SUMMERSCHOOL OF NANOSCIENCE 2017
EXAM

Chose one correct answer per question (except last question)

NANOPHYSICS

1. In an energetically forbidden region, an incoming electronic plane wave function

a) Is continued as a plane wave of smaller amplitude
b) Is continued as an evanescent wave
c) Cannot penetrate
d) Is either continued as a plane wave or as an evanescent wave, as a result of a probabilistic process

2. A freely propagating electron wave packet tends to

a) Spread in real space and in reciprocal (i.e. momentum) space
b) Spread in real space and narrow in reciprocal space
c) Narrow in real space and in reciprocal space
d) Narrow in real space and spread in reciprocal space

3. The temperature of the surface of a star can be determined

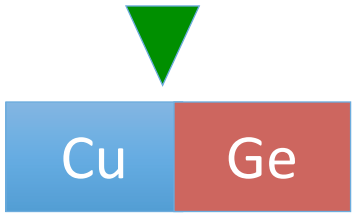
a) From its luminosity
b) From the energy of the emitted photons
c) From the relative weight of electronic transitions from higher energy levels
d) From the amount of hydrogen determined from the emission spectra

4. Kelvin probe force microscopy is a measurement of

a) The work function
b) The electronic density of states
c) The van der Walls force
d) The Casimir force

5. In an STM experiment, the tunneling current is seen to decay exponentially over a characteristic length z_0=0.8 Angström. While measuring an average tunnel current of 1 nA at a constant position, the signal is seen to fluctuate by 50 pA because of vibrations. What is the associated relative tip-sample vibration level?

a) About 1 % of the size of a single atom
b) About 10 % of the size of a single atom
c) About the size of a single atom
d) More than the size of a single atom



6. The left side of a sample is copper, the right side is germanium. The whole sample, including the interface, is perfectly flat as seen from the top. A STM tip, using a tip-sample bias voltage of 10 mV, is scanning over the interface, from left to right, with a fixed set-point tunnel current. As the Cu-Ge interface is reached,

a) the observed atomic lattice changes
b) current noise increases
c) the tip crashes into the surface
d) Germanium atoms are picked up in a controlled way by the tip

7. Which quantity is quantized in a Coulomb blockaded single-electron transistor ?

a) energy
b) momentum
c) density of states
d) charge

MICROELECTRONICS

1. **In ALD process, precursor and reactant are introduced simultaneously:**
   a. yes
   b. no

2. **In Plasma enhanced ALD process, cold plasma is used for:**
   a. The dissociation of the precursor
   b. The dissociation of the reactant
   c. The dissociation of the precursor and the reactant

3. **For the deposition of a thin Al_2O_3 barrier layer on plastic, you should buy:**
   a. An ALD Roll to Roll process
   b. An ALD stand-alone process
   c. An ALD batch process

4. **Using a wet oxidation (with water) instead of a dry oxidation (with O_2) gives:**
   a. Faster oxidation rate and higher oxide quality
   b. Slower oxidation rate and higher oxide quality
   c. Faster oxidation rate and lower oxide quality
   d. Slower oxidation rate and lower oxide quality

5. **A silicon wafer has a green oxide color on its 2 faces. The oxide has been obtained by:**
   a. a thermal oxidation process
   b. A CVD deposition process

6. **For the reduction of the interconnect delay we are using a low K dielectric SiOCH. In this material the CH_x groups are:**
    a. Bonded to O atoms
    b. Bonded to Si atoms

7. **Whatever the deposition process, a key to increase the conformality is to:**
    a. Increase the deposition rate
    b. Decrease the deposition rate

8. **The working pressure of a PVD process is:**
    a. 10^{-6} mbar
    b. 1 mbar
    c. Atmospheric pressure

9. **The definition of plasma etching should be:**
    a. Sputtering etching
    b. Chemical etching
    c. Ion beam etching
    d. Chemical etching assisted by ions

10. **For a gap-filling SiO_2 PECVD process, best results can be obtained with:**
    a. $SiH_4 + O_2$
    b. TEOS ($Si(OC_2H_5)_4$) + O_2
    c. Both, the precursor has no influence

NANOBIOLOGY

1. What is the usual size range of a Eucaryotic cell?
A. 1-2 nm
B. 1-2 µm
C. 10-20 µm
D. 100-200 µm

2. What is the diameter of a DNA double helix?
A. 2 nm
B. 20 nm
C. 200 nm
D. 2 µm

3. Which DNA function(s) is(are) found in Nature?
A. small drug recognition (aptamers)
B. data storage
C. nanometric self-folding involving staples (origamis)
D. nanovehicle

4. Holliday junction conformation (extended X-form or stacked X-form) of DNA structures can be tunned with...
A. Copper
B. Gold
C. Magnesium

D. Sodium

5. **DNA based metallized nanowires (with copper) can be as thin as...**
A. 0.5 nm in diameter
B. 5 nm in diameter
C. 500 nm in diameter
D. 5 µm in diameter

6. DNA might be used for positive or negative SiO_2 etching by adjusting...
A. the temperature
B. the DNA length
C. the humidity level
D. the nature of DNA counter-ion

MICROSYSTEMS

1. In the Injection Moulding technique …
    a. Thermoplastics are heated up to their melting point
    b. Thermoplastic are kept cold
    c. Thermoplastics are heated up to their glass transition temperature
    d. Thermoplastics cannot be employed

2. Surface Micromachining is based on:
    a. Alternation of polymeric materials
    b. Etching of the silicon bulk substrate
    c. Alternation of thin films of structural and sacrificial materials
    d. Patterning of high aspect ratio feature

3. In a positive photoresist …
    a. Light induces cross-linking of the polymer chains to make them less soluble in the developing solution
    b. They are not sensitive to light
    c. Light etches the photoresist
    d. Light breaks the polymer chains to make them more soluble in the developing solution
4. The aim of DRIE (Deep Reactive Ion Etching) is to …
    a. Deposit high aspect ratio features on the substrate
    b. Etch high aspect ratio trenches in the substrate
    c. Eliminate contamination from the substrate
    d. Etch low aspect ratio trenches in the substrate

5. A SAW (Surface Acoustic Wave) device is fabricated by …
    a. A magnetic material
    b. A piezoresistive material
    c. A piezoelectric material
    d. A shape memory alloy

6. The Force Balance approach for capacitive accelerometers is applied to …
    a. Improve the trade-off between sensitivity and linearity range
    b. Improve the trade-off between accuracy and linearity range

c. Improve the trade-off between sensitivity and robustness
d. Improve the trade-off between cost and performance

7. A microfluidic mixer works thanks to …
    a. Turbulence between two liquids
    b. Increase of temperature of the two liquids
    c. Diffusion between two liquids
    d. Difference of viscosity between the two liquids

8. Reciprocating micropumps consist of:
    a. 3 pressure chambers with a flexible diaphragms driven by a sequence of 3 actuators
    b. Micropumps without moving parts
    c. A pressure chamber with a flexible diaphragm driven by a sequence of 3 actuators
    d. A pressure chamber with a flexible diaphragm driven by an actuator and passive microvalves

9. A Point-Of-Care is …
    a. A device for the clinical tests performed outside a standard laboratory for clinical analysis
    b. A miniaturised sensor
    c. A device for the clinical tests performed inside a standard laboratory for clinical analysis to minimize costs
    d. A device for the clinical tests performed inside a standard laboratory for clinical analysis to improve the sensitivity

NANOFUNCTIONAL MATERIALS

1.The graphene sheet is very strong mechanically in plane due to …
a. σ-bonding of sp^2 hybridized orbitals
b. σ-bonding of sp^3 hybridized orbitals
c. π-bonding of unhybridized *s*-orbitals
d. π-bonding of unhybridized *p*-orbitals

2. The carrier transport along the armchair direction of a single layer graphene ribbon is semiconducting, and the bandgap scales with …
a. the value of ribbon width, w
b. the square value of ribbon width, w^2
c. the reciprocal value of ribbon width, $1/w$
d. the reciprocal square value of ribbon width, $1/w^2$

3. The kinetic energy of electrons in single-layer graphene is proportional to …
a. the reciprocal square value of electron effective mass, $1/(m^*)^2$
b. the reciprocal value of electron effective mass, $1/m^*$
c. the square value of wavevector, k^2
d. the value of wavevector, k

4. A (9,6) carbon nanotube is …
a. superconductive
b. metallic
c. semiconducting

d. insulating

5. Carbon nanotubes are usually produced by…
a. mechanical exfoliation of a large graphite crystal
b. physical vapor deposition
c. chemical vapor deposition
d. electro-deposition

6. As a possible solution for future CMOS technology, graphene FETs are highly interesting, because …
a. graphene is mechanically very strong for manufacturing nm-sized devices
b. graphene is highly conductive with a larger current handing capability
c. graphene has excellent thermal properties for efficient power dissipation
d. graphene channel can easily be controlled for a higher on/off current ratio

7. The conductance of a graphene ribbon is very sensitive to any additional charged gas molecules, because of …
a. strong molecule absorption on a uniform single atomic sheet
b. active interaction with π electrons
c. very high carrier mobility in graphene
d. low density of states near the Dirac point is very due to linear energy dispersion

8. CN_x fullerene-like molecule and film materials are super elastic, because … a. 4 sp^3 σ -bonds of carbon atoms that equally share stress in any directions
b. a perfect construction in tubular form
c. sp^2 bonding of a spherical shell to recover the bond-angle deformation, but no bond breaking
d. delocalized π-electrons that travel across several carbon atoms to increase strength

9.Draw the chiral vector C_h of a CNT with (n,m) = (6,9) on the lattice shown on the answer sheet

Summerschool Exam Solutions

	Nanophysics	Microelectronics	Nanobiology	Microsystems	Nanofunct. mat.
1	b	b	c	a	a
2	b	b	a	c	c
3	c	a	b	d	d
4	a	c	c	b	b
5	a	a	b	c	c
6	c	b	c	a	b
7	d	b		c	d
8		b		d	c
9		d		a	
10		b