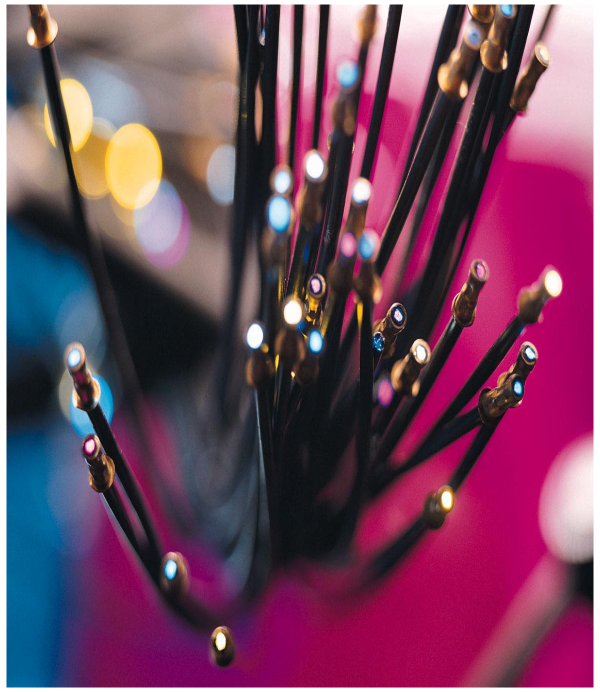
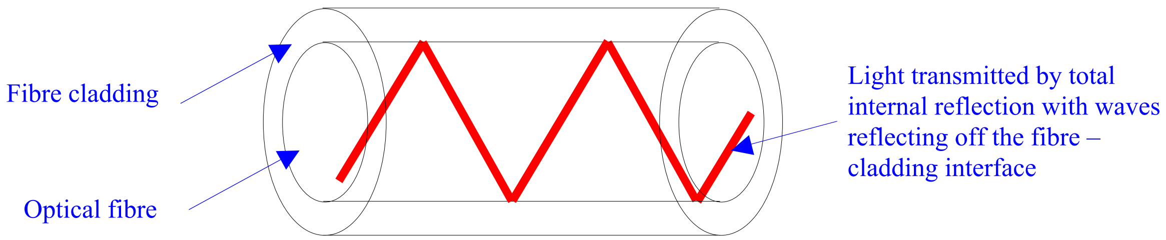
- For the same data capacity optical fibres are significantly smaller in diameter and lighter than equivalent copper cables, making them easier to install
- Optical fibres are cheaper than copper wires
- There is very little reduction in the signal.



Optical or glass fibres are made from very pure silica (silicon dioxide) glass which allows light signals to be transmitted with very little interference or degradation of the signal. The optical fibres themselves have a diameter similar to that of a human hair and are made using a two stage process. The first stage involves making a pre-form of very pure glass and this is done by a process called Modified Chemical Vapour Deposition (MCVD). During MCVD the physical and optical properties of the glass are determined by varying the mixture of the reacting chemicals (silicon chloride and germanium chloride). The glass is produced by bubbling oxygen gas through solutions of the reactants and the resulting vapours are deposited on the inside of a synthetic silica tube (which becomes the fibre cladding) mounted in a special lathe. As the vapours are deposited the lathe turns ensuring an even coating of the glass. Once this pre-form has been tested it is drawn into a fine fibre. The blank is heated until the tip melts and as this molten droplet is cooled it is drawn in to a fibre and coiled. During this process the diameter of the fibre is carefully monitored using a laser micrometer and after processing the properties of the fibre are measured.



Optical fibres transmit light pulses by total internal reflection with the light reflected at the interface between the fibre and the cladding material. As this process is not associated with an electrical current degradation of the signal is not a problem. However signal boosters or repeaters are required at a separation of around 100km rather than 1.5km as with copper cables. This makes optical fibres ideal for transmitting information over large distances. Optical fibres also have advantages over traditional cables for local area networks since they small and light weight.

Further information

www.howstuffworks.com/fiber-optic
http://encarta.msn.co.com
www.leb.e-technik.uni-erlangen.de/lehre/mm/html/start.htm

