# Popular summary*


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The range of electromagnetic waves spanning from 0.1 THz to 10 THz (wavelengths from 30μm to 3000μm) is commonly denoted as terahertz waves, representing the transitional domain between infrared and microwave frequencies. Terahertz waves boast attributes such as formidable penetrability, low photon energy, and a wealth of spectral resources. As a result, they find diverse applications across radar communications, security screenings, biomedicine, environmental monitoring, and military operations [1]. However, despite their potential, this spectral band is often dubbed the 'THz gap' due to the challenges in efficient generation, modulation, and detection of THz waves [2]. Hence, the development of THz quantum cascade lasers (QCLs) is pivotal, given their compactness, low energy consumption, facile integration, and tunability compared to alternative terahertz sources. These advancements hold significant promise across various domains, including biomedical imaging [3][4], terahertz communication technology [5], security measures [5], and counter-terrorism efforts [5]. Consequently, enhancing the performance of THz QCLs stands as a paramount objective for the future. The efficacy of THz QCLs hinges greatly upon operating temperature, frequency tuning range, and output power [6].

In my project, the primary objective is to identify the factors limiting the performance of THz quantum cascade lasers (THz QCLs) to enhance their efficacy. Additionally, we aim to draw preliminary conclusions regarding the feasibility of THz QCLs operating below 4 THz. To achieve this, comprehensive simulations will be conducted using the nonequilibrium Green's function (NEGF) model previously developed within our research group.

The primary objective of this paper is to pinpoint the factors limiting the performance of THz QCLs. Our subsequent goal is to ascertain the optimal structure, which entails identifying the parameters in simulations that yield the highest-performing THz QCL. Concurrently, it's imperative to continue uncovering additional factors limiting the performance of THz QCLs. As a result, I've identified some factors limiting the performance of the QCL and have also discovered some structures that make THz QCLs operating below 4 THz feasible.

Moreover, given the substantial demand for terahertz light in diverse applications such as security screening and biomedical applications, the efficient generation of terahertz light using THz QCLs holds particular significance. In conclusion, research on THz QCLs remains highly promising, and we hope that my thesis can contribute to the advancement of THz QCLs.

*Syntax and grammar of the text have been polished with the aid of Chatgpt.

## References


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