

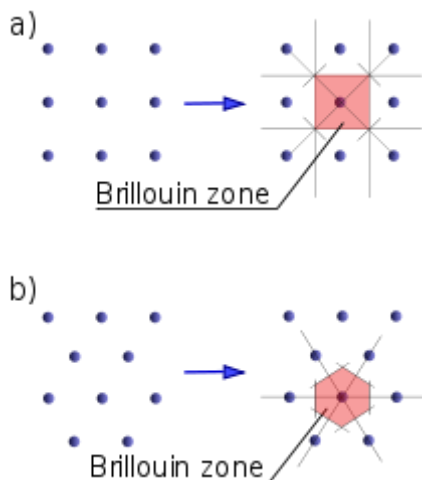
## CONTENT BEYOND SYLLABUS

### BRILLOUIN ZONE

In mathematics and solid state physics, the first **Brillouin zone** (also known as the **Bouillon cube**) is a uniquely defined primitive cell in reciprocal space. In the same way the Bravais lattice is divided up into Wigner–Seitz cells in the real lattice, the reciprocal lattice is broken up into Brillouin zones. The boundaries of this cell are given by planes related to points on the reciprocal lattice. The importance of the Brillouin zone stems from the Bloch wave description of waves in a periodic medium, in which it is found that the solutions can be completely characterized by their behavior in a single Brillouin zone.

The first Brillouin zone is the locus of points in reciprocal space that are closer to the origin of the reciprocal lattice than they are to any other reciprocal lattice points (see the derivation of the Wigner-Seitz cell). Another definition is as the set of points in  $k$ -space that can be reached from the origin without crossing any Bragg plane. Equivalently, this is the Voronoi cell around the origin of the reciprocal lattice.

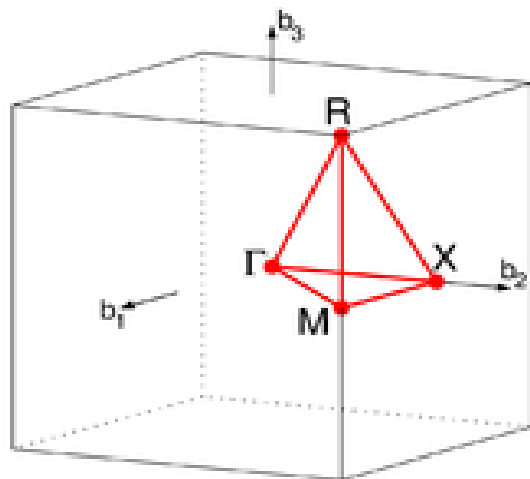
There are also second, third, *etc.*, Brillouin zones, corresponding to a sequence of disjoint regions (all with the same volume) at increasing distances from the origin, but these are used less frequently. As a result, the *first* Brillouin zone is often called simply the *Brillouin zone*. (In general, the  $n$ -th Brillouin zone consists of the set of points that can be reached from the origin by crossing exactly  $n - 1$  distinct Bragg planes.)



### **Critical point**

Several points of high symmetry are of special interest – these are called critical point.

## Cubic lattice system



### Simple cube

- M Center of an edge
- R Corner point
- X Center of a face

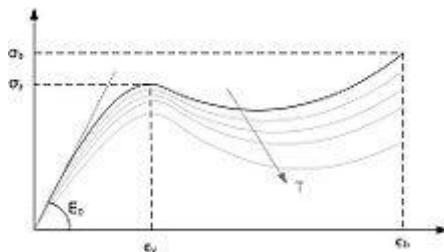
CUB path:  $\Gamma$ -X-M- $\Gamma$ -R-X|M-R

[Saityawan & Cuttarello, DOI: 10.1016/j.commatsci.2010.05.010]

## THERMOPLASTIC SMA

A **thermoplastic**, or **thermosoftening plastic**, is a plastic material, polymer, that becomes pliable or moldable above a specific temperature and solidifies upon cooling.<sup>[1][2]</sup>

Most thermoplastics have a high molecular weight. The polymer chains associate through intermolecular forces, which weaken rapidly with increased temperature, yielding a viscous liquid. Thus, thermoplastics may be reshaped by heating and are typically used to produce parts by various polymer processing techniques such as injection molding, compression molding, calendering, and extrusion.<sup>[3][4]</sup> Thermoplastics differ from thermosetting polymers, which form irreversible chemical bonds during the curing process. Thermosets do not melt, but decompose and do not reform upon cooling.



