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Semiconductors: What the Controls Look At

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Introduction

How did we go from the **Electronic Numerical Integrator and Computer** (ENIAC)?

To the current Laptop?

Answer: Modern Integrated circuit technology

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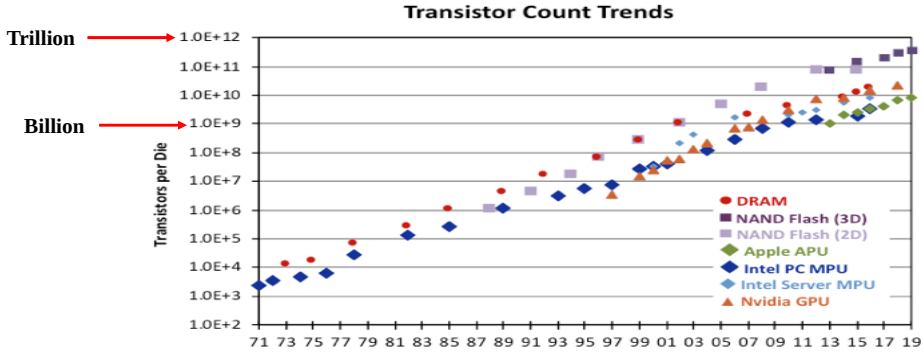
Introduction

- Semiconductor materials are what allow integrated circuit technology to work.
- Semiconductors are the basis for the invention of the transistor. Transistors are the key active components in practically all modern electronics. In 1947, John Bardeen, William Shockley and Walter Brattain at Bell Labs created the first point-contact transistor that achieved amplification.
- On September 12th, 1958, Jack Kilby of Texas Instruments demonstrated the first working Integrated Circuit (IC) and applied for a patent on February 6th, 1959. Kilby's description of the device being a work of an electronic circuit that was totally integrated led to the coining of the term, integrated circuit.

MOORE'S LAW

- The primary yardstick by which the IC industry measures its technological performance and progress remains Moore's Law, which states that there is a doubling of the number of transistors per chip every two years. It pertains to the growth rate of components per chip, but it is sometimes generalized to describe the exponential growth in raw computational power achieved with each new generation of ICs.



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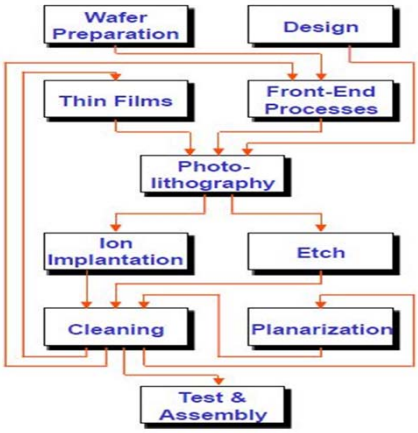
Semiconductor Manufacturing Steps

Design
Photolithography
Etching
Ion Implantation/Doping
Metallization
Testing and Assembly



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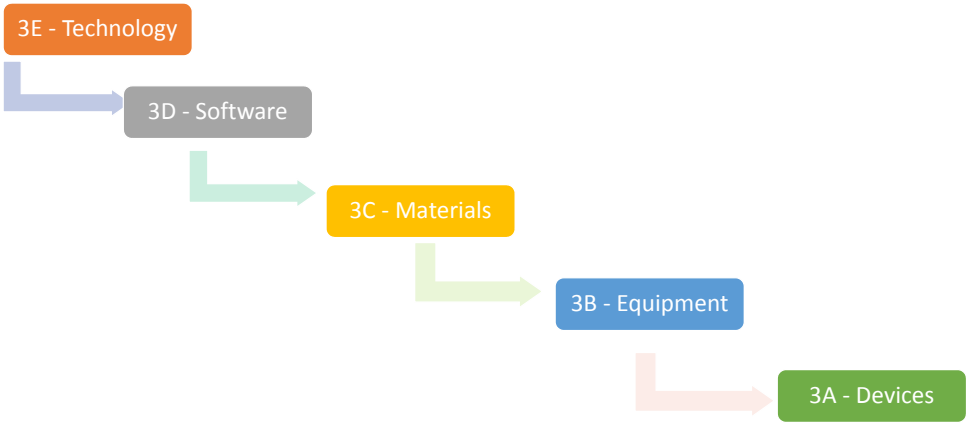
Product Groups and Semiconductor Processing



