Fabrication of Novel Digital Optical Spectrometer-on-chip

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A novel type of planar digital optical holograms has been theoretically proposed and first results of their fabrication and characterization have been reported. These devices combine the spectral selectivity of Bragg gratings [1], focusing properties of elliptical mirrors [2], superposition properties of thick holograms [3], photonic bandgaps of periodic structures, and flexibility of lithographic fabrication on planar waveguides. The spectrometer involves millions of lines specifically located and oriented in order to direct the output light into the designated focal points according to the wavelength. The principle is schematically shown in Figure 1a.

In this paper, we report the first fabrication and testing of Digital Optical Spectrometer-on-chip. The fabrication was done using electron beam lithography and dry etch. Spectrometers were made using two types of substrates: $Si/SiO_2/SiO_2Ge^x$ and SiO_2/HfO_2, where Ge-doped silicon dioxide and hafnium oxides films were used as a core waveguide. 100 kV Gaussian beam EBL system and a 50 kV variably shaped beam system were used for patterning. Inductively Coupled Plasma (ICP) etching and ion milling were used for pattern transfer into silicon dioxide and hafnium dioxide films respectively. An example of gratings in SiO_2Ge^x waveguide is depicted in Figure 1b: The device is composed of etched grooves on the top of a planar waveguide's core. The etched linewidth was typical between 80 nm and 200 nm and the area of device is several square millimeters.

The optical performance of fabricated devices was measured. Spectrometers with 128 channels and channel spacing of $\Delta\lambda=0.3$ nm (see Figure 2) as well as spectrometers with 1000 channels were characterized; the optical performance is in good agreement with designed characteristics of these devices.

1. R. Kashyap, Fiber Bragg Gratings. San Diego, CA: Academic, 2000
2. C. H. Henry, R. F. Kazarinov, Y. Shani, R. C. Kistler, V. Pol, and K. J. Orlovsky, J. Lightwave Technol., vol. 8, pp. 748–755, May 1990
3. H. Kogelnik, Bell Syst. Tech. J., vol. 48, no. 9, pp. 2909–2947, Nov. 1969
4. V. Yankov et al, IEEE Photonics Techn. Lett. 15 (2003) 410

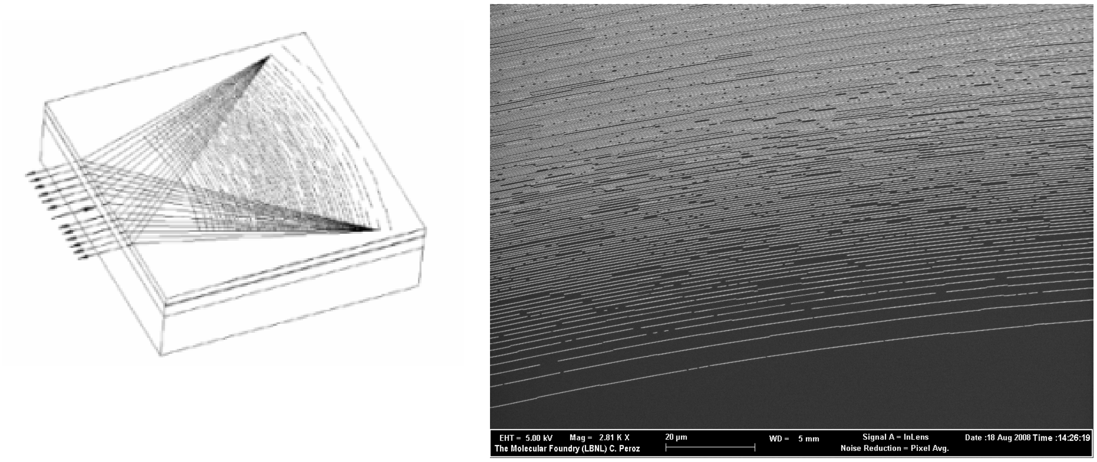

Figure 1. a) Principle of spectrometer-on-chip; b) SEM image of a part of spectrometer.

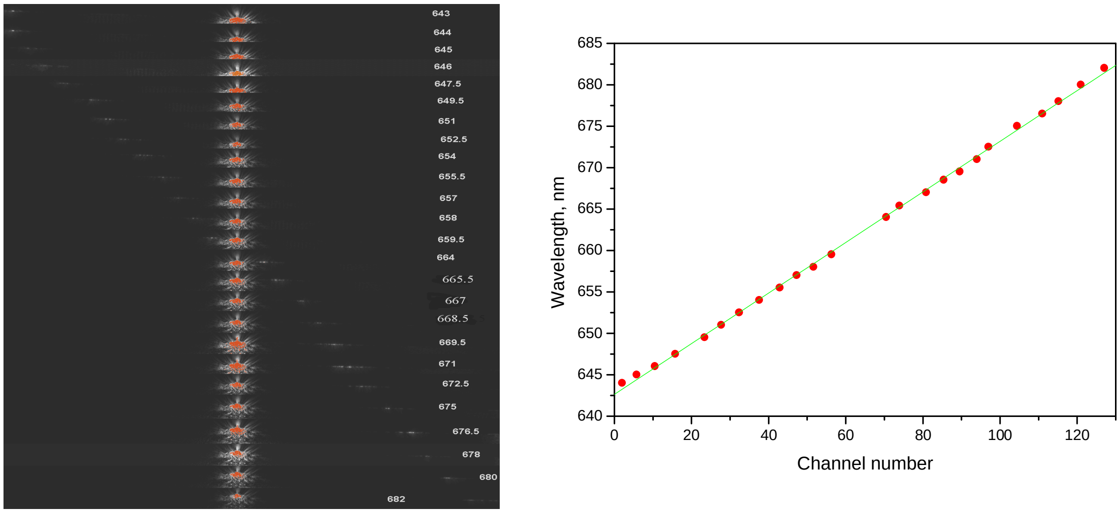

Figure 2. a) Images of the Input-Output plane at variable wavelength of input light. Each line corresponds to one measurement at specific wavelength. Central spot is a reflection of the laser input beam. b) Linear dispersion characteristic of the spectrometer was measured.