Tutorial - THz GaAs/AlGaAs (Fathololoumi)

Summary

This tutorial is based on the following publication.

`[Fathololoumi2012]`
Terahertz quantum cascade lasers operating up to ~200 K with optimized oscillator strength and improved injection tunneling
S. Fathololoumi, E. Dupont, C.W.I. Chan, Z.R. Wasilewski, S.R. Laframboise, D. Ban, A. Mátyás, C. Jirauschek, Q. Hu, H. C. Liu
Optics Express 20, 3866 (2012)

This article describes an AlGaAs/GaAs THz quantum cascade laser (QCL) operating at around 2.6 to 3.22 THz. The corresonding input file is called `THz_QCL_GaAs_AlGaAs_Fathololoumi_OptExpress2012_10K-MEDIUM.xml`.

Note that we also provide an input file called `THz_QCL_GaAs_AlGaAs_Fathololoumi_OptExpress2012_10K-FAST.xml` which is faster but does not produce accurate result. This “**fast**” file is only intended to show the user how to run a “quick” simulation. The results shown here correspond to the “**medium**” file.

Simulation details

We simulate the structure at a temperature of 10 K.

```
<Temperature unit="K"> 10 </Temperature>
```

Device definition

First, the well and barrier materials have to be defined.

```
  <Material_Well>
   <name> GaAs </name>                          <!-- GaAs -->
  </Material_Well>

  <Material_Barrier>
   <name> Al(x)Ga(1-x)As </name>                <!-- Al(x)Ga(1-x)As -->
   <Alloy_Composition> 0.15 </Alloy_Composition> <!-- x, i.e. Al0.15Ga0.85As
-->
  </Material_Barrier>
```

Then, alternating layers consisting of barrier and well have to be specified.

```
<Layer>   <!-- #1 -->
 <Barrier_Thickness unit="nm"> 4.1 </Barrier_Thickness>
 <   Well_Thickness unit="nm"> 16.0 </   Well_Thickness>
</Layer>

<Layer>   <!-- #2 -->
 <Barrier_Thickness unit="nm"> 4.3 </Barrier_Thickness>
 <   Well_Thickness unit="nm"> 8.9 </   Well_Thickness>
</Layer>

<Layer>   <!-- #3 -->
 <Barrier_Thickness unit="nm"> 2.46 </Barrier_Thickness>
 <   Well_Thickness unit="nm"> 8.15 </   Well_Thickness>
</Layer>
```

The resulting conduction band edge profile can be found in the file called `Band-Edge_vs_position.dat`. This file includes the band bending due to the electrostatic potential. At a bias voltage of 54 mV per period, it looks as follows.