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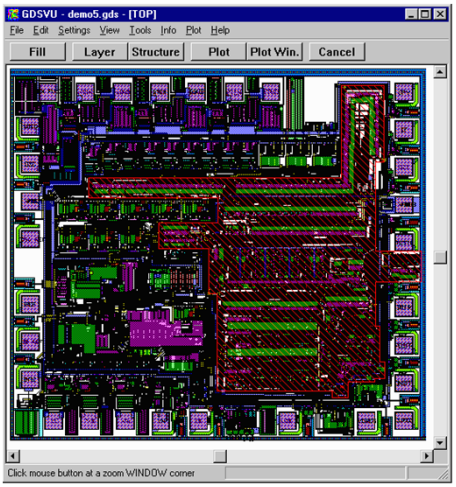
Design

- A design is a plan or specification for the construction of an object or system or for the implementation of an activity or process, or the result of that plan or specification in the form of a prototype, product or process.
- Circuit design is the first step for every electronics design project and requires the creation of a schematic diagram.
- ECAD Tool: Computer-aided design (CAD) software
- GDS File: Graphic Database System
- Electronic design automation (EDA), also referred to as electronic computer-aided design (ECAD), is a category of software tools for designing electronic systems such as integrated circuits.
- GDSII files are usually the final output product of the IC design cycle and are given to IC foundries for IC fabrication.



GDS II File

```
# KEY file for GDS-II
# File = example.key
# ------------------------------------------------------------------

HEADER 5; # version
BGNLIB;
LASTMOD (98-8-25  15:53:12); # last modification time
LASTACC (98-8-25  15:53:12); # last access time
LIBNAME TEMPEGS.DB;
UNITS;
USERUNITS 0.01; PHYSUNITS 1e-08;

BGNSTR; # Begin of structure
CREATION (98-8-25  15:53:12); # creation time
LASTMOD  (98-8-25  15:53:12); # last modification time
STRNAME AAP;

BOUNDARY; LAYER 1;  DATATYPE 0;
   XY 5;
   X     -920000.000; Y      452000.000;   X      656500.000; Y      765500.000;
   X      175000.000; Y     -174000.000;   X     -756000.000; Y     -198000.000;
   X     -920000.000; Y      452000.000;
ENDEL;

ENDSTR AAP;

BGNSTR; # Begin of structure
CREATION (98-8-25  15:53:12); # creation time
LASTMOD  (98-8-25  15:53:12); # last modification time
STRNAME LAYOUT;

BOUNDARY; LAYER 0;  DATATYPE 0;
   XY 5;
   X    -2032000.000; Y     1410000.000;   X     1427000.000; Y     1666000.000;
   X      502000.000; Y    -1580500.000;   X      502000.000; Y    -1523500.000;
   X    -2032000.000; Y     1410000.000;
ENDEL;

BOX; LAYER 2;  BOXTYPE 0;
   XY 5;
   X     1526500.000; Y    -1034500.000;   X     2623500.000; Y    -1034500.000;
```

```
0000000  0006 0002 0005 001c 0102 0062 0008 0019
                  header                bgnlib
0000020  000f 0035 000c 0062 0008 0019 000f 0035
0000040  000c 000e 0206 5445 4d50 4547 532e 4442
                        libname
0000060  0014 0305 3f28 f5c2 8f5c 28f6 3a2a f31d
                  units
0000100  c461 1874 001c 0502 0062 0008 0019 000f
                        bgnlib
0000120  0035 000c 0062 0008 0019 000f 0035 000c
0000140  0008 0606 4141 5000 0004 0800 0006 0d02
                  strname               boundary    layer
0000160  0001 0006 0e02 0000 002c 1003 fff1 f640
0000200  0006 e5a0 000a 0474 000b ae3c 0002 ab98
0000220  fffd 5850 fff4 76e0 fffc fa90 fff1 f640
0000240  0006 e5a0 0004 1100 0004 0700 001c 0502
                        endel                 endstr
0000260  0062 0008 0019 000f 0035 000c 0062 0008
0000300  0019 000f 0035 000c 000a 0606 4c41 594f
0000320  5554 0004 0800 0006 0d02 0000 0006 0e02
                        boundary
0000340  0000 002c 1003 ffe0 fe80 0015 83d0 0015
0000360  c638 0019 6bd0 0007 a8f0 ffe7 e22c 0007
0000400  a8f0 ffe8 c0d4 ffe0 fe80 0015 83d0 0004
0000420  1100 0004 2d00 0006 0d02 0002 0006 2e02
                        box
0000440  0000 002c 1003 0017 4ae4 fff0 36fc 0028
0000460  080c fff0 36fc 0028 080c 0010 de5c 0017
0000500  4ae4 0010 de5c 0017 4ae4 fff0 36fc 0004
0000520  1100 0004 0a00 0008 1206 4141 5000 000c
                        sref
0000540  1003 ffef 064c ffec aac8 0004 1100 0004
0000560 0900 0006 0d02 0003 0006 0e02 0000 0008
```


