**Slow Light via Resonant-Tunneling Induced**

**Transparency in Quantum Well Heterostructures**

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We present a theoretical and computational investigation of the possibility of achieving slow terahertz light by exploiting the tunneling induced transparency effect in suitably engineered quantum well heterostructure devices [1].

In our model, we consider a periodic structure consisting of two quantum wells per module, in which the lowest energy eigenstate of module I couples via resonant tunneling to the excited state of the next period, i.e. II, and the resulting triplet and forms a type system (see Fig. 1a), intimately familiar from the field of electromagnetically induced transparency (EIT) [2]. For our calculations, we couple Schrödinger-Poisson, ensemble Monte-Carlo [3] and Maxwell-Bloch simulation codes, which enables us to self-consistently design and analyze various systems with the desired properties. Fig. 1b-d illustrates preliminary results from Maxwell-Bloch equation simulations for the propagation of a weak 30 picosecond pulse through a 2 mm long active region (shaded area), in the ideal case of vanishing dephasing. Our calculations reveal a group refractive index of , however we believe that higher values can be achieved after a more thorough parameter study.

**II**

**I**

**a**

**b**

**c**

**d**

z (nm)

0

10

20

30

40

50

x (mm)

0

1

2

3

4

5

**t = 96.0857 ps**

0

1

2

3

Intensity (a.u.)

**t = 144.1285 ps**

0

1

2

3

Intensity (a.u.)

**t = 264.2356 ps**

0

1

2

3

Intensity (a.u.)

x (mm)

0

1

2

3

4

5

x (mm)

0

1

2

3

4

5

0

0.05

0.1

0.15

0.2

Energy (eV)

Fig. 1. **a,** Schematic representation of two periods (module I and II) of the active region of the simulated structure together with the relevant wave functions, calculated in the tight-binding basis. **b**-**d,** Consecutivesnapshots from Maxwell-Bloch equation simulations of a 30 picosecond pulse propagating through 2 mm length of the active region in **a**. Notice the strong compression of the pulse upon its incidence on the active region followed by broadening upon exit. This is namely due to the group velocity delay induced by the sample under consideration.

In contrast to the EIT effect [2], the suggested approach offers the possibility to electrically control the coupling between the |𝑠⟩ and |𝑒⟩ states via simply varying the applied bias. Furthermore, given the rapid advances in the growth and processing technologies for quantum well heterostructure devices and fine level of control achieved, especially by the quantum cascade laser research community [4, 5], this technique seems to offer a good alternative for the on-chip integration of optical buffers.

**References**:

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