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IrSens II RTD 2015

FNSNF

Multi-color single-beam QCLs

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Motivation & Goal

Gas sensing is an important method with applications in environmental monitoring, air quality control, process control, medical diagnosis, leak detection, traffic security…

State of the art:
- Combination of several detection systemas
- Bulky
- Expensive
- High power consumption

IrSens I approach:
- Laser spectroscopy in single instrument
- High sensitivity from efficient multipass cell
- Portable
- Lower cost and power consumption

IrSens II approach:
- Leverage on IrSens
- Add wavelengths (Lasers) for more gases
- Use the same setup, get 10 for 1

Left: rack with gas analyzers, picture taken at NABEL station Zürich
Right: IrSens II target instrument

Challange

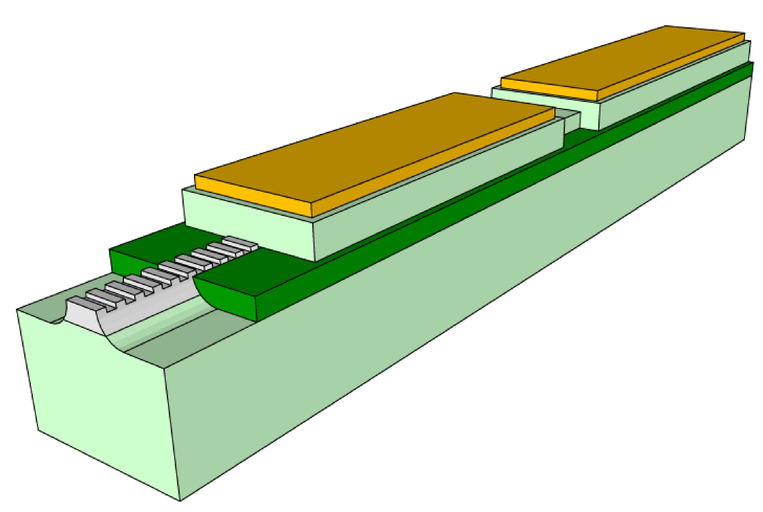
- Detect the **10** most common environmental gases in one optical setup
- Can be achieved with **7** laser frequencies

Gas	Typical conc. range [ppb]	Frequency [cm^{-1}]
NH_3 (ammonia)	2-20	1046.4
O_3 (ozone)	5-200	1046.4
CH_4 (methane)	1700	1275.5
N_2O (nitrous oxide)	331	1275.5, 2179
SO_2 (sulphur dioxide)	0.1-10	1352
NO_2 (nitrogen dioxide)	1-100	1600
NO (nitrogen monoxide)	1-100	1900
CO (carbon monoxide)	1-10	2179
CO_2 (carbon dioxide)	380 ppm	2281.5
H_2O (water vapour)	0.2-4 %	1275.5, 2179

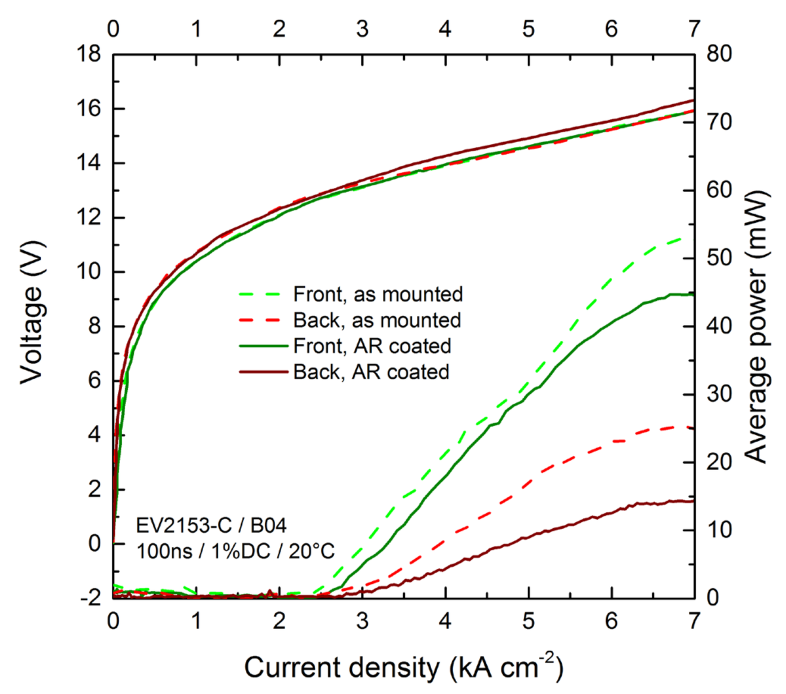
- Idea: **3** multi-color DFB-QCLs to keep the optical complexity low