Technologies considered under the FDPR

3E001

"Technology" according to the General Technology Note for the "development" or "production" of equipment or materials controlled by 3A (except 3A980, 3A981, 3A991,3A992, or 3A999), 3B (except 3B991 or 3B992) or 3C (except 3C992).

3E002

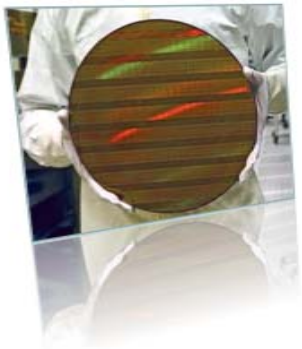
"Technology" according to the General Technology Note other than that controlled in 3E001 for the "development" or "production" of a "microprocessor microcircuit", "micro-computer microcircuit" and microcontroller microcircuit core, having an arithmetic logic unit with an access width of 32 bits or more and any of the following features or characteristics.

3E003

Other "technology" for the "development" or "production" of the following: a) Vacuum microelectronic devices b) Hetero-structure semiconductor electronic devices such as high electron mobility transistors (HEMT), hetero-bipolar transistors (HBT), quantum well and super lattice devices; c) "Superconductive" electronic devices; d) Substrates of films of diamond for electronic components; e) Substrates of silicon-on-insulator (SOI) for integrated circuits in which the insulator is silicon dioxide; f) Substrates of silicon carbide for electronic components; g) 'Vacuum electronic devices' operating at frequencies of 31.8 GHz or higher

Materials

(ECCNs 3C001 – 3C006)



❖Substrates: Silicon, Germanium, Silicon Carbide, III-V Compounds

❖Photoresists

❖Chemicals

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Semiconductor Manufacturing Equipment

Etch	Lam, AMAT	TEL, Hitachi HT	TEL, HHT, AMEC
CVD	Novellus	Jusung	ASM
PVD	Applied	Ulvac	Unaxis
Implant	Varian	SEN	Nissin
Lithography	ASML	Nikon	Canon
Track	Sokudo	TEL	Suss Micro
Mask Making	Nuflare	Micronic	Hitachi
CMP	Applied	Ebara	Tokyo Seimitsu
Process Control	KLA-Tencor	Vistec	Nova Measuring

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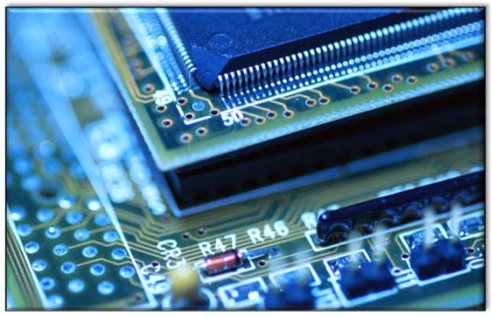
Devices

ECCNs 3A001 & 3A991

- Microprocessors
- A/D Converters
- D/A Converters
- FPGAs, Flash Memories
- MMIC Amplifiers
- Microwave Transistors
- SRAMs
- Microcontrollers



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Foreign-Produced Direct Product Interim Final Rule (FPDP)

