PS-11-6

Extended Abstracts of the 2012 International Conference on Solid State Devices and Materials, Kyoto, 2012, pp370-371

Infra-Red Absorption Spectrum Measurement Combining Si Microfluidic Trench and Supercontinuum Light from Fiber

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1. Introduction

Many molecules show their own absorption peaks. When the vibration mode changes the dipole moment of the molecule, such mode is infrared active. Especially for the bio-molecules, there are many needs to measure or to analyze the molecules. Infra-red absorption spectrum is usually measured using FI-IR equipment, which does not match with the small device. Supercontinuum (SC) light was generated in bulk glass by Alfano and Shapiro in 1970 [1], and has been the subject of numerous investigations using the wide variety of nonlinear media and various types of waveguide. Starting from the applications related to the ultra-broadband optical communication, SC light has found numerous applications in many fields as spectroscopy, pulse compression, and the ultrafast femto-second laser sources. Generation of the ultra-broadband SC light expanding from ultraviolet to 6.28 μm is reported using a centimeter-long fluoride fiber [2].

For the telecom applications using mainly light having wavelength of 1.55 μm, MEMS devices have been combined with the fiber using the guide trenches [3]. When the broad and bright mid IR light can be introduced, variety of molecular vibration spectrum can be measured.

In this study, we first combine the fiber emitting the SC light and the liquid channel device for measuring the infra-red absorption spectrum. As the first demonstration, the water is measured.

2. Design

Figure 1(a) shows the lateral design of the device, which has the crossing of the light path (lateral) and the liquid channel (vertical). The paired optical fiber is placed face to face. The gap between the fiber ends is 104 μm in-cluding Si side walls. Since Si is transparent for IR, Si walls are introduced for realizing the separated liquid channel. The channel has the neck at the crossing. The lar-ger outside area (2 mm-size up- and down-side area in Fig. 1(a)) of the liquid channel is for making the setup easy for connecting the syringe. Figure 1(b) shows the magnified design around the crossing. The liquid channel width is 45 μm. This width is decided considering the cell size having the typical diameter of 10 μm. GI fiber having 50 μm-diameter core is combined. Figure 1(c) shows the ver tical design. The top cover is PDMS film (Toray Silpot 184). Since the standard fiber has the diameter of 125 μm, PDMS film deforms against the protrusion.

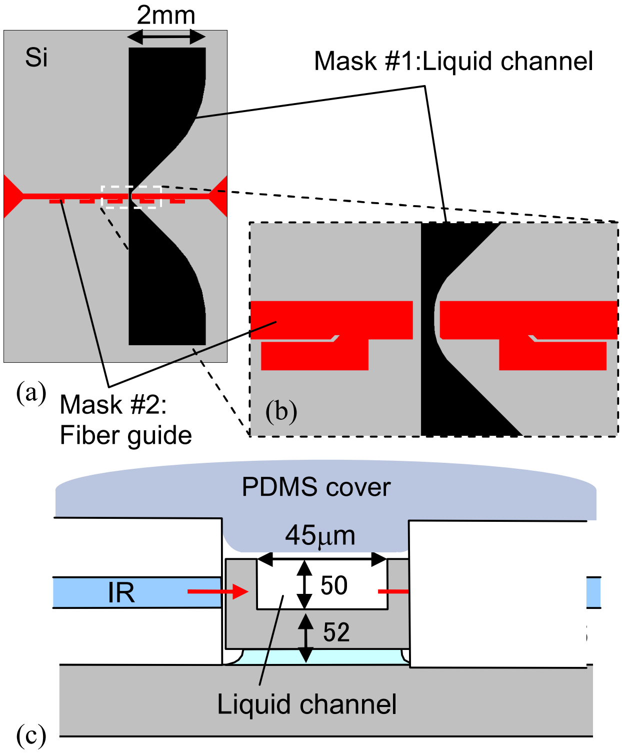

Figure 1. (a) Whole lateral design of the device. Magnified (b) lateral and (c) vertical designs at around the crossing.

Figure 2 shows the fabrication sequence. Starting material is SOI wafer. The device Si layer is 100-μm thick. The top surface has 2 μm thick SiO_2 film. The delayed masking process is used. The first mask is for the liquid channel pattern and transferred to top SiO_2 film. The second mask is for the guide for the fiber setting. After the etching of 100-μm thick device layer, the liquid channel is prepared with the etching depth of 50 μm. The sacrificial SiO_2 etching is for releasing the bias spring for the fiber alignment.

Figure 3 shows the fabricated device. The magnified image is one bias spring. The with and the length of the bias spring is 10 and 255 μm, respectively. Since this structure is hard against the vertical deflection, the cantilever can be released by drying from the liquid fluorinert (3M, C_mF_n, m,n=1, 2, 3…) having low surface tension. Figure 3 shows the bended bias spring after the fiber setting indicating the mechanical release. Taking the advantage of the mechanical guide, the manual assembly is possible. The opposite end of the fiber is connected to SC light source

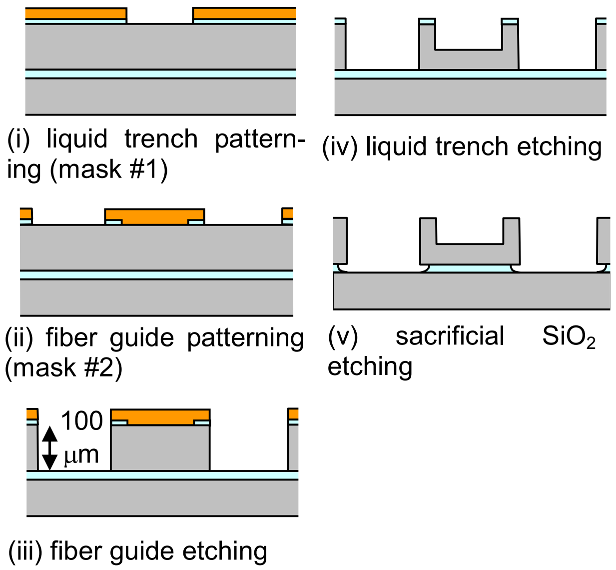

Figure 2. Fabrication sequence of Si device.

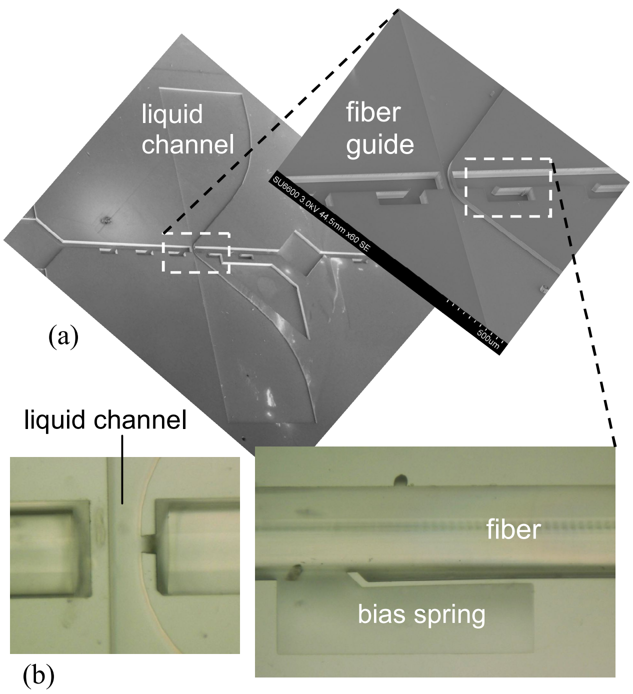

Figure 3. Images of fabricated device. (a) Si device. (b) Assembled device with optical fibers.

(SC450, Fianium).

Between two fiber ends, there is the liquid channel having the width of 45 µm. For obtaining the liquid channel, the flat PDMS film is covered. The hole is previously open for the syringe connection. The water is confirmed to flow inside the liquid channel without the leakage.

3. Results

Figure 4 shows the transmission spectrum obtained using the device fabricated. SC light source used is SC450, Fianium. The blue and light-blue curves are the spectra obtained through air and water, respectively. The red curve

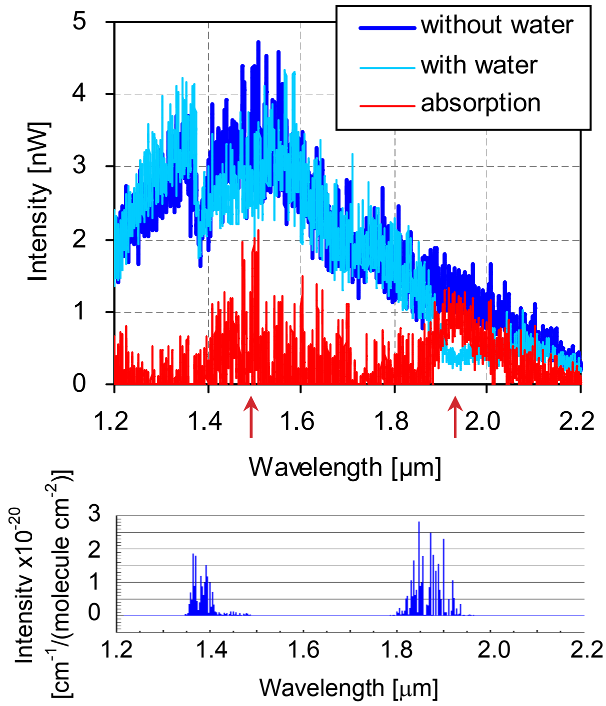

Figure 4. (a) Measured transmission spectra without/with water and their difference of the absorption. (b) Absorption peaks of water molecule from HITRAN data base.

is the difference showing the absorption spectrum. Two absorption peaks are observed at the wavelength of 1.45 and 1.95 µm. According to HITRAN data base of the water molecule, the absorption bands are at the wavelength of 1.38 and 1.87 µm. The phenomenon that the measured peak wavelength shows the red-shift is explained by the hydrogen bonding between water molecules in water liquid compared to the gas.

4. Conclusions

Infra-red absorption spectrum can be measured using the micro-device having the crossed setup of Si microfluidic trench and SC light from fiber. Taking the advantage of the light source, the characteristic absorption peaks of water are measured as a demonstration.

Acknowledgements

This research was supported by MEXT program for forming strategic research infrastructure from 2011.

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