UNIVERSITY OF OSLO

Faculty of Mathematics and Natural Sciences

Guide for this exam:

Exam in:	FYS4260 Microsystems and Electronic Packaging & Interconnection Technologies
Exam date:	Monday, June 2nd, 2008
Time for exam:	14:30 – 17:30 (3 hours)
The examination test set consists of:	3 pages including this front page
Attachments:	No attachments
Allowed examination aids:	None except the general allowed aids as for instance approved electronic calculators. For instance, tables and programmed data in calculators not allowed.

The student should check that the test set is complete before you start answering the questions.

Miscellaneous:

Course responsible Per Øhlckers will not be present at University of Oslo on June 2nd, but can be reached on cell phone 95 90 39 89.

The test questions are given in English only, but can be answered in either Norwegian or English. Use maximum 1 page for each question; that is for the sum of both the a) and the b) answers.

Question 1: Technology Trends

a.) Discuss the specific challenges for electronic interconnection and packaging technology for automotive electronics, assuming a car lifetime of more than 10 years. Give some recommendations to the automotive manufacturers how they should design and build the electronics to assure that today's new cars after 10 years have well functioning automotive electronics on operation functions as well as safety issues.

Suggested answer:

A few proposals:

10 years in harsh environment is an extremely long lifetime for electronics in general, and calls for specific design precautions.

Environment and mode of use have large span and variation. Extreme heat, extreme cold, high humidity, vibrations, salinity, etc., etc.

Often, even frontier high tech cars have quality and reliability problems because they use new electronics that is not debugged, tested and modified enough and thereby get short lifetime.

This industry is traditionally a mechanical industry where electronics is rather an add-on after finished mechanical design instead of an integrated part of the total car design.

Electronics is located in available space with is hard to get by for repair. That applies to cabling as well.

This industry has generally insufficient competence in electronics, including the garages.

Some examples of advices:

Use well proven designs – ref Japanese design philosophy versus European.

Design for a life time of at least 10 years for more than 90% of normal application areas.

b.) We have seen and will probably still see dramatic improvements of the performance/price ratio for electronic products. Describe and explain what you consider to be the 3 most important reasons for this development.

Suggested answer:

Some important aspects:

1. Moore's law with ever shrinking feature size gives added performance and/or reduced cost.
2. Higher speed
3. Improved packaging and interconnection technologies
4. Improved reliability engineering
5. Larger production volumes give reduced unit costs
6. Better design tools
7. Better manufacturing equipment
8. More efficient manufacturing administration, sales and distribution.
9. Stepping up the learning curve on all issues
10. Etc., etc.

Question 2: Green Electronics and Adhesives in Electronics

a.)Which environmental challenges are specific to electronics? Describe 2 environmental harmful materials or chemicals that are used or have been used in electronic products and their manufacture. Give examples where these are used or have been used. Explain shortly the concepts "Life cycle perspective" and "Producer responsibility" and explain shortly how these influence design and production of electronic products.

Suggested answer:

The environmental challenges within electronics manufacturing and use are mostly related to disposal of electronics when defective or obsolete. There are also some issues related to manufacturing, while use of electronics is mostly environmental friendly.

During manufacture of electronics, some hazardous materials are used, as for instance heavy metals like lead (Pb), solvents like fluorocarbons, and etching solutions like ferrous chloride. The electronic manufacturing industry was earlier a large contaminator, for instance with excessive output of freon that breakes down the ozone layer, until that was banned. Another example is lead, which regrettably still is allowed for use in defence electronics and biomedical electronics. Lead and some of the other environmental hazardous materials are first of all an environmental problem for those products that are not recycled

Livsløpsperspektiv: **Design and production** of electrical and electronic equipment to aid **repair, possible upgrading, re-use, disassembly and recycling at end-of-life**.

