15 (2003) 410
2. C. Peroz, et al, “Fabrication of Novel Digital Spectrometer-on-chip”, J. Vac. Sci. Technol. B 27 3187 (2009)

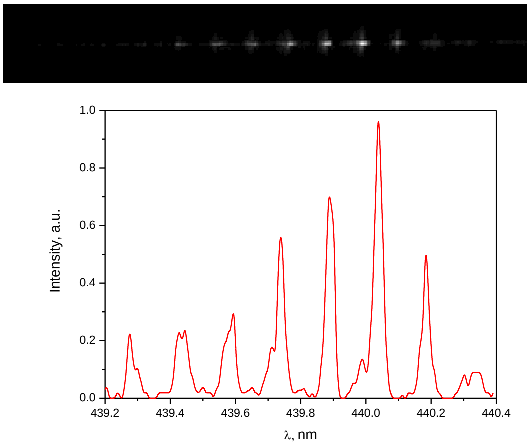
contact author: sb@abeamtech.com

Figure 1. Principle of the spectrometer-on-chip: Digital Planar Holography.



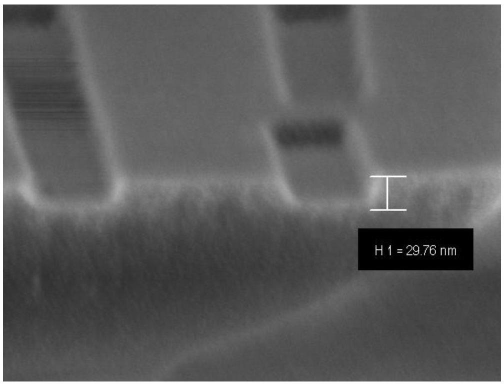


a

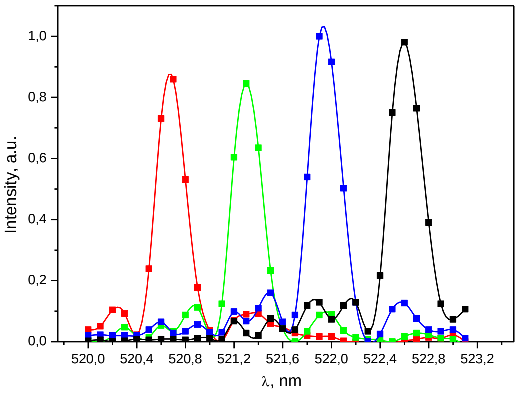


b

Figure 2. a) SEM image of a part of the spectrometer with Si-Ge core; b) optical response for a laser irradiation at 440 nm.



a



b

(b)

Figure 3. a) SEM image of a hologram with silicon nitride core and b) spectral output response of the spectrometer with 300 channels.