Lectures, presentations *etc*. (Only for subscribers)

SPQEO Journal goes on the rubric “Lectures, Presentations *etc*.” to disseminate information about fundamentals of sciences close to SPQEO directions and areas. The lectures could be both interesting and useful for scientists, PhD students and other persons with an inquiring nature, who is working or studying not only in the area of semiconductor physics, but in solid state physics, chemistry, biology, and informatics, too.

This issue of SPQEO Journal continues the cycle of lectures by Prof. Vyacheslav Kochelap with his lectures 5 and 6. This cycle is devoted to one of the actual directions in modern physics, namely: nanophysics and nanoelectronics.

Lecture 5 of the cycle “Nanoelectronics and Optoelectronics: Science, Nanotechnology, Engineering and Application”

by Prof. Vyacheslav O. Kochelap

Graded-gap materials and heterostructures.

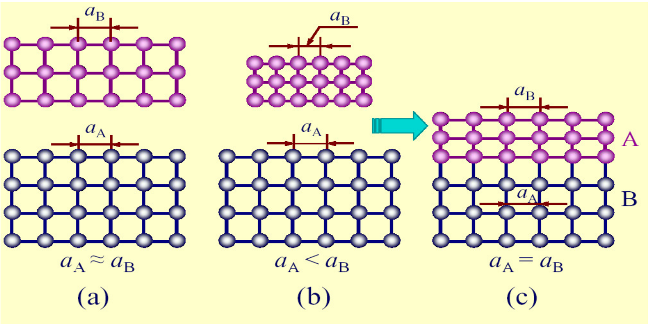
H. Kroemer:

“They present a new degree of freedom for the device designer to enable him to obtain effects that are **basically impossible** to obtain using only “real” electric fields. . . . a drift field may also be generated through a variation of the energy gap itself, by making the base region from a nonstoichiometric mixed crystal of different semiconductors with different energy gaps (for example, Ge-Si), with a composition that varies continuously through the base”.

(H. Kroemer, 1954).

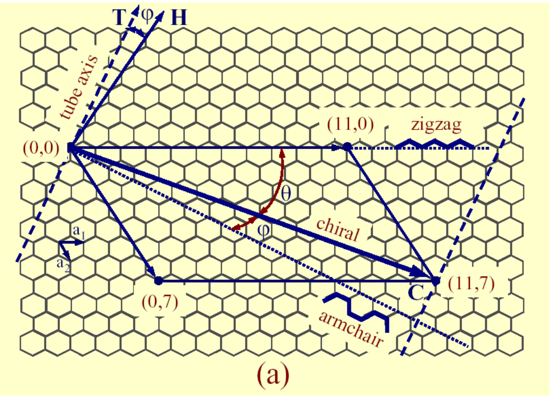
The *Lemma of New Technology*: The principal applications of any sufficiently new and innovative technology always have been – and will continue to be – applications *created* using that technology.

Semiconductor heterostructures. Constrains: Lattice matching.



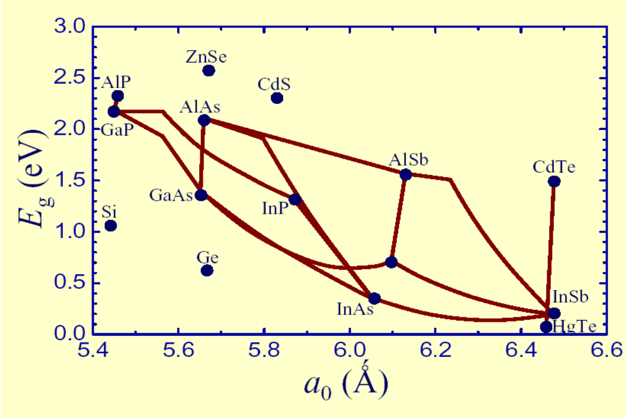
(a) lattice-matched materials; (b) lattice-mismatched materials; (c) strained (pseudomorphic) heterostructures

That is, the extra strain energy is the main physical reason for the instability and degradation of heterostructures fabricated from materials with a large mismatch of lattice parameters.



Relation between the hexagonal carbon lattice and the chirality of carbon nanotubes.

CNT can be constructed from a single graphite sheet, called **graphene,** by rolling up the sheet along the wrapping vector **C**.



Room temperature bandgaps E_g as functions of lattice parameter a_0 for selected III-V and II-VI compounds, and selected group IV materials as well as their alloys.

Lecture 6 of the cycle “Nanoelectronics and Optoelectronics: Science, Nanotechnology, Engineering and Application”

by Prof. Vyacheslav O. Kochelap

Here you can find the following points:

6. Electron transport in semiconductors and nanostructures
    - 6.1. Introduction
    - 6.2. Time and length scales of electrons in solids
    - 6.3. Statistics of electrons in solids and nanostructures
    - 6.4. Density of states of electrons in nanostructures
    - 6.5. Electron transport in nanostructures
    - 6.6. Closing remarks
    - 6.7. Problems

If the system is free of randomness, and other scattering mechanisms are sufficiently weak, electron motion is ***quasi-ballistic,*** and the only length, with which the geometrical sizes need to be compared, is the electron de Broglie wavelength.

Since only an integer number of half-waves of electrons can fit into any finite system, instead of a continuous energy spectrum and a continuous number of the electron states, one obtains a set of discrete electron states and energy levels, each of which is characterized by the corresponding number of half-wave lengths.

This is frequently referred to as ***quantization of electron motion.***

Classification of transport regimes.

Quantum regime	Intercontact distance, L_x, is comparable with the electron wavelength $L_x \le \lambda$
Mesoscopic regime	Intercontact distance, L_x, is less than dephasing length $L_x \le L_\phi$
Classical regime (one-, two-, and three-dimensional electron transport)	Intercontact distance exceeds the dephasing length, $L_x > L_\phi$: - classical ballistic regime, $l_e \ge L_x$ - quasi-ballistic regime (energy conserving), $L_E \ge L_x \ge l_e, l_\phi$ - transverse size effects: effect related to the mean free path, $L_z, L_y \sim l_e$, diffusion effects, $L_z, L_y \sim L_E$

Time scales and temporal (frequency) regimes

Characteristic times:

scattering time	τ_e
transit time	$t_{tr} = L_x/v$
“quantum time”	$\hbar/\Delta E$
$\omega \tau_e >> 1$	– high-frequency classical regime
$\omega \tau_e << 1$	– low-frequency regime
$\omega \sim \Delta E/\hbar$	– quantum regime (ultra-high-frequency regime).

Comparison of characteristic lengths and device dimensions as well as comparison of characteristic times and that of time-dependent signals allow classifying the transport regimes and finding adequate description and understanding of physics of non-equilibrium processes.

We are looking for feedback, new proposals for lectures, presentations, *etc*.