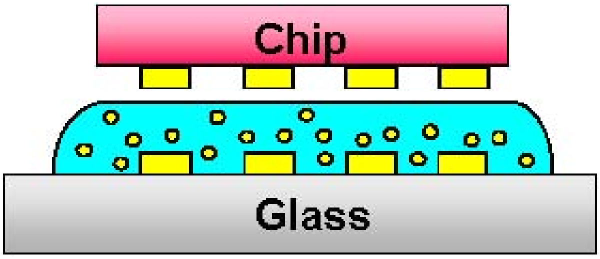
Produsentansvar: Fra EU's RoHS direktiv: Manufacturers will need to ensure that their products - and the components of such products - comply with the requirements of the Regulations by the relevant date in order to be placed on the Single Market. The Regulations will also have an impact on those who import EEE into the European Union on a professional basis, those who export to other Member States and those who rebrand other manufacturers' EEE as their own.

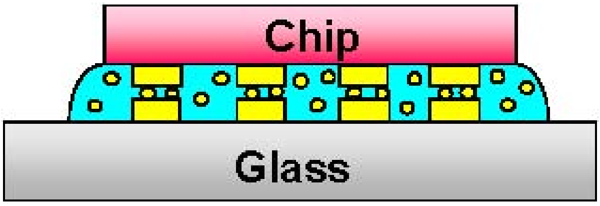
Dette påvirker selvsagt bade konstruksjon og produksjon av elektronikk, fordi det må gjøres i harmoni med RoHS- direktivet. F.eks. betyr det at bransjen selv har tatt ansvar for gjenvinning når ødelagte eller foreldete produktet blir avfall.

b.)Describe the constitution and principle of operation of one kind of anisotropic conductive adhesive, and describe how such an adhesive can be used for electronic interconnections in an electronic system containing a Liquid Crystal Display (LCD) panel, for instance a Global positioning System (GPS) system.

Løsningsforslag:

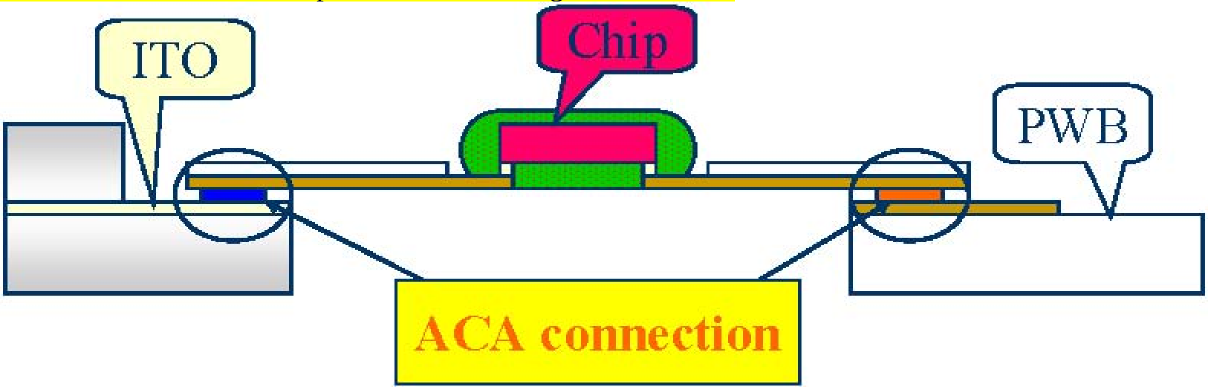
Et godt eksempel er Conpart's anisotrope lim basert på Ugelstad-kuler, se ppt-fil på "Adhesives in Microelectronics and MEMS Applications"





Prinsippet er kort fortalt at de monodisperse gullpletterte plastkulene presses mellom elektrodene. Matrix-limet herdes, og da med krymp, slik at det blir et presstrykk som opprettholder den elektriske kontakten.

Dette kan brukes for LCD-paneler som vist i figuren nedenfor.



Question 3: Components

a.) Describe the principal construction and a common used manufacturing technology for multilayer ceramic capacitors. This is best done by graphics with a supplemental text.

Recommended answer: See page 4.6-4.7.

