UNIVERSITETET I OSLO

Det matematisk-naturvitenskapelige fakultet

Fasit (Guide) for

Eksamen i:	FYS3260/FYS4260 Mikrosystemer og Elektronikk Byggemetoder
Eksamensdag:	Torsdag 1. juni 2006
Tid for eksamen:	14:30 – 17:30 (3 timer)

The guide is only given in English, partly with a full proposal, partly with reference the chapters in the text book.

Oppgave 1: Sammmenkoplingsnivåer og arbeidsdeling

a) Beskriv en fornuftig hierarkisk oppdeling i sammenkoplingsnivåer innen elektronikk byggemetoder - fra IC-nivået og oppover i systemhierarkiet. Beskriv spesielt hvordan miniatyriseringsdrivet innen integrerte kretser påvirker teknologiutviklingen i de høyere sammenkoplingsnivåene i et typisk systemprodukt.

b) Beskriv hvordan en slik teknologioppdeling også skaper en fornuftig arbeidsdeling både mellom bedrifter og mellom eksperter, og gi et eksempel på 1 kritisk ekspertkompetanse på hvert nivå.

Question 1: Levels of interconnections for electronics and sharing of work

a) Give a reasonable hierarchical grouping of levels of interconnection in electronic packaging and interconnection technology - from IC level and upwards in the system hierarchy. Describe specifically how the drive for miniaturisation of integrated circuits influences the technology development in the higher interconnection levels of a typical system product.

Suggested answer: Make graphical presentation or text description of figure 1.2:

1.3 LEVELS OF INTERCONNECTION

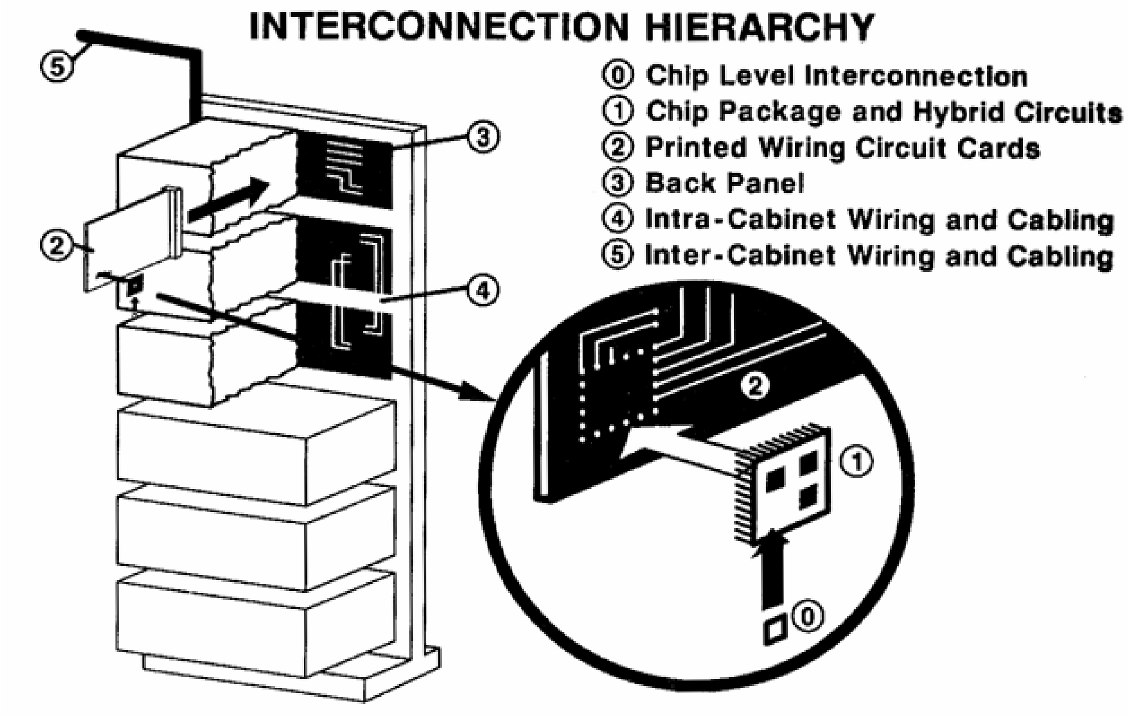

Fig. *1.2: Levels of interconnection in large electronic systems.*

In electronic systems we talk about different "levels of interconnection", please refer to Figure 1.2. The lowest, level 0 is the interconnection of integrated, single transistors on a silicon (or gallium arsenide) integrated circuit (IC) chip. The chips communicate by interconnection on level 1, which is a hybrid circuit or a module. Alternatively it can be the wiring inside an IC package, between the chip and the external solder joints of the package. Level 2 is the wiring on a printed circuit board (PCB) where ICs and discrete components are mounted.