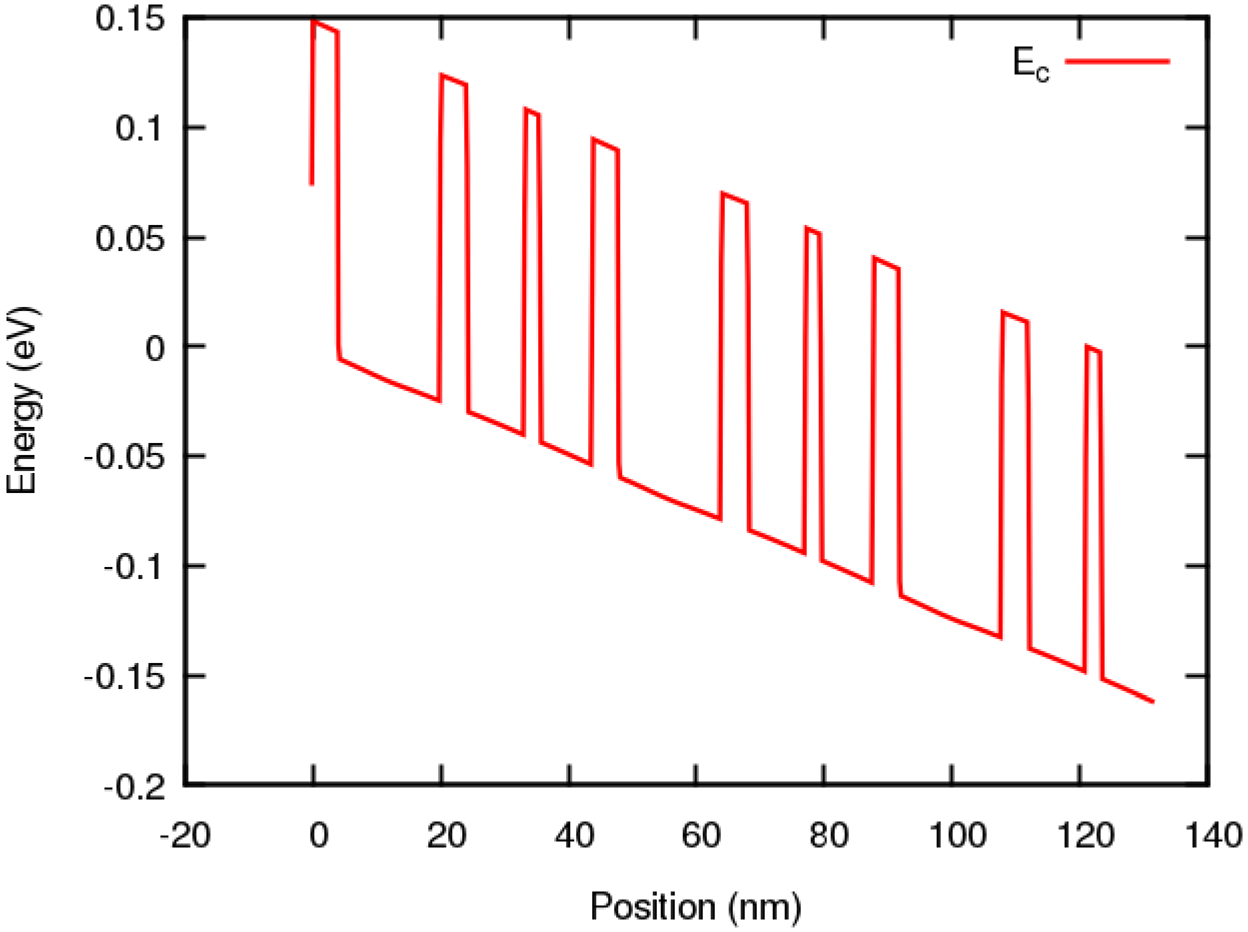

Figure 1: Conduction band edge at a bias of 54 mV/period which corresponds to an electric field of 12.3 kV/cm

Doping

(Discuss the doping here.)

Electric field

(Discuss the potential drop per period here.)

Material parameters

(Discuss chosen masses and band offsets.)

```
<Material_Parameters>
 <Band_Offset            unit="meV"> 120 </Band_Offset>
 <Effective_Mass_Well    unit="m0" > 0 </Effective_Mass_Well>
 <Effective_Mass_Barrier unit="m0" > 0 </Effective_Mass_Barrier>
</Material_Parameters>
```

Local density of states

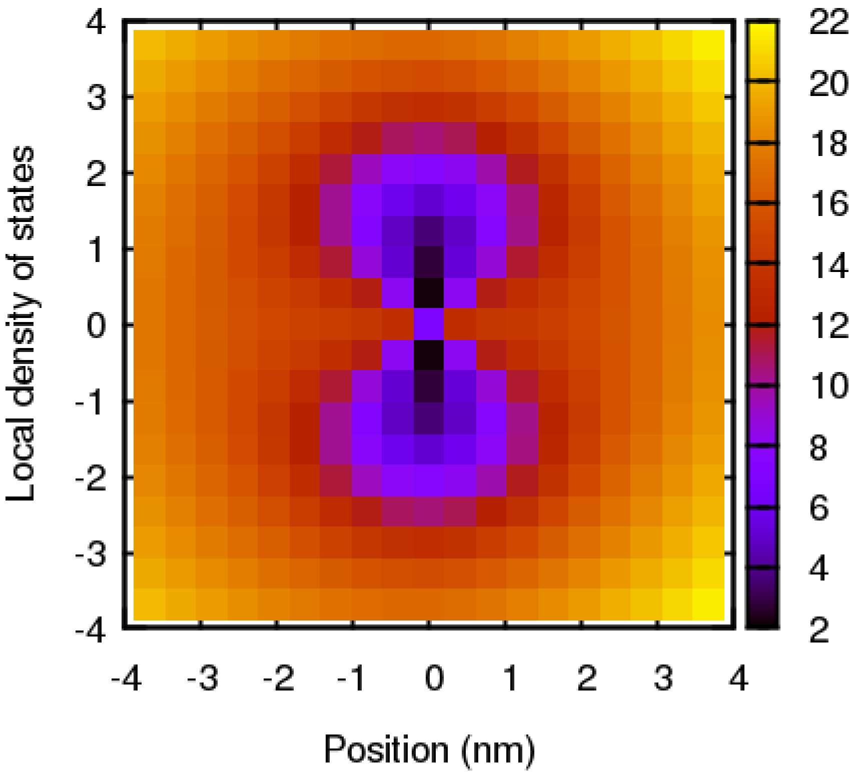

Figure 2: Local density of states at a bias of 54 mV/period corresponding to 12.3 kV/cm

Gain

(Plot and discuss gain results.)