フォトニックナノ構造面発光 THz-QCL の動作特性の解析

Analysis of operating characteristics of photonic nanostructured surface emitting THz-QCL

理研光量子工学研究センター[1]，東北大学[2]　○(D3)陳　明曦[1,2]，林　宗澤[1]，
大谷　知行[1,2]，平山　秀樹[1]

RIKEN Center for Advanced Photonics (RAP) [1], Tohoku Univ. [2], ○(D3) Mingxi Chen[1,2], Tsung-Tse Lin [1], Chiko Otani[1,2], Hideki Hirayama[1]

E-mail: Mingxi.chen@riken.jp

The prospect of terahertz-band quantum cascade laser (THz QCL) on being compact and high-emission-power THz source has been proved in recent decades. Although watt-level emission has been achieved by edge-emitting THz QCL with Fabry–Pérot cavity, its energy conversion efficiency is still stay at a low level, besides, the far-field pattern is not good enough for real application too. We proposed to design and fabricate surface emitting QCL (SEQCL) with distribute feedback structure, which according to reports, both the luminous efficiency and far field pattern will be significantly improved [1]. We applied 3-dimensional coupled wave theory (3D CWT) to simulate the operating characteristics of SE THz QCLs.

3D CWT can give accurate simulation results with clear physical picture. And it consumes little time and computing power comparing with finite-difference time-domain (FDTD) or plane-wave expansion method (PWEM) [2]. Here we used single plasma waveguide QCL working at 1THz with photonic crystal structured active region as a simulation sample (shown in Fig. 1(a), (b)). The diameter of air node d=0.6a. Although it is an initial rough attempt, the structure also has shown nearly 1% radiative efficiency (radiative energy/guided mode energy), which can be improved further with structure optimization. The result demonstrated the potential of surface emitting THz QCL as a improvement direction over the conversional ones.

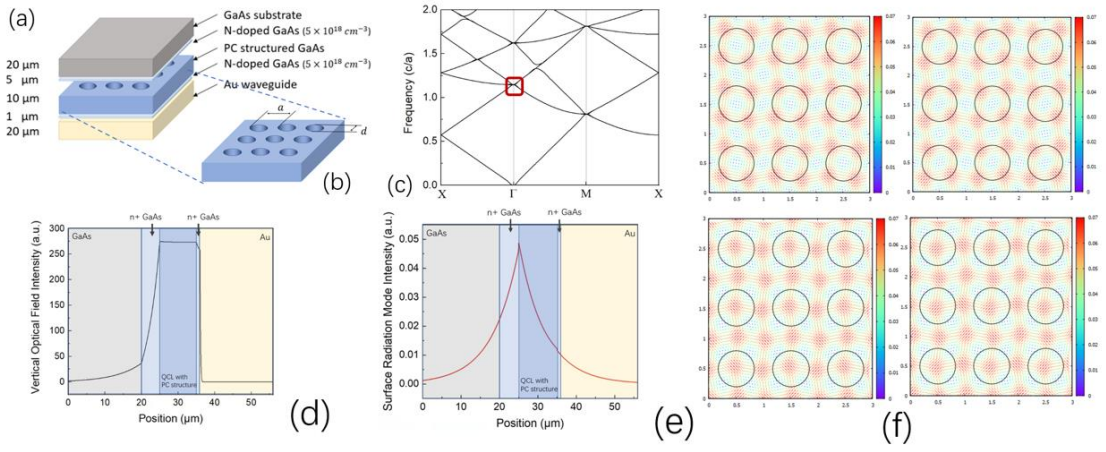

Fig 1.Simulated SEQCL's structure sketch and its photonic crystal structued QCL layer are shown in (a) and (b). (d) and (e) are guided mode vertical optical profile and surface radiation intensity curave with foundimental modes' pattern are shown in (f).

[1] Amanti M I, et al. Nature Photonics, 2009, 3(10): 586-590.

[2] Liang Y, et al. Physical Review B, 2011, 84(19): 195119.