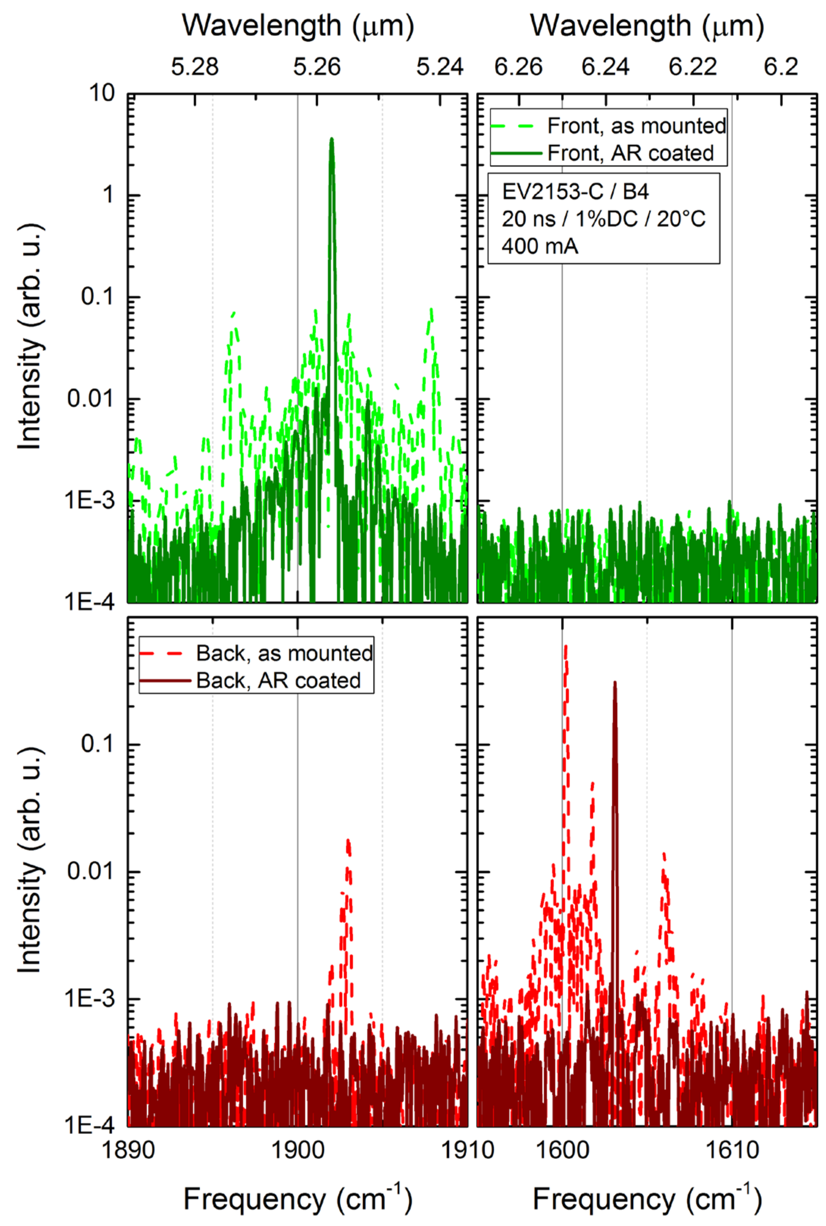
Species	Frequency (cm^{-1})	Device type
NH_3; O_3	1046.4	Vernier tuner (alternatively triple section DFB)
CH_4; N_2O; H_2O	1275.5	
SO_2	1352.0	
NO_2	1600.0	Multi section DFB
NO	1900.0	
CO; N_2O;H_2O	2179.0	Multi section DFB
CO_2 (^{12}C & ^{13}C)	2281.5	

