

1.1.3 Electronic Materials and Products

So what are "Electronic Materials"? Ask Google and [you get an answer!](#)

Progress in Electrical Engineering was always dependent on progress in materials. For quite some time, electrical engineering meant electro**mechanical** engineering, and electrical products were made from "trivial" materials, as seen from a modern point of view. What was needed were cables, insulators, ferromagnetic sheet metal for transformers and generators, and a lot of metal for the general mechanics. A few applications centered around some mysterious materials - out of that grew **electronics** and electronic materials. But even then there were key materials:

- **Cu wires** of all kinds. Not so trivial - how do you make a insulated but still flexible wire?
- Insulating materials - plastics didn't quite exist yet. **Mica** was one of the key materials - there were mines for it!
- **Graphite** and **tungsten** were important, whenever things got hot, like the filament in the light bulb or in a **vacuum tube**.
- The "tube of **Braun**" - the "**Braunsche Röhre**" as it was known in Europe - the first **cathode ray tube (CRT)** in other words - needed complicated glass work and some **ZnS** as electroluminescent material
- Strange compounds like "**phosphor bronze**" were developed for contacts.
- And **Selenium (Se)** was important for rectifiers, although nobody quite understood how it worked.

The essential break through in the thirties was the **vacuum tube**; with it came electronics: Rectifiers, amplifiers, radio, black-and white **TV**, colour **TV**. It's not that long ago, but obviously long enough for some [not to remember!](#)

The next break-through was called **transistor**; it happened in **1947**. **Integrated circuits** followed around **1970**, and since then we witness exponential growth with growth rates in the complexity of electronics (at constant prices) of up to **40%** a year!

- A good (german) book covering this development in some detail is Hans **Queissers** "**Kristallne Krisen**".

1.2.2 Electronic Materials and Electronic Products

Electronic Products

Electronic Materials are what you find inside the **components** making up **electronic products**. They consist of some stuff that you cannot easily exchange with something else - not even in principle - without losing the function.

- What you **can** change easily for example, is the material for the box, the housing. Use **Al** instead of plastic or vice versa for your video recorder - it would still work, needing at most some minor adjustments.
- You also may change (in principle) the metal for real wires. Using **Au**, **Ag**, or **Al** instead of - let's say - **Cu**, makes little difference for the function.
- But exchange **any** material in a "chip" (i.e. in an **integrated circuit**) with something else (even allowing for minor adjustments) - and that definitely will be the end of your product.

Let's look at some typical products or product groups that contain electronic materials:

- **Electronics** in general (Computer, **TV**, Radio, Radar, Microwave, ...).
- **Flat panel displays (FPD)**.
- **Micromechanics** and **Microsystems (MEMS)**.
- **Solar cells**.
- **Lasers** (in particular semiconductor Lasers).
- **Batteries, Accumulators**; energy storage systems in general.
- **Sensors**, in particular solid state sensors, that convert whatever they sense directly into a current or a voltage.
- **Fuel Cells**.
- **Magnetic Memories**.

Looking at Components

Consider, e.g., a **laptop** or **notebook** in more detail. If you take it apart, you find the "high tech" stuff:

- Any number of *chips*, i.e. integrated circuits.
- Some **quartz oscillators**.
- A **hard disc**, i.e. a magnetic memory for the bulk memory.
- A reading head for the hard disc that uses the "**giant magnetoresistance effect**"
- A **CD ROM**, i.e. an optical memory and a semiconductor *Laser*
- A **flat-panel display (FPD)** using "liquid crystals", which is pretty big as a single component, but cannot be subdivided in smaller pieces.

But there is also "low tech" - or so it seems:

- Capacitors** and **inductors**.
- Switches*, connectors, the keyboard as a unit.
- Insulation*.
- Mechanical stuff like the disk drive, but also the *housing*.

Some components betray their key material in their name ("*quartz*" oscillator) or by common knowledge (who, besides some so-called intellectuals, does not know that the word "chip" is almost a synonym for Silicon?), but for most components we have to look deeper - we must open them up (which will almost always destroy them). What do we find?

Electronic Materials

Lets open up a chip. We find

- Packaging material** - either some *polymer* blend or *ceramics*.
- A "chip" mostly consisting of **Si**, but interlaced in an intricate pattern with other materials like **P, B, As, SiO₂, Si₃N₄, MoSi₂, W, TiN, Al, Cu...**
- A **lead frame** - the little pins sticking out of the package - made of some *metal alloys*.
- Tiny **wires** connecting the leads to the chip or some pretty sophisticated stuff doing this job.

Now open up the **FPD**. You will find many materials, the most suspicious beyond what we already found in chips are:

- Liquid crystals**, some strange liquid stuff.
- Amorphous Si**.
- Indium tin oxide ITO**, a transparent electrode.
- Plastic foils* acting as *polarizers*.
- A plastic (or *glass*) front and end plate.

Now lets look at the **Laser** coming with the **CD** drive :

- You find a complex mix of **GaAs, GaAlAs**, some other elements, as well as wires and packaging materials.
- And all of this is quite different from what you find in the **Si** chips!
- Soon you would find **GaN** in your Laser diode - and the capacity of your **CD** memory will quadruple!

We could continue this, *but by now you got the idea*:

**Progress in Electronic and Communication Technology is
driven by
Progress in Material Science
(and almost nothing else)**