The circuit boards in a larger system are mounted on to a back plane, interconnection level 3. Several back planes may make up a cabinet, with internal cabling, level 4. Very large systems have several cabinets with cabling between them, interconnection level 5.

The strong and consistent miniaturisation of the IC have the effect that all higher levels of interconnections, for instance on PC board are pressured to try to match this miniaturisation, like interconnection of high pin-count IC packages calling for small solder pads and low pitch. A good reference would be fig.2.10 showing the miniaturisation "gap" between ICs and printed circuit boards.

b) Describe how such a technology grouping also creates a reasonable sharing of work assignments between companies as well as between professional experts, and give an example of 1 critical expert competence on each level.

Suggested answer: As companies increasingly are focusing on only one or a few levels of interconnection technologies, they will team up with other companies, either as subcontractors on lower level(s) or as customers at higher levels. In this way the companies can concentrate their investments in equipment, technologies and human resources much more focused and thereby become more competitive.

In the same way, experts can concentrate their knowledge base and refinement in a specialised field instead of trying to do "everything" Thereby they will acquire deep knowledge and competence in their selected field, for instance in thin film hybrid technology:

For each level the following expert competence is proposed:

Level 1: Chip Packaging and Hybrid Circuits: Thick Film Technology processing expert

Level 2; Printed Wiring Boards: Chemist on metal etching techniques

Level 3: Back Panel: Expert on Computer-Assisted-Design of the Back Panel PC Board

Level 4: Intra-Cabinet Wiring and Cabling: Mechanical engineer doing mechanical computer-assisted design,

Level 5: Inter-Cabinet Wiring and Cabling: System design engineering

Oppgave 2: Materialer for elektronikk og de viktigste prosessteknologier

a) Oppgi navnet på 3 forskjellige polymermaterialer (plast) som brukes mye innen elektronikk byggemetoder. Oppgi en viktig anvendelse for hvert av materialene innen elektronikk. Ranger de tre materialene etter fallende verdi på materialegenskapene glassningstemperaturen, den relative dielelektrisitetskonstanten og den termiske utvidelseskoeffisienten.

b) Tinn/bly legering benyttes mye til lodding av elektronikk. Forklar hensikten med å bruke loddefluks ved lodding med tinn/bly, og beskriv de tre hovedtypene av vanlige brukte loddeflukser. Forklar hvorfor det er vanlig å tilføre 2 % sølv i loddtinnet. Skriv kort også hvorfor tinn/bly legeringer som loddetinn nå blir erstattet med tinn/kobber legeringer.

Question 2: Materials for electronics and basic processes

a) Give the names of 3 different polymers (plastics) that are used extensively in electronic packaging. Describe one important use for each of these materials in electronics. Set up a list for the three materials with falling values for the following three material properties: The glass transition temperature, the relative dielectric constant and the thermal expansion coefficient.

Suggested answer: Refer to tables in Ch. 3:

Glass transition temperature: 1) PTFE 2) Polyimide 3) Epoxy-glass laminate (FR4)

Relative dielectric constant: 1) Epoxy-glass laminate (FR4) 2) Polyimide 3) PTFE

Thermal expansion coefficient: 1) Polyimide 2) PTFE 3) Epoxy-glass laminate (FR4)

b) Tin/lead alloy are used extensively for soldering of electronics. Explain the rational for using soldering flux when soldering with tin/lead solder. And describe the three main types of solder fluxes. Explain why it is quite common to add 2 % silver in the solder metal. Write shortly why tin/lead alloys as soldering material these days are being replaced by tin/copper soldering alloys.

Suggested answer:SeeCh. 3.10.3 Flux and cleaning

Fluxes are used to improve the soldering and have several functions:

- *Dissolve and remove harmful surface layers (oxide, etc.)*
- *Protect the surface against new oxidation*
- *Improve the wetting*

Many types of flux are used. They consist of active ingredients dissolved in a liquid. They are of two main categories:

- *Soluble in organic liquids*
- *Water soluble*

The category determines how one will be able to clean the flux residues.