4.3.3 Multilayer ceramic capacitors

Ceramic multilayer capacitors, see Figure 4.7, are the dominating type for SMD. They are composed of a number of metal electrodes, isolated from each other by thin layers of a ceramic dielectric. Every other electrode is connected to the end termination on the left and the right side. The dielectric layers are only of the order 20 µm thick, and the dielectric may have a very high relative dielectric constant. Thus, one achieves very high capacitance to volume ratio. The capacitors are manufactured by processes similar to those used for making multilayer ceramic packages and multichip modules, please refer to Chapters 3 and 8 and [4.2, 4.3, 4.6, 4.8]. Due to the high temperatures used during sintering the inner electrodes are normally made of the noble metals Pt or Pd, which have a high melting point. The end electrodes are AgPd or Ag, see Figure 4.7, and a diffusion barrier of Ni outside it, and on top of that, a eutectic composition of SnPb solder. See also Section 4.7.

The ceramic dielectrics are of different types. Designations and compositions vary between manufacturers, but properties are similar. The dielectrics are divided into classes according to relative dielectric constant and other properties. The ceramic is often based on barium- or strontium titanate with additives. These materials are ferroelectric, therefore the high dielectric constant, please refer to Figure 4.8. Near the Curie temperature ε_r *is strongly temperature dependent, and the purpose of the additives is to move the Curie point or in other ways reduce the temperature dependence in the temperature region of use.*

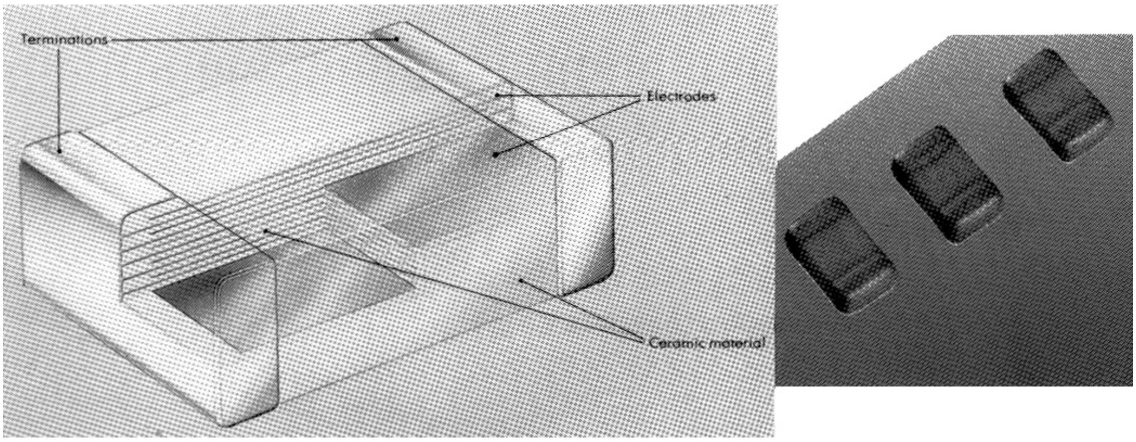


***Fig.** 4.7 a): SMD multilayer ceramic capacitor.*

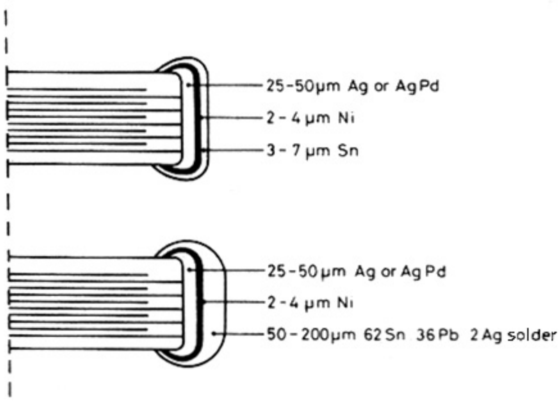


***Fig.** 4.7 b): Metal system for the end termination of multilayer ceramic capacitors.*

There are two main classes of ceramic capacitors [4.8]:

<u>Class 1</u>*: Capacitors with low capacitance values, dielectric with $\varepsilon_r < 100$, low dielectric losses, low temperature coefficient. Ceramics composed of $MgTiO_3$, Mg_2SiO_4, $BaTiO_3$ and various other materials are used for Class 1 capacitors, which are designated NP0, N220, N750, COG, etc.*

<u>Class 2</u>*: Capacitors of higher capacitance values, based on ceramics with ε_r up to about 15 000. The capacitance varies strongly as a function of temperature and voltage. Tan δ is higher than for Class 1, and the properties change in time. Dielectric designations are X7R, Z5U, etc.*

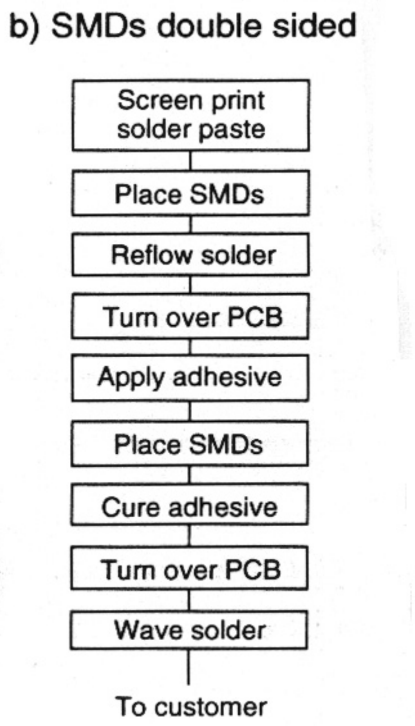
b.) Explain different ways to achieve different capacitance values for multilayer ceramic capacitors with the same outer dimensions.

Recommended answer: See page 4.6-4.7. Reasoning: More layers, higher dielectric constant, and thinner dielectric.

Question 4: Printed Circuit Boards

a.) Explain a common used manufacturing technology for double sided printed circuit boards with surface mount devices (SMD) on both sides of the board. This is best done by outlining a flow chart with a supplemental text for each process step.

Recommended answer:See page 7.40:



NB: With small components it might be possible to use 2 reflow soldering steps and no wave soldering by skipping the adhesive step and rely on surface tension to keep the components hanging during second reflow

b.) Explain the wave soldering process for a printed circuit board. Describe the two most important solder defects when using wave soldering, and how they best can be minimised.

Recommended answer: See page 7.11-7.12:

Wave soldering

Wave soldering is done in the same way as for hole components, but it is more critical. Problem areas are: not wetted surfaces, generation of solder bridges and thermal stress on the components.

The component bodies cast shadows for themselves and their neighbours, see Figure 7.14, and the simplest solder machines give unreliable contact between the solder areas and the wave. To remedy this, many machines have two waves, see Figure 7.15. The first is a turbulent wave, reaching and wetting all corners and crevasses. However, it will create solder bridges. The second, called the "lambda wave" is a gentle wave that removes the superfluous solder. In addition to the solder process conditions, also the dimensions of the solder pads are very important for defect free soldering.

There are several other principles for SMD wave soldering machines. The "jet wave" moves in the opposite direction to the board at high velocity. In some machines, a vibration is generated in the solder. Solder bridges may be blown off with a stream of hot air, "air knife", and oil can be mixed with the solder to reduce dross formation.

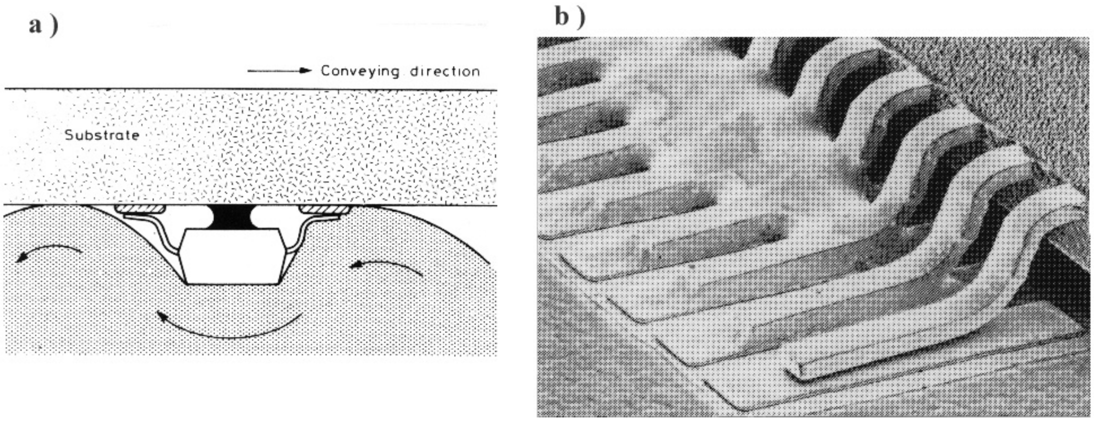
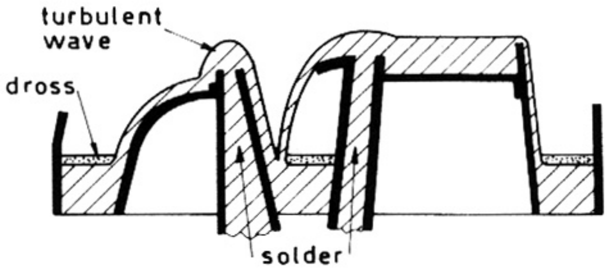


***Fig.** 7.14:* *a): Shadowing in SMD wave soldering, b): Solder bridging on fine pitch package.*



a)

***Fig.** 7.15: Double wave for SMD soldering.*

Figure 7.16 shows a typical temperature profile in a double wave solder process, as measured inside an SMD. The peak temperature is 230 - 250 °C, and the time during which the component is above 200 °C is 5 - 10 sec.

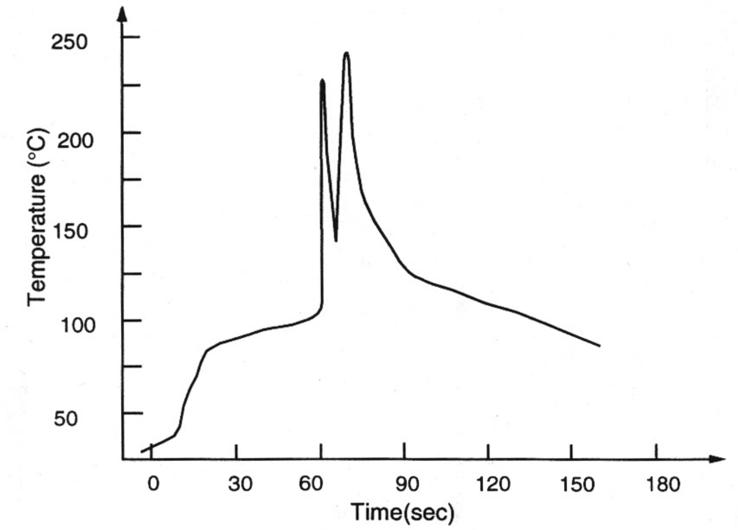
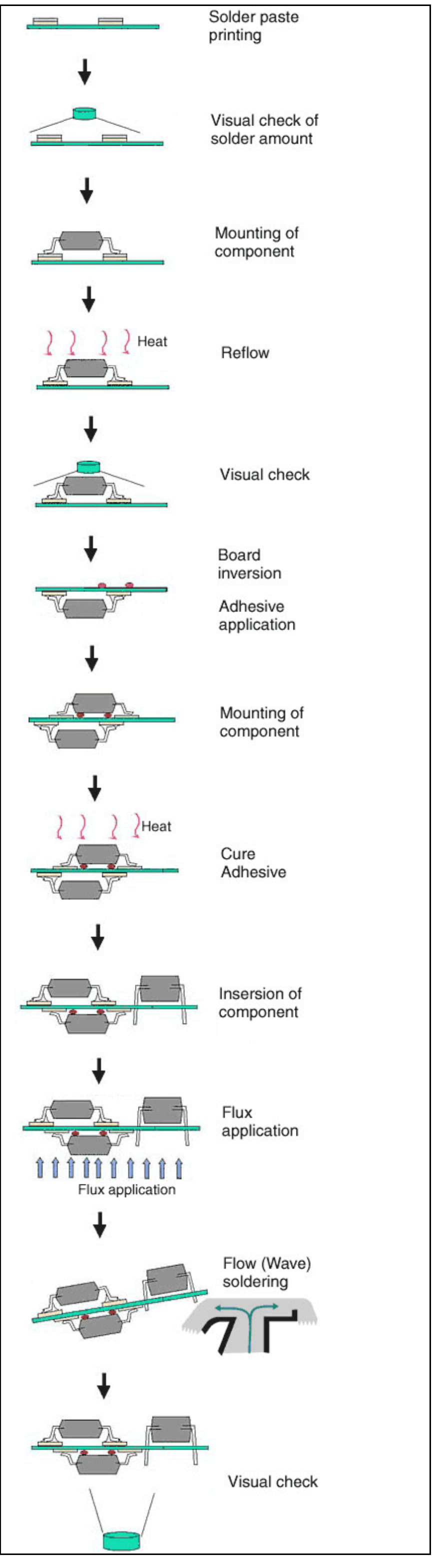