- Amendments to Foreign-Produced Direct Product Rule and Entity List effective (85 FR 29849, 5/19/2020)
  - 60 day comment period (ended 7/14/2020)
  - 120 day production savings clause (ends 9/14/2020)
- Revisions
  - Added new Entity paragraph in General Prohibition 3: §736.2(b)(3)(vi) of the EAR
  - Added new footnote 1 to the Entity List – Supp. No. 4 to part 744 of the EAR

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Public Comments

- BIS received 11 public comments
  - 1 non-responsive comment
  - 1 business confidential comment
  - 9 posted comments
    - Regulations.gov under BIS-2020-0011
- Topics of public comments
  - Traditional FPDP letter of assurance
  - How the FPDP rules are being circumvented
  - Savings Clause length extension request
  - Technical cut-off point – should only apply to lower level circuits
  - Multiple inputs at various stages of development/production

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FPDP FINAL rule

- Effective – upon public display – August 17, 2020
- Production Savings Clause – ends September 14, 2020
- Merging of 3 rules: Entity List, Temp. Gen. License (removal), FPDP
- FPDP Final Rule Details:
  - Removed paragraph (b)(2) of footnote 1 to supplement no. 4 of part 744
  - Removed "produced or developed by any entity with a footnote 1 designation in the license requirement column of this Supplement" from paragraph (a) of footnote 1.
  - Added Note 2 "*A foreign-produced item includes any foreign-produced wafer whether finished or unfinished.*"
  - Revised the license requirement in the introductory paragraph
  - Added a license review policy Note to the introductory paragraph

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When is a FPDP subject to the EAR

When the "knowledge" standard is met in the introductory paragraph of Footnote 1 to Supplement No. 4 to part 744 "Entity List"…

- The foreign-produced item is subject to the EAR when it is a direct product of ...
- "Technology" or "software" that is:
  - **Subject to the EAR;** and
  - Specified in Export Control Classification Number (ECCN) 3D001, 3D991, 3E001, 3E002, 3E003, 3E991, 4D001, 4D993, 4D994, 4E001, 4E992, 4E993, 5D001, 5D991, 5E001, or 5E991 of the Commerce Control List (CCL) in supplement no. 1 to part 774 of the EAR.

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When is a FPDP subject to the EAR

- The foreign-produced item is subject to the EAR when it is produced by . . .
- Any plant or major component of a plant that is:
  - Located outside the United States
  - Made in either the U.S. or a foreign country
  - Is a direct product of U.S.-origin "technology" or "software" subject to the EAR that is specified in ECCN 3D001, 3D991, 3E001, 3E002, 3E003, 3E991, 4D001, 4D993, 4D994, 4E001, 4E992, 4E993, 5D001, 5D991, 5E001, or 5E991 of the CCL.

Notes to paragraph (b) of Footnote 1

*(1) A **major component of a plant** located outside the United States means equipment that is essential to the "production" of an item, including testing equipment.*

(2) A foreign-produced item includes any foreign-produced wafer whether finished or unfinished.

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FPDP rule – When is a license required?

- You may not reexport, export from abroad, or transfer (in-country) without a license or license exception any foreign-produced item specified in paragraph (a) or (b) of footnote 1 to the Entity List when there is "knowledge" that:
  1) The foreign-produced item will be:
     - Incorporated into, or will be used in the "production" or "development" of any "part," "component," or "equipment" that is
     - produced, purchased, or ordered by any footnote 1 entity; **or**
  2) Any footnote 1 entity is a party to any transaction involving the foreign-produced item, *e.g.*, as a "purchaser," "intermediate consignee," "ultimate consignee," or "end-user."

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License Application Review Policy

- Note to introductory paragraph of footnote 1
  - Sophistication and capabilities of technology in items is a factor in license application review; license applications for foreign-produced items controlled by this footnote that are **capable of supporting** the "development" or "production" of telecom systems, equipment and devices at **only below the 5G level** (e.g., 4G, 3G, etc.) will be reviewed on a **case-by-case basis**.

- **All other** license applications
  - will be reviewed using the license review policy in the license requirement column of the Entity List for each footnote 1 designated entity, which is **presumption of denial.**

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QUESTIONS?