Stress-strain graph of a thermoplastic material

Above its glass transition temperature,  $T_g$ , and below its melting point,  $T_m$ , the physical properties of a thermoplastic change drastically without an associated phase change.

Some thermoplastics do not fully crystallize below the glass transition temperature  $T_g$ , retaining some or all of their amorphous characteristics. Amorphous and semi-amorphous

plastics are used when high optical clarity is necessary, as light is scattered strongly by crystallites larger than its wavelength. Amorphous and semi-amorphous plastics are less resistant to chemical attack and environmental stress cracking because they lack a crystalline structure.

Brittleness can be decreased with the addition of plasticizers, which increases the mobility of amorphous chain segments to effectively lower  $T_g$ . Modification of the polymer through copolymerization or through the addition of non-reactive side chains to monomers before polymerization can also lower  $T_g$ . Before these techniques were employed, plastic automobile parts would often crack when exposed to cold temperatures.

## **Uses of Thermoplastics**

### **Polyvinyl chloride**

Polyvinyl chloride (PVC) is a tough, lightweight material that is resistant to acids and bases. Much of it is used by the construction industry, such as for vinyl siding, drainpipes, gutters and roofing sheets. It is also converted to flexible forms with the addition of plasticizers, thereby making it useful for items such as hoses, tubing, electrical insulation, coats, jackets and upholstery. Flexible PVC is also used in inflatable products, such as water beds and pool toys.

### **Teflon**

Teflon is the brand name given by DuPont Corp. for a polymer called polytetrafluoroethylene (PTFE), which belongs to a class of thermoplastics known as fluoropolymers. It is famous as a coating for non-stick cookware. Being chemically inert, it is used in making containers and pipes that come in contact with reactive chemicals. It is also used as a lubricant to reduce wear from friction between sliding parts, such as gears, bearings and bushings.etc.,

## **BOHR ATOM MODEL**

Bohr developed his theory of atomic structure by retaining the two essential features of Rutherford's planetary model i.e.,

- (i) The atom consists of a central positively charged hard core called the nucleus and
- (ii) The electrons revolving round their nucleus in circular orbit the outward centrifugal force is balanced by the net electrostatic attraction towards the nucleus. However using the planck's quantum theory, Bohr made the following assumption
- (iii) He assumed that an electron in the field of nucleus is not capable of moving along each of the paths that were possible on the basis of classical theory but the electron can move along are the discrete sets of allowed paths. Only those orbits are possible for which the orbital angular momentum of the electron is equal to an integral multiple of  $h/2\pi$ .

As the momentum of revolving electron is  $mv$  and its moment about then nucleus is  $mvr$ , hence

$$mvr = n \cdot \frac{h}{2\pi}$$

where  $n = 1, 2, 3$  for first, second, third orbits respectively and  $h$  is Planck's constant. Such orbits are known as stationary orbits.

- (iv) No energy is radiated by the electron as long as it remains in its definite or stationary orbit. Thus the permitted orbits are non-radiating paths of electrons.
- (v) The radiation of energy takes place only when an electron jumps from one permitted orbit of higher energy to another permitted orbit of lower energy. The difference of energies is radiated and must be a quantum of energy  $h\nu$  i.e.

$$E_2 - E_1 = h\nu$$

## SODIUM CHLORIDE

Sodium chloride is a compound formed from the ionic bonding of sodium and chloride. The result is a salt that is very important biologically and commercially. This article discusses sodium chloride, its properties, and its uses.

### **What Is a Salt?**

We see it on the tables of restaurants, in shakers at home, and taste it when we swim in the ocean. But what really is a salt?

**Salts** are inorganic compounds, which means they do not contain carbon and hydrogen together in one molecule. Salts form when a positively-charged atom, called a **cation**, attracts a negatively charged atom, known as an **anion**.

This positive to negative attraction is known as an **ionic bond** and is key in maintaining the chemical structure of salts. One of the most important salts in nature and biological systems is sodium chloride. Let's look at sodium chloride and discuss what makes it such a valuable salt in nature.

