SOLUTIONS MANUAL

to

INTRODUCTION TO MICROELECTRONIC FABRICATION

SECOND EDITION

by

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CHAPTER 1

1.1

Answering machine
Alarm clock
Automatic door
Automatic lights
ATM
Automobile:
   Engine controller
   Temp. control
   ABS
   Electronic dash
Automotive tune-up equip.
Bar code scanner
Battery charger
Calculator
Camcorder
Carbon monoxide detector
Cash register
Cellular phone
Copier
Cordless phone
Depth finder
Digital watch
Digital scale
Digital thermometer
Digital Thermostat
Electric guitar
Electronic door bell
Electronic gas pump
Exercise machine
Fax machine
Fish finder
Garage door opener
GPS
Hearing aid
Inkjet & Laser Printers
Light dimmer
Musical greeting cards
Keyboard synthesizer
Keyless entry system
Laboratory instruments
Model airplanes
Microwave oven
Musical tuner
Pagers
Personal computer
Personal planner/organizer
Radar detector
Radio
Satellite receiver/decoder
Security systems
Smoke detector
Stereo system
   Amplifier
   CD player
   Receiver
   Tape player
Stud sensor
Telephone
Traffic light controller
TV & remote control
Variable speed appliances
   Blender
   Drill
   Mixer
   Food processor
   Fan
Vending machines
Video games
Workstations

Electromechanical Appliances*

   Air conditioning
   Clothes washer
   Clothes dryer
   Dish washer
   Electrical timer
   Thermostat
   Iron
   Oven
   Refrigerator
   Stove
   Toaster
   Vacuum cleaner

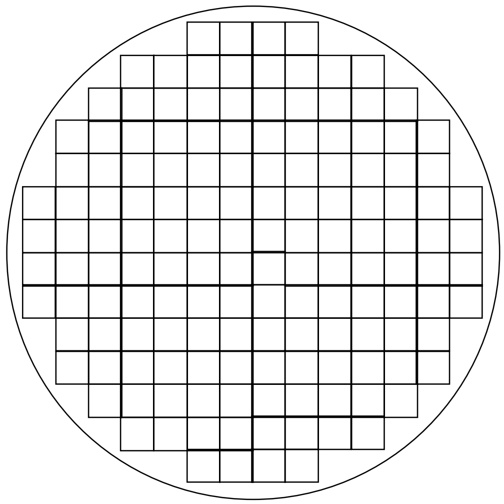
*These appliances are historically based only upon on-off (bang-bang) control. However, many of the high-end versions of these appliances have now added sophisticated electronic control.

1.2 (a) $A = \pi d^2/4$

d (mm)	25	50	75	100	125	150	200	300	450
A (mm^2)	491	1960	4420	7850	12300	17700	31400	70700	159000

(b) $n = \pi (450)^2/(4)(1^2) = 159043$ (b) $n = \pi (450)^2/(4)(25^2) = 254$

1.3 (a) $n = \pi (300)^2/(4)(20^2) = 177$



(b) n = 148

1.4 $B = 19.97 \text{ x } 10^{0.1977(2020-1960)} = 1.45 \text{ x } 10^{13} \text{ bits}$

1.5 $N = 1027 \text{ x } 10^{0.1505(2020-1970)} = 34.4 \text{ x } 10^{9} \text{ transistors}$

1.6

$$B = 19.97 \text{ x } 10^{0.1977(Y-1960)} \qquad Y_2 - Y_1 = \frac{\log\left(B_2/B_1\right)}{0.1977}$$

$$\text{(a) } Y_2 - Y_1 = \frac{\log(2)}{0.1977} = 1.52 \text{ years} \quad \text{(b) } Y_2 - Y_1 = \frac{\log(10)}{0.1977} = 5.06 \text{ years}$$

