Chalmers *Kursnr.: MMK 072*
Material och tillverkningsteknik

Exam in Material och tillverkningsteknik, October 23rd, 2006

Examiner: Uta Klement (772 1264)
and Antal Boldizar (772 1314) responsible with respect to polymer materials
and Gustav Holmqvist (7725026) responsible for manufacturing part
The answers will be posted Tuesday, 24th October 2006.
The results of the exam will be posted on Thursday November 9th,.
Checking (*granskning*) of the corrected exams: Tuesday, November 14th, between 12:30 and 13:15h at the department.

Questions:

First, please read all questions! Don't write long answers but always motivate them.
Please, give back all the pages, even this front page!

Metals/Semiconductors/Ceramics:

1. Pb-Sn phase diagram	4 P
2. Electrical properties	4 P
3. Atomic structure and chemical bonding	3 P
4. Failure	7 P
5. Tools and tool wear	6 P
6. Calculation of machine settings in turning	3 P
7. Sheet-metal forming	5 P
8. Forging	4 P
9. Basic concepts about polymeric materials	5 P
10. Manufacturing processes and mechanical properties for polymeric materials	5 P
11. Properties and application of polymeric materials	4 P
	Σ : 50 P

Ranking :
3 ≥ 40 % (20,5 P)
4 ≥ 60 % (30,5 P)
5 ≥ 75 % (38,0 P)

Notice: During the exam a **type-approved calculator** (*typgodkänd räknare är tillåten*) and a English-Swedish dictionary (or the wordlist) is allowed. The periodic system and 3 pages with formulas are included in the exam handout **- nothing else is needed!**

Göteborg, October 17th, 2006

Good luck !!

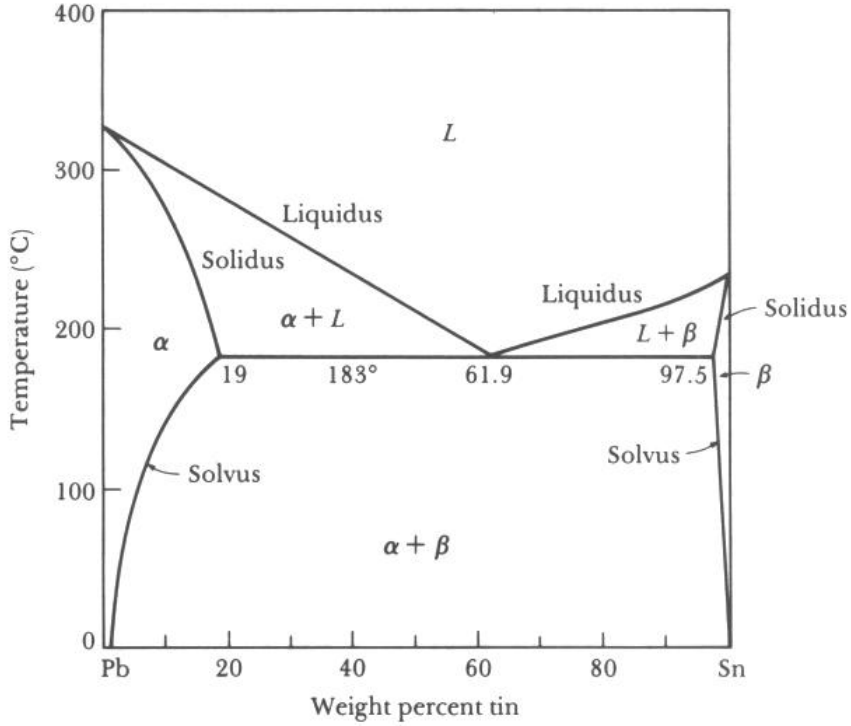
Uta & Antal & Gustav

1. Pb-Sn-phase diagram (4 P)

a) Eutectic or near-eutectic systems are usually used for soldering of electronic components. Why? (1 P)

b) Consider a Pb - 50wt.% Sn solder at 200ºC and 100ºC and determine

i) the phases present (0.5 P)
ii) their compositions (0.5 P)
iii) their relative amounts in weight percent. (1 P)
iv) make sketches of the microstructures. (1 P)