### **Characteristics of a Sodium Chloride**

**Sodium chloride** is formed when sodium atoms interact with chlorine atoms. When this occurs, sodium will donate an electron (which is a negatively-charged particle) to chlorine. This makes sodium slightly positive and chlorine slightly negative.

Opposite charges attract, right? So then, sodium ions will attract chloride ions and form an ionic bond. By the way, chloride is the term used to designate the anion form of chlorine. The result is a crystallized salt that has properties that are different from the two parent elements (sodium and chlorine). The chemical formula for sodium chloride is  $\text{NaCl}$ , which means that for every sodium atom present, there is exactly one chloride atom.

Sodium chloride has a molar mass of 58.44 grams per mole. It appears as a solid, clear crystal with little or no odor. As a salt, sodium chloride dissolves well in water and the ions in the crystals will separate when in solution. Have you ever added salt to a pot of boiling water, maybe to make pasta? You can see how instantly the little crystals dissolve, or break apart in the water.

Sodium chloride molecules can also stack on top of each other in a structure known as a lattice and the solid crystals of sodium chloride will contain this lattice-type arrangement.

### **Commercial Uses of Sodium Chloride**

Sodium chloride can be used in many commercial products as well as in public works projects. For example, whenever the temperature drops close to freezing, sodium chloride is often used to prevent ice buildup on the roads and bridges in order to preserve safe driving conditions. Sodium chloride is also used in the production of several commercially-important metals, such as copper, steel, and aluminum. Other uses of sodium chloride include glass production, rubber production, and hardening of soil during construction.

### **NON – DESTRUCTIVE TESTING (NDT)**

Non – Destructive Testing means the testing of a specimen without impairing its future usefulness.

#### **Various steps involved in any NDT methods:-**

- (a) Application of a testing medium.
- (b) Modification of the testing medium by defects.
- (c) Detection of this modification by a suitable detector.
- (d) Converting the detector output into a suitable form.
- (e) Interpretation of the information obtained.

#### **Various NDT methods:-**

- (a) X – Ray Radiographic technique
- (b) X – Ray Fluoroscopy technique
- (c) Liquid penetrant method
- (d) Ultrasonic flaw detector method
- (e) Ultrasonic scanning

## PHOTO ELECTRIC EFFECT

Whenever light or electromagnetic radiations such as X-rays, ultraviolet rays falls on a metal surface, it emits electrons.

The process of emission of electrons from a metal plate when illuminated by the light of suitable wavelength is called the photoelectric effect.

The electrons emitted are known as the photoelectrons as they are emitted by the action of light. The resulting current is known as photo –electric current.

### Experimental verification of photoelectric effect:-

Photo electric effect can be easily studied with the help of the apparatus shown in Fig.