The common fluxes are also characterised as:

- *Organic resin fluxes ("rosin")*
- *Organic non resin based fluxes*
- *Inorganic fluxes*

Resin fluxes are most used and they contain natural resin from (pine-) trees, dissolved in alcohol, etc. It has a certain effect without additives, but it is normally "activated" by adding an organic chlorine compound: Dimethyl-ammonium chloride (DMA-HCl) or diethyl-ammonium chloride (DEA-HCl). The effect of the chlorine added is shown in Figure 3.19, while wetting of pure copper takes 6 seconds without activation, the time is below 1 sec. with 1 % Cl^- - content.

2% silver is added because SMD (Surface Mount Devices) resistors and capacitors often have silver in their terminals (please refer to Chapter 4), and the dissolution of the termination metal ruins the metallurgical and the electrical properties ("leaching" [3.11, p. 165]). For surface mounting it is therefore common to add 2 % Ag in the solder metal to impede the dissolution of silver into the solder metal, Figure 3.18. Another way to reduce the solubility is to alloy Pd or Pt into the silver in the component terminals.

Tin/lead is replaced by tin/copper because of the health and environmental problems with lead, and is now banned for consumer electronics by most countries, including the RoHS directive of EU, which Norway is also committed to. Tin/copper has around 30 degrees higher melting point, calling for corresponding higher soldering temperatures.

Oppgave 3: Mønsterkort (Ubestykkete kretskort) og kretskortproduksjon

a) Lag en tverrsnittsskisse av et via-hull i et tolags gjennomplettert mønsterkort som viser de forskjellige metall-lagene, og beskriv ved hjelp av et flytdiagram og tekst de prosesstrinn som må utføres for å skape slike gjennompletterte via-hull når mønsterkortet fremstilles.

b) Forklar en vanlig benyttet fremstillingsmåte for tosidige kretskort med kun overflatemontasjekomponenter på begge sider. Dette gjøres best ved å skissere et flytdiagram og med en utfyllende tekstforklaring for hvert prosesstrinn.

Question 3: Wiring boards (Unassembled printed circuit boards) and printed circuit board production

a) Make a cross-section view of a via hole in a two layer through plated printed wiring board that shows the different metal layers, and describe those manufacturing process steps needed for making such through plated via holes when the printed wiring board is produced, by outlining a flow chart with supplemental text for each process step.

Suggested answer:See Chapter 5.6 DOUBLE SIDED THROUGH HOLE PLATED BOARDS

b) Explain a common used manufacturing technology for double sided printed circuit boards with exclusively only surface mount components on both sides. This is best done by outlining a flow chart with a supplemental text for each process step.

Suggested answer:See Chapter 7.5 SEQUENCE IN THE PROCESS OF SMD- AND MIXED SMD/HOLE MOUNTED PCB's

Oppgave 4: Tynnfilmteknologi

a) Forklar en vanlig benyttet fremstillingsmåte for multilags tynnfilmkretser med tynnfilmmotstander. Dette gjøres best ved å skissere et flytdiagram og med en utfyllende tekstforklaring for hvert prosesstrinn.

b) Foreslå en teknisk-økonomisk god måte å kombinere tynnfilmteknologi og høytemperatur tykkfilmteknologi i samme hybridkrets. Påpek fortrinn og ulemper ved en slik kombifilmteknologi, og gi 2 mulige anvendelseseksempler.

Question 4: Thin film technology

a) Explain a widespread way of making thin film hybrid circuits. This is best done by outlining a flow chart with a supplemental text for each process step.

Suggested answer: See Chapter 8.4, page 8.18-27.

b) Propose a technical and cost wise a good way to combine thin film technology and high temperature thick film technology in the same hybrid circuit. Point out advantages and disadvantages by such combifilm technology, and give 2 possible application examples.

Suggested answer: See Chapter 8.7.2 Thin film on thick film

Oppgave 5. Mikromaskinerte komponenter

a) Sett opp en liste med 5 viktige prosessteknologier som kan benyttes for mikromaskinerte komponenter, med en kort forklaring på deres virkemåte.

b) Foreslå en liste med de 10 viktige suksessfaktorer som fremmer utbredelsen av mikromaskinerte komponenter, og begrunn kort hvorfor hver enkelt faktor er viktig.

Question 5: Micromachined devices

a) Give a list of 5 important process technologies which can be used for micromachined devices with a short explanation on how they work.

***Suggested answer: See Chapter** 9.4, 9.5 and 9.6 BATCH PROCESSES ……..*

b) Propose a list with 10 important success factors stimulating the application of micromachined devices, and for each of them give reasons for importance.

***Suggested answer:See list given in Chapter** 9.2. KEY FACTORS TO SUCCESSFUL INDUSTRIAL INNOVATION OF MICROMACHINED DEVICES*

----- Slutt/End -----