***Fig.** 7.16: Temperature profile during wave soldering in a double wave machine.*

To the right: Schematic presentation of combined reflow and wave soldering. Please note that use of adhesive is necessary.



Question 5: Micromachined Devices/Microsystems MultiProject Wafer (MPW) foundry services

a.) Tronics in France is offering microsystems MPW foundry services based upon their Silicon On Insulator High Aspect Ratio Micromachining (SOI HARM) technology. A cross-sectioned view of the process is shown in Figure 5.1 below.

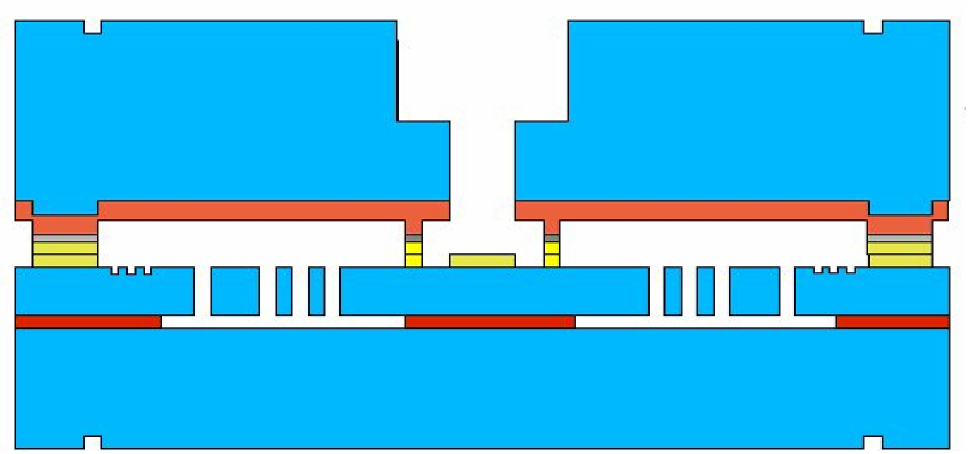
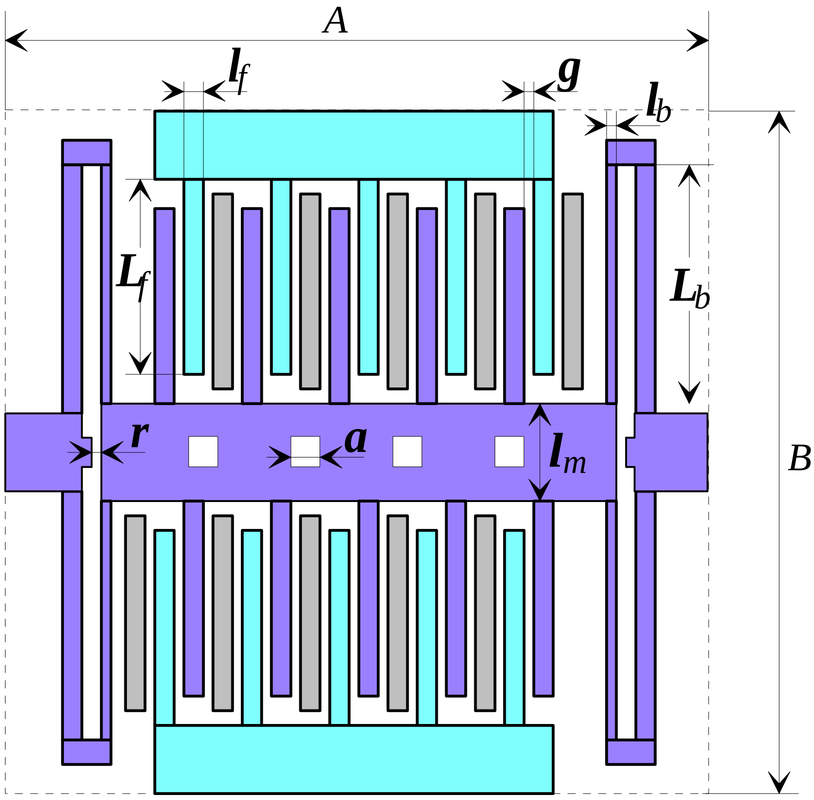