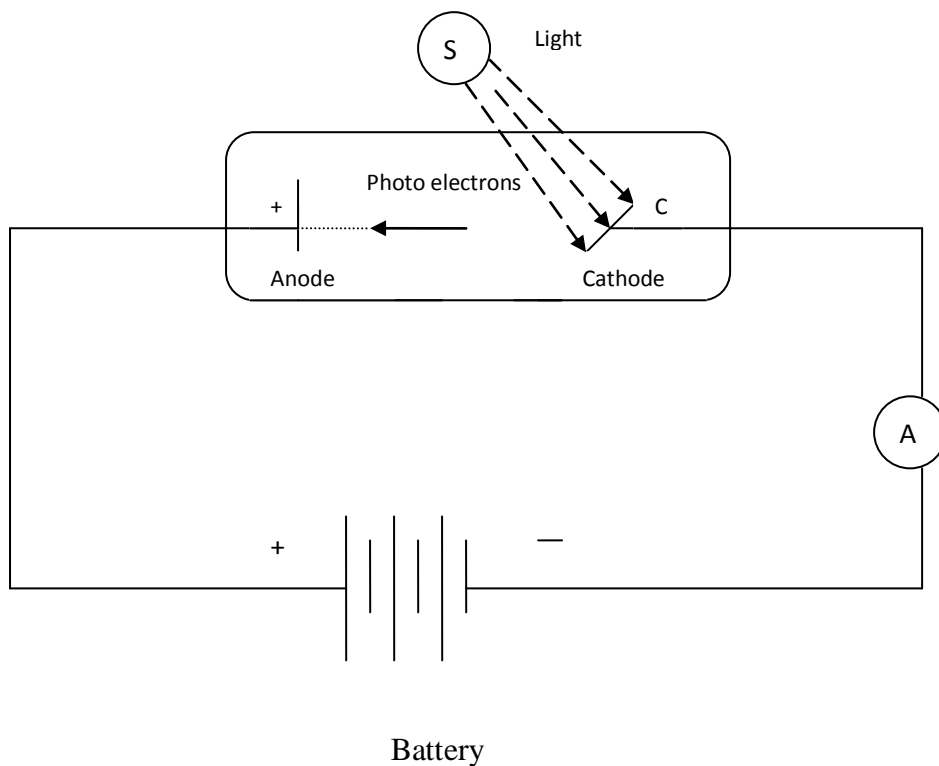


Figure – Photo electric effect

It consists of a photo sensitive plate C (called cathode) and another metal plate A (called anode) enclosed in an evacuated quartz tube.

The following observations is made

1. In the absence of light, there is no flow of current in the circuit and the ammeter A reads zero
2. When the light of suitable wavelength from a source falls on the surface of Cathode C, electrons are emitted from the cathode. These photo electrons are immediately attracted by the positive anode (collector plate) thereby constituting current in the circuit as indicated by ammeter.

### **Applications of the Photoelectric Effect**

#### **Automatic Doors**

Many elevators and garage-door systems use a beam of light and a photoelectric device known as a *photocell* as a safety feature. As long as the beam of light strikes the photocell, the photoelectric effect generates enough ejected electrons to produce a detectable electric current. (Walker, 988) When the light beam is blocked (by a person) the electric current is interrupted and the doors are signaled to open.

#### **Solar Energy Panels**

Photocells are also the basic unit in the solar energy panels that convert some of the energy in sunlight into electrical energy. These panels are able to operate billboards and safety lights in remote areas far from power lines (Walker, 988). Large solar panels (240 ft.) will power the International Space Station.

#### **Others that use a Photocell**

- Television Camera Tubes
- Light-Activated Counters
- Automatic Doors
- Intrusion Alarms
- Turn on Street Lights at Dawn

#### **Others that use Solar Energy**

- Pocket Calculators
- Turn on Safety Lights

### **DIFFERENT TYPES OF CRYSTAL GROWTH TECHNIQUES**

What is meant by crystal growth?

Crystal growth is a major stage of a crystallization process, and consists in the addition of new atoms, ions, or polymer strings into the characteristic arrangement of a crystalline Bravais lattice.

How a crystal is formed?

When solutions are completely saturated with mineral components, crystals can begin to form on rock walls, on other crystals, or even on particles of dust. They can grow quickly

or slowly — or even stop — depending on changes in temperature and the concentration of the solution.

What is nucleation and crystal growth?

Nucleation, the initial process that occurs in the formation of a crystal from a solution, a liquid, or a vapour, in which a small number of ions, atoms, or molecules become arranged in a pattern characteristic of a crystalline solid, forming a site upon which additional particles are deposited as the crystal grows.

What is the crystallization method?

Crystallization is also a chemical solid–liquid separation technique, in which mass transfer of a solute from the liquid solution to a pure solid crystalline phase occurs. In chemical engineering crystallization occurs in a crystallizer.

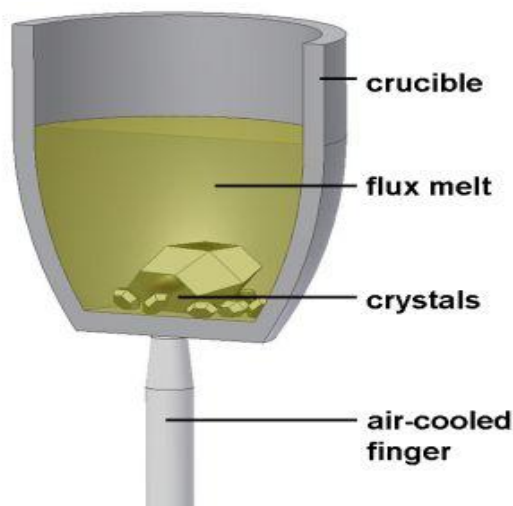
### **Slow cooling bottom growth (without seed)**

Solution growth techniques are often applied to fabricate high-quality single crystals which cannot be grown from their own melts. Depending on the particular crystal class aqueous solutions or flux melts (high-temperature solutions) are usually employed.