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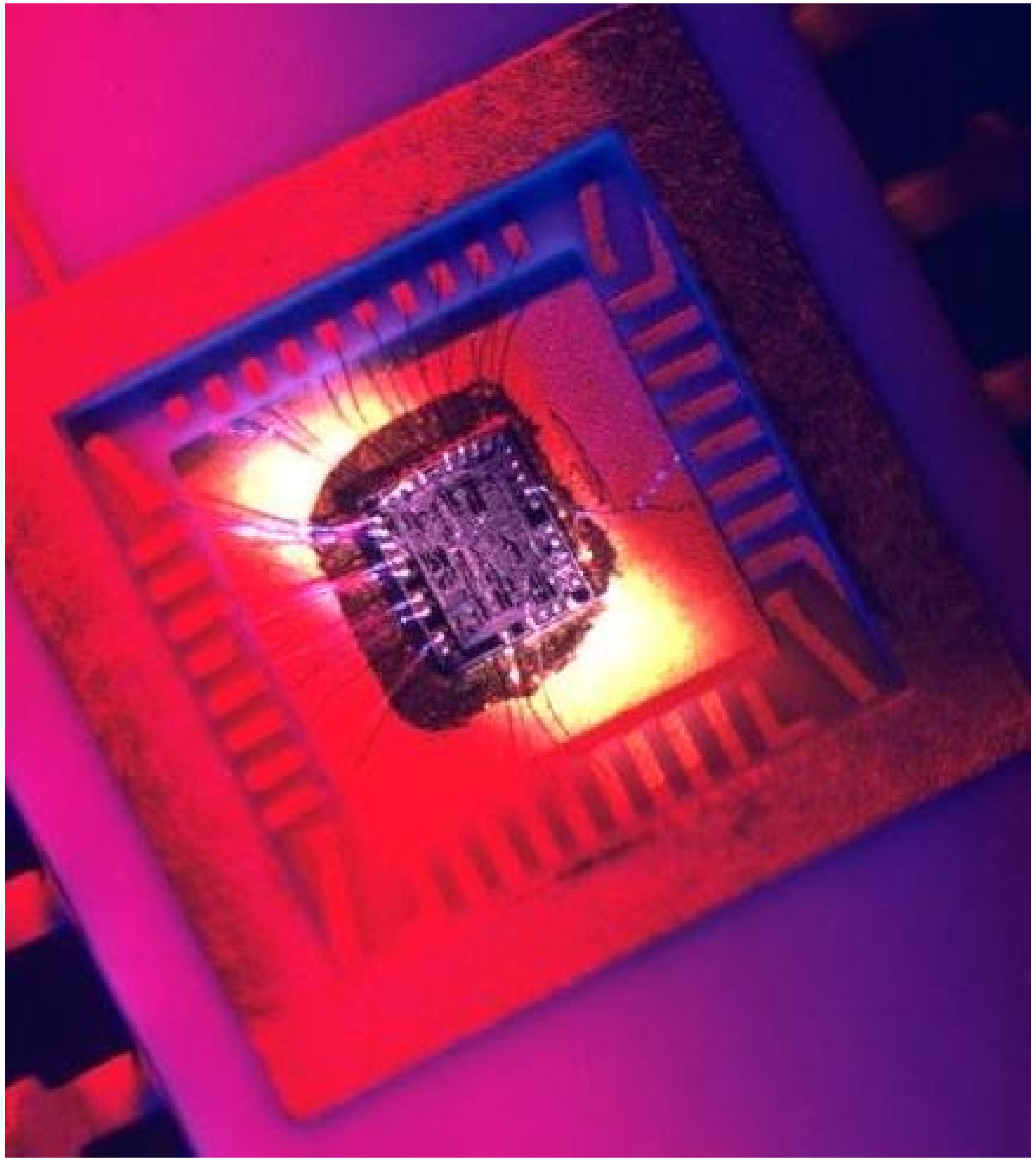

Materials in Communication

Materials for data processing

Materials for data transmission

Materials in Communication

The twentieth century saw a revolution in the way in which we communicate. The development and introduction of silicon microchips has had a huge impact on our lives not just in terms of the personal computer but also other electrical items such as personal stereos and washing machines which contain a small microprocessor. The advent of the internet meant that new methods for allowing remote computers to communicate were sought and optical fibre technology was implemented along with satellite transmission.

Materials have played a central role in the advancement of our communication technology. In particular silicon has had a major influence both in its elemental form in microchips and as its oxide silica in optical fibres. For this reason the it has been suggested that we are now in the Silicon Age.

Materials for data processing

Silicon is the second most abundant element in the Earth's crust, where it is found in combination with other elements such as oxygen and aluminium in rocks (granite, quartz and sand) and clays. Discovered in 1823 by Jons Berzelius silicon is situated immediately below carbon in the Periodic Table and is classified as a *metalloid*. The metalloids are a small number of elements that have the properties of both metals and non-metals. In its pure elemental form silicon is a blue-ish grey material with a dull luster, it has a melting point of 1410ºC and a density of 2.329 gcm^{-3}. The most exploited property of silicon is that it can behave as a semiconductor.

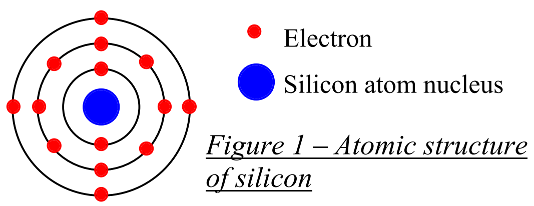

Figure 1 – Atomic structure of silicon

The atomic structure of silicon is rather special in that its outer electron shell is half full, containing four electrons (figure 1). This configuration allows a silicon atom to form perfect covalent bonds with its four nearest neighbours. However, this structure is a poor electrical conductor as there are no free electrons to carry the current. In order for silicon to conduct it must be doped with small quantities (10^{15} atoms per cm^3) of other elements to produce a surplus or deficiency of electrons. The resulting material is called a semiconductor and there are two types.