2. Electrical properties (4 P)

a) i) Make sketches of the electron energy band scheme of a semiconductor with donor and acceptor impurity level, respectively. (1 P)

ii) Explain briefly why no hole is generated by the electron excitation involving a donor impurity atom. (0.5 P)

iii) Explain briefly why no free electron is generated by the electron excitation involving an acceptor impurity atom. (0.5 P)

b) The figures below illustrate the variation of electrical conductivity with temperature of different metals and of silicon. Explain the differences for the two types of materials. (2 P)

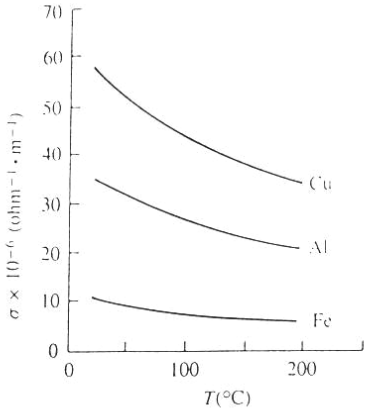


FIGURE 2 *Variation in electrical conductivity with temperature for some metals.*

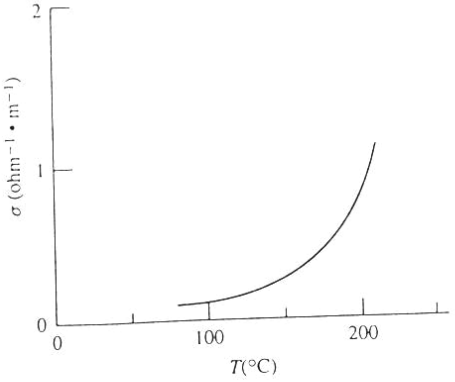


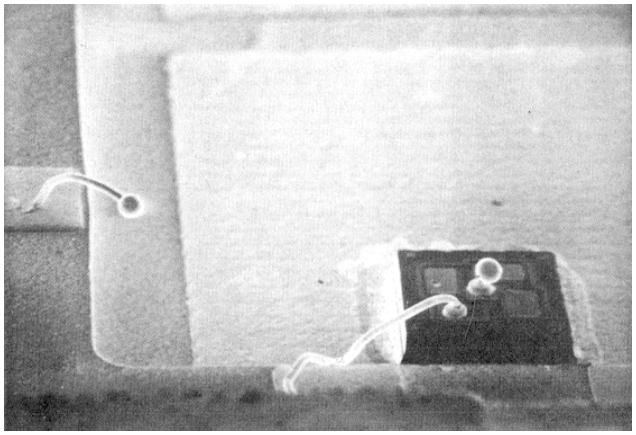
FIGURE 3 *Variation in electrical conductivity with temperature for semiconductor silicon.*

3. Atomic structure and chemical bonding (3 P)

a) Describe ionic and covalent bonding and give an example of a material with the respective type of bonding! (2 P)

b) Give the electron configuration of Vanadium (V) and Gallium (Ga) (1 P)

4. Failure (7 P)



a) From the figure above determine
   i) What types of wire bonding can you see? (1 P)
   ii) Which wire material was used? Why? (1 P)
   iii) What type of failure must have occurred? (1 P)

b) With an ongoing miniaturization in the electronic industry electromigration is getting more important as failure mechanism. Explain the process and where/when it occurs! (2 P)

c) Sketch of a stress-strain curve and mark in the curve where necking occurs. Explain necking! (2 P)

