TUNABLE SINGLE-FREQUENCY DIODE LASER AT WAVELENGTH λ=1,52μm FOR AMMONIA CONCENTRATION MEASUREMENTS

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We present a novel tunable single-frequency diode laser on an InGaAsP/InP heterostructure and meant for ammonia concentration measurements. The laser has a hybrid cavity based on a fiber Bragg grating (FBG) and the rear facet of the laser diode. To our knowledge, so-designed lasers have not been previously used for gas analysis. In our previous paper [1] we showed that, if constructed properly, FBG-based external cavity diode lasers can be very a convenient, simple, and cheap solution for the gas-analysis applications.

In this work, a mode-hop-free tuning range of hybrid lasers as wide as Δν=40 GHz (1,33 cm^{-1}) has been achieved for the first time. Single-frequency operation with a linewidth of less than 15 MHz has been obtained, the SMRS being larger than 20 dB and the output about 5 mW. These parameters enabled us to detect a doublet structure of the ammonia absorption line near λ=1,5225 μm. The operating wavelength was tuned by the injection current.

The approach we used could be easily applied to any gases with absorption lines in the optical fiber transparency window (0.7 – 1.7 μm). The presence of a fiber-optic output is an additional advantage of the laser design developed, because it makes it possible to carry out remote gas analysis.

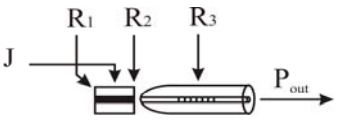

Fig.1. The design of tunable single-frequency diode laser.

As a simple and cheap solution for spectroscopy of a single absorption lines we propose an external cavity scheme (see fig.1) with a fiber Bragg grating (FBG). Such a scheme provides single-frequency operation, whereas the wavelength is tuned by controlling the injection current. In our previous work we demonstrate such approach for methane concenration measurements and in this work we use it for ammonia registration.

In the case of an FBG-based ECDL to enlarge the tuning range, one should not completely eliminate reflectivity R_2. This reflectivity should be large enough for Fabri-Perot ripples to exist, but small enough for external cavity to dominate over the laser diode cavity. In our experiments, R_2 = 0,02 was chosen.

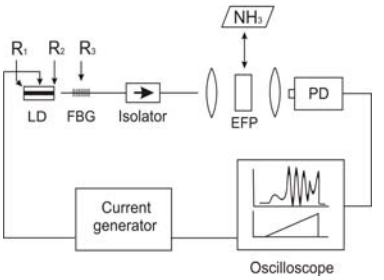

Fig. 2. Experimental setup and laser parameters.

The laser mounted on Peltier cooler, was driven by sawtooth current. Tunability of lasing frequency was investigated by Fabri-Perot etalon with free spectral range of 5 GHz. For absorption line observation, etalon was replaced by the cells containing ammonia under pressure of 150 Torr. The length of the cell was equal to 40 cm.

The laser cavity parameters were as follows:		Diode cavity length	l=350 μm
Total cavity length	L= 3 mm	Rare facet reflectivity	R1=0,4
Front facet reflectivity	R2=0,02	Coupling efficiency	η=0,3
FBG reflectivity	R3=0,13 and 0,4	FBG bandwidth	Δλ=0,35 nm

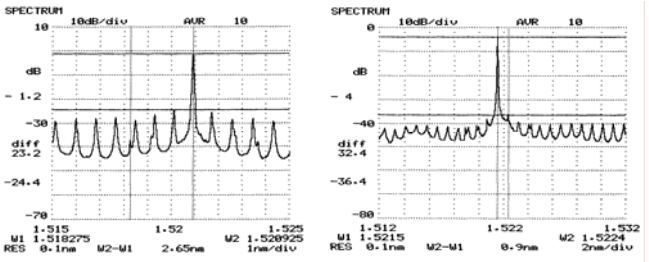

Fig. 3. The typical spectra of the laser developed.

With the aid of fiber grating with reflectivity R3=0,13 (left spectrum) was obtained side mode suppression ratio of more than 20 dB, while using FBG with reflectivity R3=0,4 (right spectrum) was achieved SMSR of more than 30 dB. The spectrum of first laser (R3=0,13) had better overlap with absorption line under registration, and all next measurements were carried out with this laser.
The linewidth measured by confocal interferometer was less than 15 MHz.

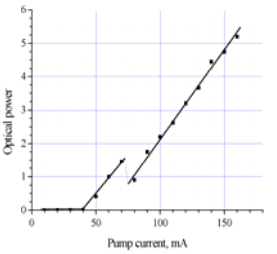

Fig. 4. The typical light intensity curve.

Single frequency operation was observed in the injection current range from 70 to 140 mA. At the present stage of development, an optical power of 5 mW was obtained at the single-mode fiber output.

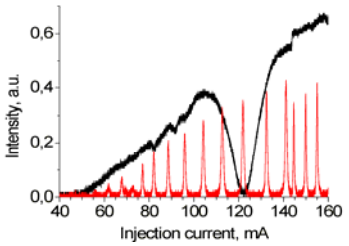

Fig. 5. The experimentally observed absorption line of ammonia near λ=1,5225 μm at pressure of 150 Torr.

Using FBG with bandwidth of Δλ=0.35 nm and reflectivity of R3=0,13 we have detected the ammonia absorption line near λ=1,5225 μm. Ammonia in the cell was under pressure of 150 Torr and room temperature. From the etalon fringes plotted on the bottom one can conclude that the mode-hop-free tuning range equals 40 GHz (1.33 cm^{-1}). This tuning range is comparable with current-induced tuning range of DFB lasers.

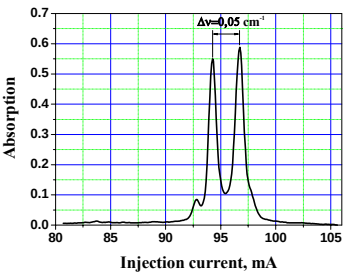

Fig. 6. The ammonia absorption line under the pressure of 12 Torr.

The same ammonia absorption line was observed at pressure of 12 Torr. As can be seen from the figure, the multiplet structure of this line is clearly resolved.

Conclusions

The usage of FBG-based external cavity diode lasers has been proposed for spectroscopy of gases having absorption lines in the optical fiber transparency window (0.7÷1.7 μm). As an example, this approach has been applied for detection of the ammonia absorption line at wavelength λ=1.5225 μm. A single frequency operation tunable by injection current over the frequency range Δν=40 GHz (1.33 cm^{-1}) has been achieved. For those applications where the detection of a single or a few absorption lines is required, such lasers are very simple and cost-effective alternative to widely used DFB lasers.