Multi-section DFBs



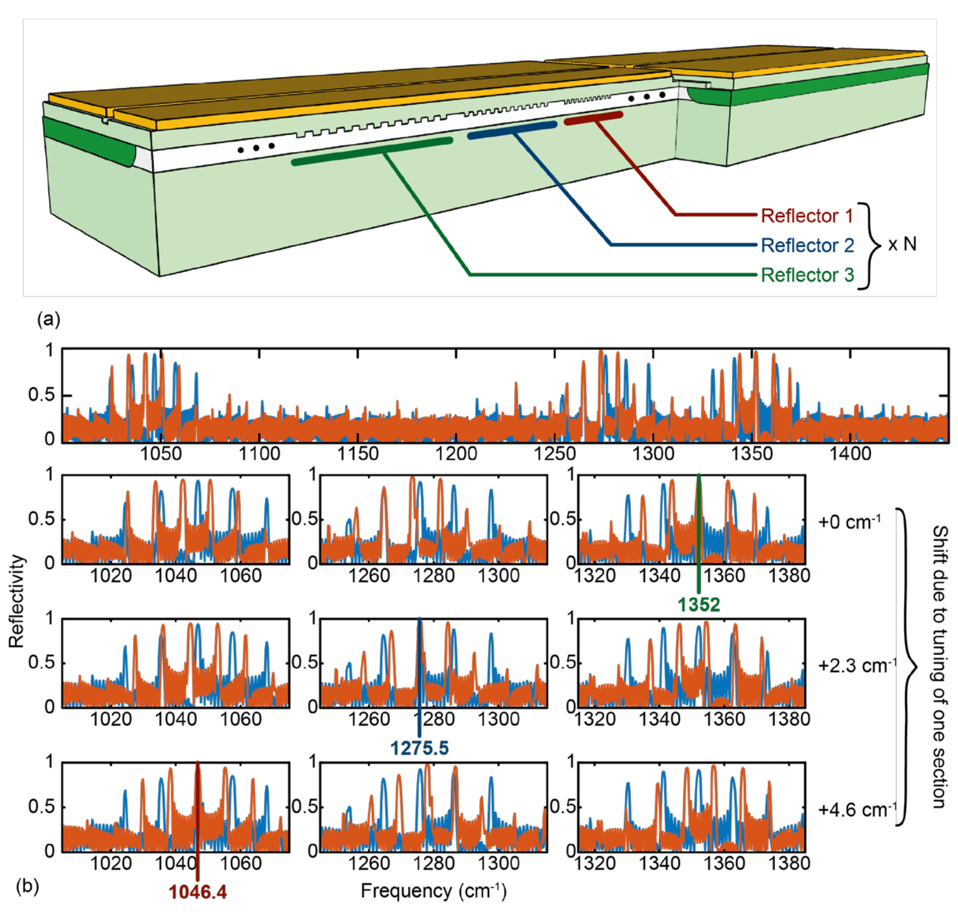
We have realized multi-section DFBs (see schematic drawing) which are able to emit two colors separately or together. The performance of the devices allow for good mode isolation and long-pulse operation with pulse length over 100 µs. Thus, these devices can be used in intermittent continuous wave operation.





Some device drawbacks include that due to the sequential pumping and losses in unpumped sections of the DFB grating prohibit a complete single mode operation. This flaw can be corrected with appropriate anti-reflection coatings (see spectra)

Vernier tuners



(a) A schematic representation of the device concept for the triple color DFB laser. The device consists of two sections (front and back) with combined and sampled Bragg reflectors selective for the desired wavelengths. The reflectivity of the reflectors of the back section are shifted ~1-5 cm^{-1} with respect to the front section.

(b) Simulated reflectivity of the front (orange) and back (blue) reflector. Tuning by means of internal temperature modulators or specific driving conditions leads to shifts of the reflectivity more than 3 cm^{-1} [3], which allows to compensate the designed shift between the two reflectors, and thus matching the reflectivity for one of the three desired wavelengths.

The device sections are pumped simultaneously, thereby using the full length of the device and the gain medium. The included temperature modulation layer is used to shift the front or the back section to match the reflectivity of a single particular frequency to the other section. Thus, single mode operation at a three specified frequencies will be possible, without the drawback of flawed mode-control.