# University of California at Berkeley
# College of Engineering
# Mechanical Engineering Department

**ME118/ME218N, Spring 2024** **Liwei Lin**

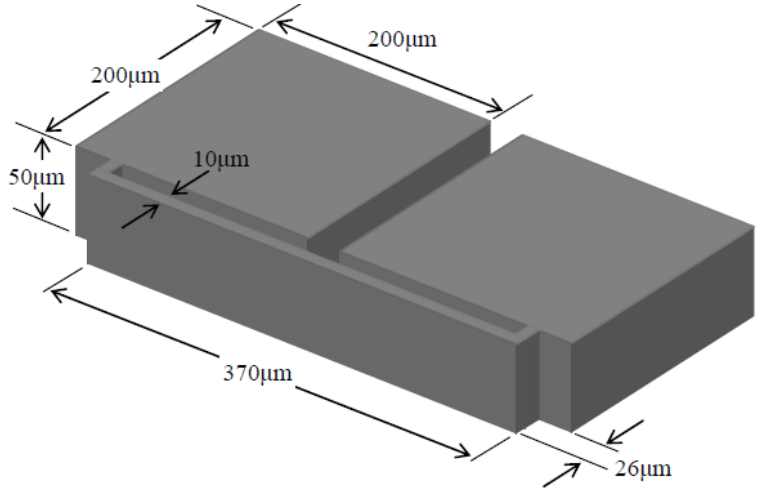
**Problem Set #2**
**Due Feb. 8 (Thursday)**

**Problem 1 (MOSFET)**

a. Sketch the 3D view model of an n-channel MOSFET (can be the same as the one we have discussed in class and the same figure). Please clearly mark all regions such as n and p doped regions, terminals …
b. Explain the principal operation of the n-channel MOSFET. Is the charge through the channel transported by holes or electrons?
c. Explain modes of operation of a MOSFET, including graphic illustrations.

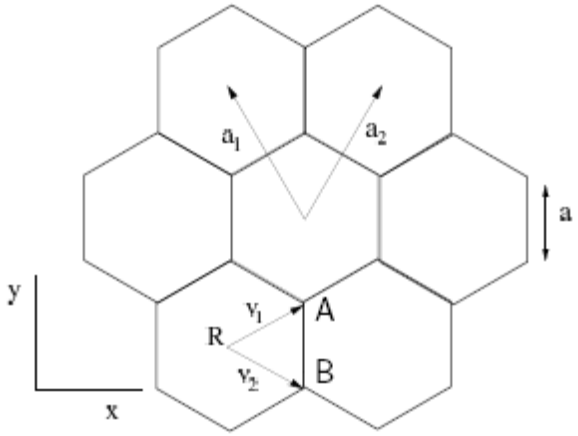
**Problem 2 (Top-Down Process – MEMS)**

The figure shows an old experimental sample we used in previous ME 118 class for laboratory. The structure is made from the SOI (Silicon on Insulator) substrate using the top silicon layer as the structural layer. Please design a process flow chart to make this device – cross sectional view figures on the left and concise process explanations on the right. Please also draw the "mask(s)" to make the device.




**Problem 3 (Graphene & CNT)**

A graphene sheet is a honeycomb lattice of carbon atoms (see figure). Let the distance between carbon atoms be "a". A good model for graphene is to consider a single plane in which there is one valence electron per carbon atom. We will use the tight-binding approximation, in which this electron can occupy a single $\boldsymbol{p_z}$ orbital at each carbon site. Let **R** denote the centers of the hexagons in the honeycomb: these form the underlying hexagonal Bravais lattice. Please notice that the latter is indeed a Bravais lattice differently from the graphene honeycomb lattice. The unit cell spanned by $a_1$ and $a_2$ contains two carbon atoms conventionally labeled as A and B atom, located at $\mathbf{R}+\mathbf{v}_A$, $\mathbf{R}+\mathbf{v}_B$, as shown in the figure.




Carbon nanotubes are made up of a section of the graphene lattice that has been wrapped up into a cylinder. You can specify the way the lattice is wound up by identifying the winding vector **W**. The winding vector must be a Bravais lattice vector, and so can be specified by two integers:

$$\mathbf{W} = n\,a_1 + m\,a_2;$$

where n and m are integers. To construct a nanotube, take a graphene lattice and mark one atom (either A type or B type) as the origin. Shift the origin of the vector **W** on the chosen atom. The new vector $\mathbf{W_n}$ will point to another atom of the same type. Roll up the sheet perpendicular to $\mathbf{W_n}$ so that the second atom sits exactly on top of the first. You have constructed a (n;m) nanotube! Nomenclature: we can specify some special tubes said **achiral**: they are (n; n) tubes which are called **armchair tubes**, and (n; 0) **zig-zag tubes**. All other tubes are said **chiral**.

a. Build a (5; 5) armchair tube (i.e. with scissors and adhesive tape!) by making use of transparencies - You can download this sheet from course homepage and print it out. The easy way to submit your homework is to take and print out a photo with finished structure on a white paper with you name on the paper as the evidence.
b. Construct a (8; 0) zig-zag tube.
c. Build a chiral (7; 3) tube.
d. Create and name a new tube of your own.