1 | Silicon

1.1 | refirenry

1.1.1 | from sand

1.1.2 | melted

1.1.3 | small molten crystal ”seed” lower into a vat

1.1.4 | crystal forms

1.1.5 | pull cylander from molten reigon

1.1.6 | ground to form ingots

1.1.7 | sawed with diamond blade to form wafers

1.1.8 | wafer scrubbed

1.1.9 | edges rounded and surfaces ground smooth and to create uniform thickness

1.1.10 | rinsed and etched in ”chemicals” to remove impurities

1.1.11 | final polish on one side of the wafer

1.1.12 | all so that there are no scratches or contamination

1.1.13 | then, measured for resistivity

1. function of dopant concentratian

1.1.14 | electron beam machine

1. etches patterns onto chrome plated glass plates in clean room

1.1.15 | glass plates become masks used to transfer the circuit pattern onto the wafer

1.1.16 | usage of masks

1. first mask creates divots
2. masks 4, 5 define source and drain reigons
3. mask 6 defines contact holes to allow aluminium to be inserted
4. mostly use 12-25 masks depending on complexity and type of circuit (much more now)

1.1.17 | **decontamination**

1. bunny suits
2. very high purity materials

1.1.18 | **fabrication techniques (4)**

1. formation of thin layers of silicon dioxidn
2. introduction of dopants
3. deposition of thin layers of ?
4. something?

1.1.19 | **cleaning**

1. hot acids to clean wafers, repeated throughout process
2. rinsed in deionized water and spun dry in filtered nitrogen gas
3. grow layer of silicon dioxide in a vertical furnace
   (a) protects silicon substrate benieth from unwanted reactions
      i. pure oxygen used to grow silicon dioxide
4. etch stencil to silicon dioxide using photolithography
5. photoresist coated on wafers, then solvents inside the solution is evaporated
   (a) negative resist hardens when exposed
   (b) positive resist changes and is removed when developed
      i. that's what is used in this run
6. computer controlled machine called stepper
   (a) wafer positioned under selected mask pattern
   (b) ultraviolet light projected onto photoresist
7. etching
   (a) wet etching can be bad
      i. can undercut photoresist
   (b) dry (plasma) etching
      i. use plasma to react away exposed silicon dioxide
8. removal of photoresist
   (a) acid baths?
   (b) hot oxygen?
9. same thing repeated with each mask

1.2 | **design**

1.2.1 | **circuit design**

1.2.2 | **organization of design team**

1. based on organization of the chip
2. establish microarchitecture that regulates sequences and timings
3. design divided into areas
   (a) each unit given to logic designer
   (b) each functional block given to circuit designer who works at transistor level
4. mask designer draws out blueprints on paper

1.2.3 | **transistors**

1. represents digital zero or one
2. C-MOS transistors
   (a) complementary metal oxidized transistor
   (b) n type transistor
      i. surrounded by n-type
      ii. sandwhiching a p-type layer
      iii. gate electrode is near but not connect to the p type reigon
      iv. a positive charge in gate attracts electrons and allows electrons to pass
   (c) both types can be made on the same chip using "complementary manufacturing?"
   (d) signals propogate through complex maze of switches

1.3 | **structure**

1.3.1 | **cubic atomic structure**

1.3.2 | **4 electrons valence shell**

1.3.3 | **perfect crystal will have no holes**

1.3.4 | **but at room temperature, free electrons can conduct**

1.4 | **impurities called dopants**

1.4.1 | **negative**

1. arsenic or phospherus
2. one more valence
3. n type crystal because negative free carriers

1.4.2 | **positive**

1. boron
2. missing electron acts like positive carrier, ”hole”

1.4.3 | **silicon can be either good or poor conductor (semiconductor)**

1. controlled by concentration of dopant