Figure 5.1: Cross section view of the Tronics' SOI HARM MPW process technology

Explain the basic features of the Tronics' SOI HARM process by explaining how a 2-axis accelerometer can be designed and manufactured in this process. This is best done by combining text and graphic presentation.

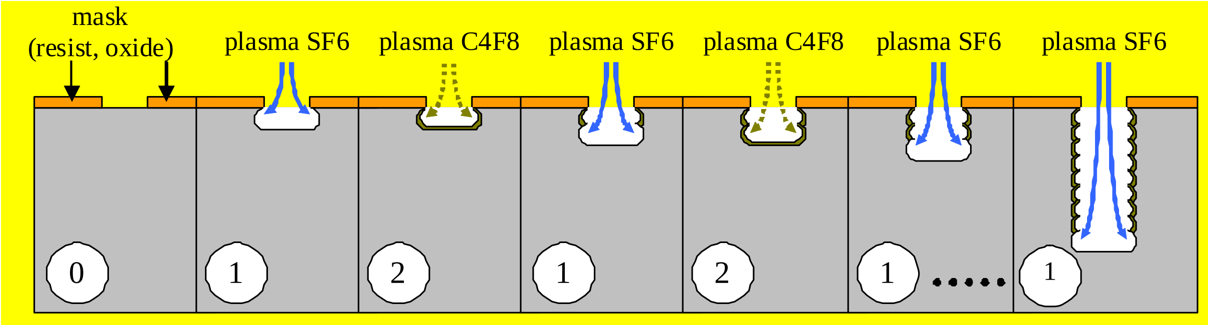
Recommended answer: See the Tronics presentation:



Pink structures are fixed electrodes. Blue are movable, partly anchored. By locating 2 such structures oriented 90 degrees tilted versus each other, we a 2-axis accelerometer structure.

b.) Describe how the Bosch process is included in the Tronics' MPW process to make vertical etch geometries with high aspect ratio. Explain specifically the principles used in the Bosch process to achieve high aspect ratio by minimising underetching. This is best done by combining text and graphic presentation.

Recommended answer: See the Tronics presentation:


mask
(resist, oxide)
plasma SF6
plasma C4F8
plasma SF6
plasma C4F8
plasma SF6
plasma SF6
0
1
2
1
2
1
1

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