The crystal growth occurs either by spontaneous nucleation in the solution volume, at container walls and at seed rods or with the help of a seed crystal dipped into a supersaturated solution. For bulk crystal growth we use the slow cooling method. Due to local bottom cooling and the use of a suitable temperature gradient, the crystal growth occurs usually at the bottom of the crucible.

For a suitable homogenization of the solution the accelerated crucible rotation technique (ACRT) is applied during the crystallization process. This warrants a more homogeneous distribution of substituents/dopants in the entire crystal volume and the minimization of flux inclusion.

Besides single-crystalline material for commercial applications we obtain seed crystals for methods that require seeds in order to grow large single crystals (see TSSG technique).





## The "Top seeded solution growth (TSSG)" technique (with seed)

Crystallization may be accomplished with the help of seed crystals by dipping these crystals into a supersaturated solution. The procedure of the TSSG technique corresponds to that of the well-known Czochralski technique<sup>1</sup> or the Nacken-Kyropoulos technique<sup>2</sup> for melt-grown material.

The TSSG technique may be applied in two ways - the vertical temperature gradient transport method (using nutrient material) and the slow cooling method (in a supersaturated solution). The former is primarily used for compounds containing substituents or dopants while the latter is commonly used for pure compounds.

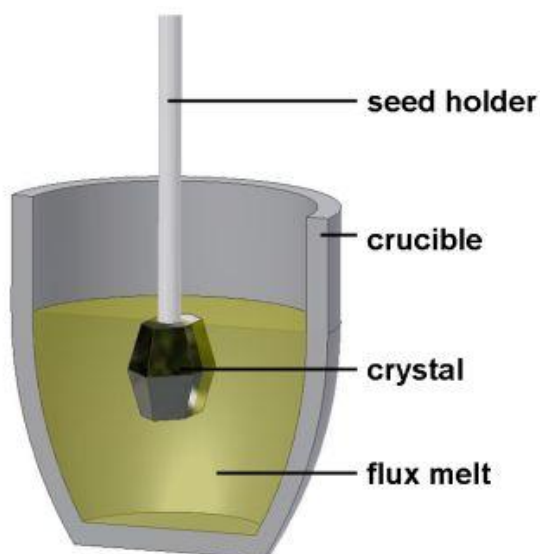
For an effective homogenization of the solution and a controlled growth process, optimized hydrodynamic conditions can be achieved by suitable seed rotation. Additionally, if the temperature gradient transport method is applied, it is necessary to pull the seed from the solution.

This method allows the growth of large, high-quality single crystals. Exposure of these crystals to any tension in the solidified solution is avoided by pulling them from the solution before the cooling process.

Usually the yield and quality of commercially applicable material obtained by TSSG crystallization is higher than that of spontaneously nucleated crystals grown by the bottom growth technique.

<sup>1</sup> Continuous pulling of the seed crystal (located on the melt surface) during the growing process

<sup>2</sup> Growth of a seed crystal dipped into the melt completely



## Liquid phase epitaxy

Liquid phase epitaxy (LPE) is an excellent method to deposit micrometer-thick films with high crystalline perfection. The epitaxial growth of dissolved solutes occurs in supersaturated solutions on preferably lattice-matched single-crystalline substrates.

For this, static or rotating substrates are immersed in supersaturated solutions until the desired film thickness is reached. Then the sample is withdrawn from the solution and remnants are removed by spin-down rotation.

Advantages of the LPE technology in contrast to deposition methods from the gas phase:

- Fast film growth with high crystalline perfection across the whole film thicknesses for layers between 1 and 500 nm thickness
- Formation of thermodynamic stable phases exhibiting ideal or nearly ideal stoichiometry
- Growth of extremely flat surfaces
- Robust and low-cost equipment

Disadvantages:

- Not suitable for film thicknesses considerably smaller than 1  $\mu\text{m}$
- Availability of lattice-matched substrates which have to be inert in the used solutions