1.7

$$N = 1027 \text{ x } 10^{0.1505(Y-1970)} \qquad Y_2 - Y_1 = \frac{\log\left(N_2/N_1\right)}{0.1505}$$

$$\text{(a) } Y_2 - Y_1 = \frac{\log(2)}{0.1505} = 2.00 \text{ years} \quad \text{(b) } Y_2 - Y_1 = \frac{\log(10)}{0.1505} = 6.65 \text{ years}$$

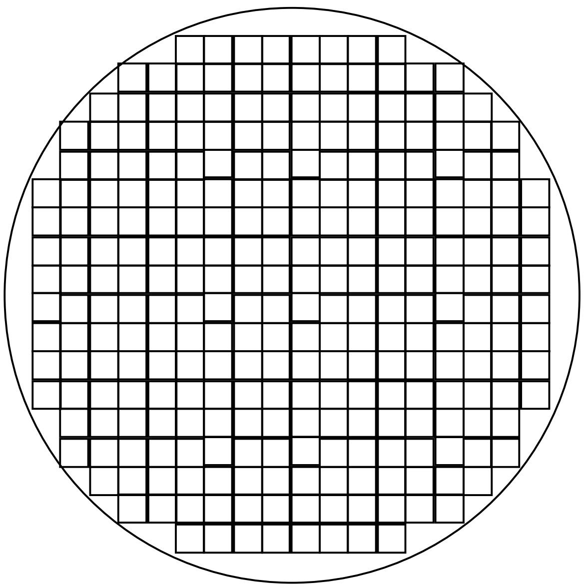
1.8 $F = 8.214 \times 10^{-0.06079(2020-1970)} \mu m = 7.50 \times 10^{-3}\ \mu m = 75$ Å. Using 5 Å for the diameter of an atom, this feature size is only 15 atoms wide. However, this narrow width can probably can be achieved.

1.9 (3×10^8 tubes)(0.5 W/tube) = 150 MW! I_{RMS} = (150 MW)/(220 V_{RMS}) = 685 kA

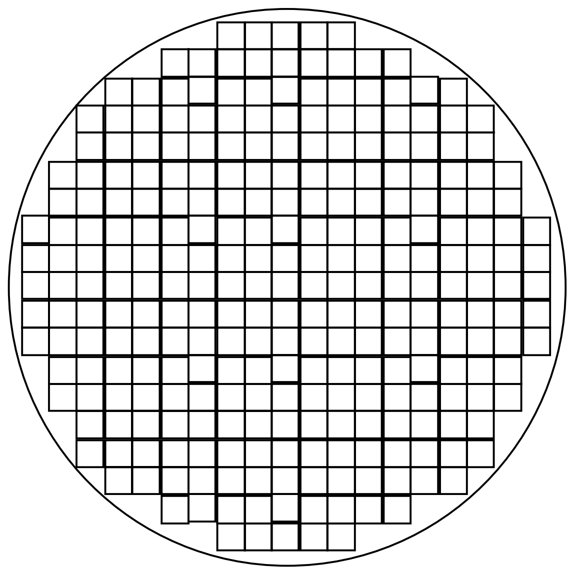
1.10 (a) L = (25mm)(18mm/0.5mm) = 0.90 m !

(b) L = (25mm)(18mm/0.2mm) = 2.25 m !!

1.11 Two Possibilities



276 Dice



277 Dice

1.12 (a) From Fig. 1.1b, a 75 mm wafer has 130 total dice. The cost per good die is \$400/(0.35 x 130) = \$8.79 for each good die. (b) The 150 mm wafer has a total of 600 dice yielding a cost of \$400/(0.35 x 600) = \$1.90 per good die.

1.13

(a) $N = 5000^2/25(1^2) = 1$ million transistors

(b) $N = 5000^2/25(0.25^2) = 16$ million transistors

(c) $N = 5000^2/25(0.1^2) = 100$ million transistors

1.14 Thermal oxidation

Thermal oxidation	
n^+ diffusion mask	Mask 1
Oxide etch	
n^+ diffusion and oxidation	
Contact opening mask	Mask 2
Oxide etch	
Metal deposition	
Metal etch mask	Mask 3
Metallization etch	

1.15