Demonstration of broadband multilayer anti-reflection coating on quantum cascade laser facet from 8.0 to 12.0 μm range

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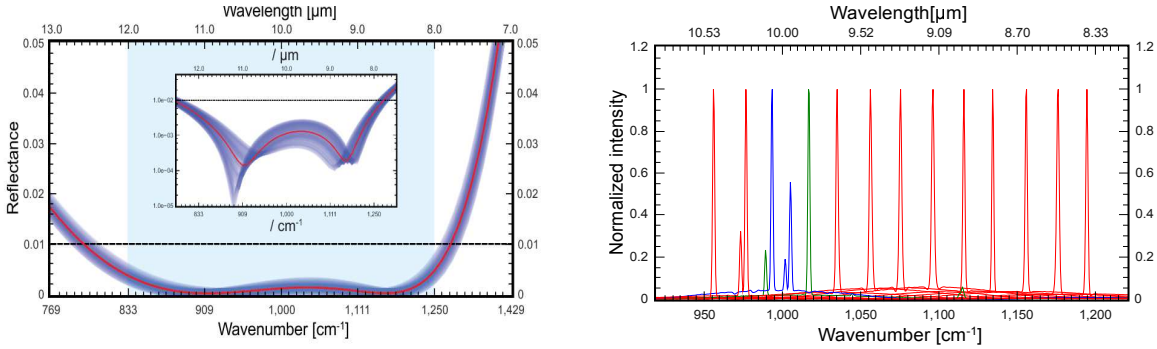
The external cavity quantum cascade laser (EC-QCL) is attractive for many mid-infrared applications due to the coherence of light, the broad tunablity, and the compactness compared to conventional infrared light source. In EC-QCL system, however, the facet reflectivity of gain chip restricts the coupling efficiency between the optical resonator and the gain media, and resulting in limiting the tunability and optical power. Thus, from the engineering point of view, high performance anti-reflection (AR) coating on the QCL facet is strongly required; typically less than 1.0%. This is difficult to achieve because of the limited number of dielectric materials with low-loss and appropriate refractive indices in designing coating. Therefore, high performance mid-infrared AR coating for waveguide facet is quite challenging.

We designed an anti-reflection coating comprising germanium (Ge), zinc sulfide (ZnS), and yttrium fluoride (YF_3) as main coating materials. As in Fig. 1a, we optimized the coating layout for 8–12μm to cover the emission of a broad gain QCL, emitting 8.5–10.5 μm range[1]. The coating performance was characterized by power-current (*P-I*) characteristics and Littrow-type external cavity system. From the *P–I* curve measurement, the coating achieves 0.77% reflection covering the entire emission spectrum of the chip. After integrating the chip into a Littrow-type external cavity system, the tuning was also performed. Good longitudinal modes were observed. At around 1000cm^{-1}, however, we observed tunable but parasitic multi-modes (Fig. 1b).

In the presentation, we will discuss the tuning performance of the external cavity system and the gain saturation mechanism by increasing the applied current on the QCL gain.



(a) Simulated performance of multilayer AR coating with 10% errors effect of the refractive index of the laser facet. Dash line represents 1.0% line.

(b) Tuning spectra selected by blaze grating set in Littrow-type EC system; parasitic modes were observed at 1000cm^{-1}

References

[1] K. Fujita, S. Furuta, T. Dougakiuchi, A. Sugiyama, T. Edamura, and M. Yamanishi, "Broad-gain ($\Delta\lambda/\lambda_0$ ~0.4), temperature-insensitive (T_0 ~510 K) quantum cascade lasers," Opt. Express 19, 2694-2701 (2011)