5. Metal cutting: Tools and tool wear (verktyg och förslitning) (6 P)

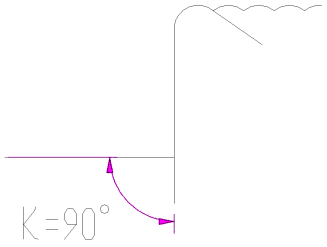
a) Describe at least three of the four wear types mentioned in the lectures and literature. Two of the wear types mentioned in the literature and on lectures are flank wear (fasförslitning) and plastic deformation. Explain the cause of the wear for each type, and describe the appearance of the wear on an insert (skär) (for instance make a simple sketch). (3 P)

b) Describe what materials (basic elements) constitute a carbide insert (hårdmetall-skär). Also describe what motivates the use of coating (beläggning). (2 P)

c) Mention two other inert material types which are harder than carbide which are commonly used as inserts. (1 P)

6. Metal cutting: Calculation of machine settings in turning (svarvning) (3 P)

An axis with a starting diameter of 75 mm is turned (svarvas) with a feed-rate (matning) 0,5 m/rev and a cutting depth (skärdjup) of 2,5 mm. The attack angle (ställvinkel) is 90º (see figure below). The power of the lathe motor (svarvens motoreffekt) is 3 kW, and the efficiency of the η_{tot} = 75%.



The specific cutting force (specifika skärkraften) of the material of the axis is described by the following equation;

$$k_c = \left(600 + \frac{250}{h_D}\right) \text{ [N/mm}^2\text{]}$$

Calculate the number of revolutions per minute (varvtal) considering that the maximum possible power is used. (3 P)

7. Metal Forming: Sheet-metal forming (Plåtformning) (5 P)

a) Two methods of forming, which sometimes in industry are combined, are stretch-pressing (sträck-pressning) and draw-pressing (drag-pressning). Discuss the differences of these methods including such aspects as hold-down force (tillhållarkraft), thickness of the sheet-metal (plåttjocklek) before and after the forming, and possible geometries that can be produced. (4 P)

b) Stretch-forming (sträckdragning) is a particular forming method used for more specific tasks. Explain shortly how stretch-forming differs from the above mentioned methods. (1 P)

8. Metal Forming: Forging (Smidning) (4 P)

A wheel is cold-forged (kall-smids) to the following dimensions: Diameter; 85 mm, thickness; 40 mm. The cold-forging is made from an axis (axel) with a starting diameter of 70 mm, which has manufactured (tillverkats) to the right dimensions prior to the forging.

Ludwik's equation for the material is: $\sigma_\varepsilon = 300\ \varepsilon_e^{\,0,3}$ [N/mm^2]
(The formula could also as in the literature be written $k_f = 300\ \phi^{0,3}$ [N/mm^2])

Calculate the maximum force (maximal kraft) during the operation assuming no friction. (4 P)

9. Basic concepts about polymeric materials (5 P)

a) Explain the concepts of plastic, polymer, mer unit, monomer, polymerization and macromolecule (plast, polymer, repeterande enhet, monomer, polymerisation och makromolekyl)! Also, describe the connection between these concepts!! (3 P)

b) Explain what happens at the glass transition and at the melting point (glasomvandlingstemperatur respektive en smältpunkt) for polymeric materials at a molecular level! (2 P)

10. Manufacturing processes and mechanical properties for polymeric materials (5 P)

a) Describe the manufacturing processes of injection moulding and extrusion (formsprutning och extrudering) by briefly describing the machinery and what happens with the material during the passage through the process! (2 P)

b) Most polymeric material can, depending on the temperature, exhibit elastic, plastic as well as viscoelastic deformation behaviour. Assuming room temperature, what deformation behaviour is expected for each of semi-crystalline polymers, amorphous polymers, rubbers and thermosets (delkristallina termoplaster, amorfa termoplaster, gummin respektive härdplaster)? (2 P)

c) Describe the deformation behaviour of an amorphous polymer loaded with a constant force during a long period of time, such as during one month with a load corresponding to half the load causing break! Answer by naming the deformation behaviour and by drawing a schematic figure for the deformation with time! (1 P)

11. Properties and application of polymeric materials (4 P)

Give name and abbreviation for the four most commonly used polymeric materials, also known as the commodity plastics (bulkplaster)! Also, give the mer unit (repeterande enhet) for each of the four plastics, if amorphous of semi-crystalline polymers and very shortly the main mechanical character at room temperature! (4 P)