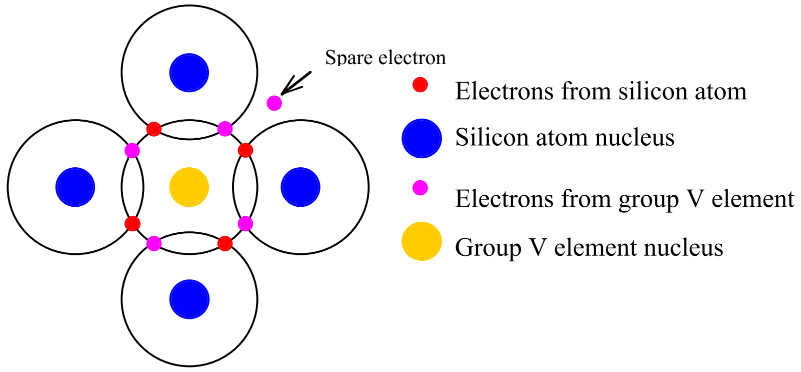

Figure 2 – N-type silicon

N-type silicon semiconductors are doped with group V elements such as phosphorus and arsenic which have five electrons in their outer shell. This means that if a group V atom is bonded to four silicon atoms there is a spare electron which is free to move and thus carry an electric current. There is an overall negative charge in the system and thus the name n-type (figure 2).

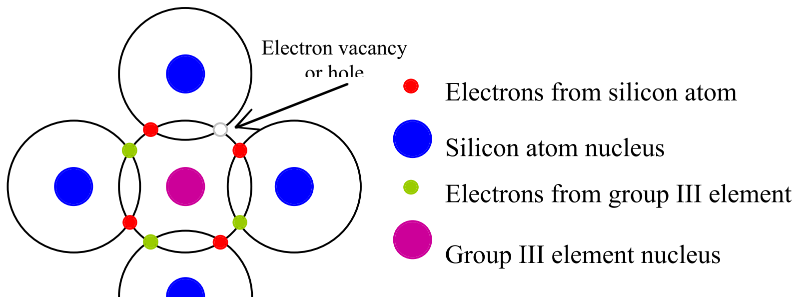

Figure 3 – P-type silicon

P-type silicon semiconductors have an overall positive charge and are doped with group III elements (gallium and boron) which only have three electrons in their outer shell. Thus when bonded with silicon atoms there is an electron vacancy or hole in the lattice which allows the surrounding electrons to move (figure 3).

It is the junction between n-type and p-type semiconductors which is important as it either only allows a current to flow in one direction or under certain conditions. Electronic components such as diodes and transistors are made up from junctions between the two types of silicon.

A transistor consists of a sandwich of n- and p-type silicon which can be either n-p-n or p-n-p. In either case the application of a small current to the central layer allows a much larger current to flow across the junctions through the component. Transistors can therefore be used as switches and they form the basis of modern microprocessors. Millions of transistors can be put on to a single small piece of silicon by selectively doping certain areas.

In order to produce microprocessors wafers or thin slices of pure single crystal silicon need to be made. A single crystal contains no grain boundaries and is made by drawing a seed crystal from a pool of molten silicon. Cylindrical single crystals up to 40cm in diameter are grown. The wafers are then carefully sliced from the single crystal ready for further processing. The whole process for producing silicon microchips must be carried out under extremely clean conditions to prevent contamination. The first step is to clean the surface of the silicon wafer. In order to protect the surface of the wafer a thin layer of SiO_2 is grown on to it during a wet or dry oxidation process at 800-1000°C. In order to construct a transistor on the surface of a pure silicon wafer a number of complex stages are carried out:

- Deposition of a layer of silicon nitride (Si_3N_4).
- Application of a mask called a *photoresist*. When selected areas of the photoresist are exposed to UV light through a mask the photoresist material breaks down and is removed.
- Removal of the Si_3N_4 layer in the exposed areas.
- Introduction of the dopant layer using ion transplantation. This is either the group III or group V element and it forms the basis of the transistor.
- Removal of the remaining unexposed photoresist and Si_3N_4.
- Removal of the protective SiO_2 layer.

Once the base layer of the transistor has been made by doping the silicon the other dopant is introduced (to produce the n-p-n or p-n-p junctions) and the gates are built up in a similar process of laying down and selectively removing layers from the surface. Adjacent transistors must then be connected together and this is achieved by applying a layer of titanium followed by aluminium on the wafer surface. This process is carried out simultaneously across the whole surface of the wafer to produce a large number of transistors, in fact an Intel Pentium 4 microprocessor contains around 42,000,000 transistors!

Materials for data transmission

Traditionally copper wires were used to transmit information such as telephone calls or messages between computers. However there are several disadvantages associated with using this method. For example, the cables are heavy and bulky making them difficult to store and transport. Furthermore the signal is transmitted using electric currents and losses in the signal occur due to resistance heating.
Today optical fibre cables are used for computer and telephone networks as they have many advantages over copper cables. These include: