University of California at Berkeley
College of Engineering
Mechanical Engineering Department

ME118, Spring 2017 **Liwei Lin**

Quiz II (80 minutes)

Close book, close notes, open two pages formula sheet

Please answer questions as concise as possible

Problem 1, Concepts (60 points)

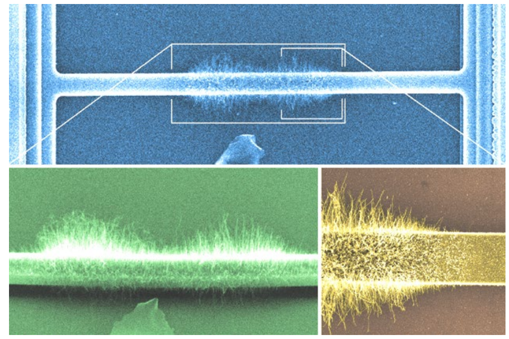
Please answer the questions as concise as possible (less than 50 words). Please use illustrations if they may help your answers

a. Draw a schematic diagram of a nanowire-based MOSFET where the nanowire is used as the "channel", including the process flow to make this MOSFET. (10%)

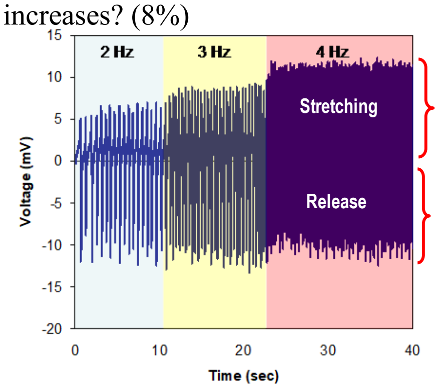
b. List at least 6 differences between the conventional electrospinning and the dip-pen based near-field electrospinning process (6%)

c. What is the "apparent" or "measured" radius (width) **ρ** of a nanowire of radius **r** if the diameter of the AFM tip is **R**? Derive an algebraic expression for **ρ**, showing all relevant steps (6%).

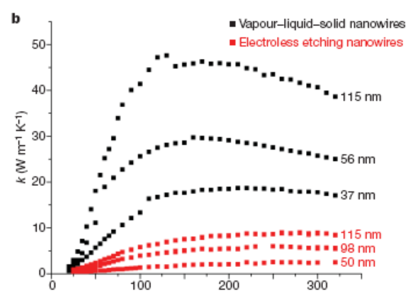
d. Explain the key mechanisms/methodologies/conditions to grow silicon nanowires as shown in the figure? What is the key reason that the nanowires only grow in the central regions of the suspended structure? Why is the nanowire length at the center of the heater is shorter than the regions slightly off the center (8%)



e. The figure shows the testing results in the PVDF nanofiber-based nanogenerator paper. What is the reason that the nanogenerator can generate electricity and why does the positive output voltage increase as the applied frequency increases? Why does the negative output voltage seem to be the same as the applied frequency increases? (8%)



f. In the discussion of the thermoelectric figure of merit, we showed an interesting result from silicon nanowires in the figure. Which type of nanowires has higher figure of merit and why? What is the fundamental reason that these two types of silicon nanowires have different thermal responses as shown? (6%)



g. Please explain the different mechanisms in creating the optical emission outputs of (1) quantum dots, (2) metallic nanoparticles, and (3) photonic crystals? (6%)

h. What is the major problem in MOSFET that "FinFET" is trying to address? Please draw a FinFET, define all regions, and explain the "gate length" and "gate width"? Please draw a figure showing the other major competing technology to FinFET? (10%)

Problem 2, QDs (20 points)

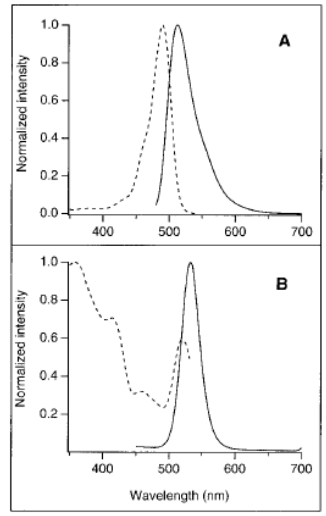
a) You are given a series of quantum dot solutions:

Blue **Green** **Yellow** **Red**

Use an arrow to indicate quantum dot size from small to large. (5%)

b) How does the bandgap change with respect to the size of the quantum dot? (5%)

c) The figure shows the adsorption (dashed line) and emission spectrum (solid line) of: (A) conventional fluorophores, and (B) quantum dots. Please describe at least two key differences in the figures and why quantum dots are better in real applications (10%)



Problem 3, Schodinger Equation (20 points)

The 1D time-independent Schrödinger Equation is defined as:

$$-\frac{\hbar^2}{2m}\frac{d^2\psi(x)}{dx^2}+U(x)\psi(x)=E\psi(x)$$

where $\hbar$ is Planck's constant $h/2\pi$, m is the mass of a particle, $U(x)$ is the potential energy, and E is the system energy. You are asked to solve the wave functions and eigen energies for the infinite square potential shown. The solutions are of the form *Asin(kx)*, so the wave function is zero at $x=0$ boundary. (a) State the condition at $x=d$ and state the allowed values of k. (b) Write down an equation for the Eigen energies. (c) Sketch the third state at t=0 on the figure below.