2006 PhD Qualifying Examination Prof. Yoshio Nishi

1. Please explain MOSFET operation at low Vg and Vd.

2. What are the factors which influence the subthreshold characteristics, i.e. s-factor, for long channel MOSFET, and for very short channel MOSFET?

3. When you see a steeper experimental subthreshold slope than theory tells, what would you question about that?

2006-2007 PhD Qualifying Examination

Professor Yoshio Nishi

1. Please describe basic operation of Si n-channel MOSFET by drawing potential diagram along the channel direction, while the surface orientation is (100) and the MOSFET is built on SOI, Silicon on Insulator, substrate.

2. What would happen if the thickness of silicon in the question 1 is decreased below the spread of electron wave function, in terms of drain current, gate leakage current and the subthreshold leakage current, and why?

3. What if silicon is replaced by a material in which ions can move around in stead of electrons and holes? Describe possible behavior of such devices where source, drain and gate electrode exist.

2007-2008 PhD Qualifying Examination

Professor Yoshio Nishi

1. Please explain basic C-V characteristics of silicon MOS capacitor with p-type substrate measured at low enough frequency and at high enough frequency at room temperature. You can ignore any series resistances in gate electrode contact and substrate contact.

2. What would happen if you do the same measurements at 600K and at 50K for (a) highly doped substrate, (b) lightly doped substrate? Please assume the acceptor doping concentrations in the substrates are uniform for both cases.

3. If the silicon MOS capacitor has very high density of interface states (traps) at the middle of silicon forbidden gap, how would the C-V curve change, and why? You can assume it is acceptor-like interface states, and substrate silicon is p-Type.

2008-2009 PhD Qualifying Examination

Professor Yoshio Nishi

1. Please describe mobility of electrons in semiconductor in which the size of semiconductor is enough large as compared to the mean free path of electrons.

2. Given that electrons can be scattered by many different scatterers such as ionized impurity atoms, lattice vibrations, etc, how can you describe overall mobility of electrons? Please derive the formula.

3. What conditions would make the formula inaccurate?

2009-2010 PhD Qualifying Examination

Professor Yoshio Nishi

1. When two different metals with different work functions are coming closer, what would happen before and after those two metals contact to each other? Draw a band diagram, and explain current-voltage characteristics across the two metals.
2. If one of the metals is replaced by a semiconductor, draw a band diagram and explain current-voltage characteristics across the metal-semiconductor..
3. If there are energetically localized electronic states between the metal and the semiconductor, how the band diagram could change?

2009-2010 PhD Qualifying Examination

Professor Yoshio Nishi

1. When two different metals with different work functions are coming closer, what would happen before and after those two metals contact to each other? Draw a band diagram, and explain current-voltage characteristics across the two metals.
2. If one of the metals is replaced by a semiconductor, draw a band diagram and explain current-voltage characteristics across the metal-semiconductor..
3. If there are energetically localized electronic states between the metal and the semiconductor, how the band diagram could change?

2011-2012 PhD Qualifying Examination
Professor Yoshio Nishi

1. Draw typical drain current-drain voltage characteristics of n channel MOSFET(long channel) made of Si if measured at room temperature for Vgs=0, 0.5, 2.0v.   Let's assume the channel doping concentration is 10E17cm^{-3}, V_T=0.5V and V_{BD} (drain breakdown voltage at Vg=0) =5V at room temperature.
2. What would happen if you measure it at 50K?
3. What would happen if you measure it at 700K?
4. If there is no scattering of electrons, how would the Id-Vd characteristics look like at room temperature, and why?

2012-2013 PhD Qualifying Examination

Professor Yoshio Nishi

1. Draw band diagrams of 3 different semiconductor MOS diodes, where the semiconductor 1 has a band gap of 0.17eV, the semiconductor 2 has a band gap of 1.1eV and the semiconductor 3 has 3.2eV. All are doped with acceptor dopants of $10^{16}cm^{-3}$
2. Draw room temperature C-V characteristics of those 3 MOS diodes, and explain how they behave when you increase the temperatures to 500C and 900C, given that those semiconductors withstand at those temperatures.
3. Explain Id-Vg and Id-Vd characteristics of nMOS FETs made of those semiconductors, where metal-semiconductor work function difference is zero in all cases