Type I Superconductor

- **Many of the elemental metals were found to exhibit zero dc resistance at** $T < T_c$
- **The critical temperatures of some superconducting materials, classified as type I superconductors, are given in the following Table.**

Superconductor	T_c (K)	B_c (0) in Tesla
Al	1.196	0.0105
Ga	1.083	0.0058
Hg	4.153	0.0411
In	3.408	0.0281
Nb	9.26	0.1991
Pb	7.193	0.0803
Sn	3.722	0.0305
Ta	4.47	0.0829
Ti	0.39	0.010
V	5.30	0.1023
W	0.015	0.000115
Zn	0.85	0.0054

- As we can see that, Copper (Cu), silver (Ag), and gold (Au), which are excellent conductors, do not exhibit superconductivity.

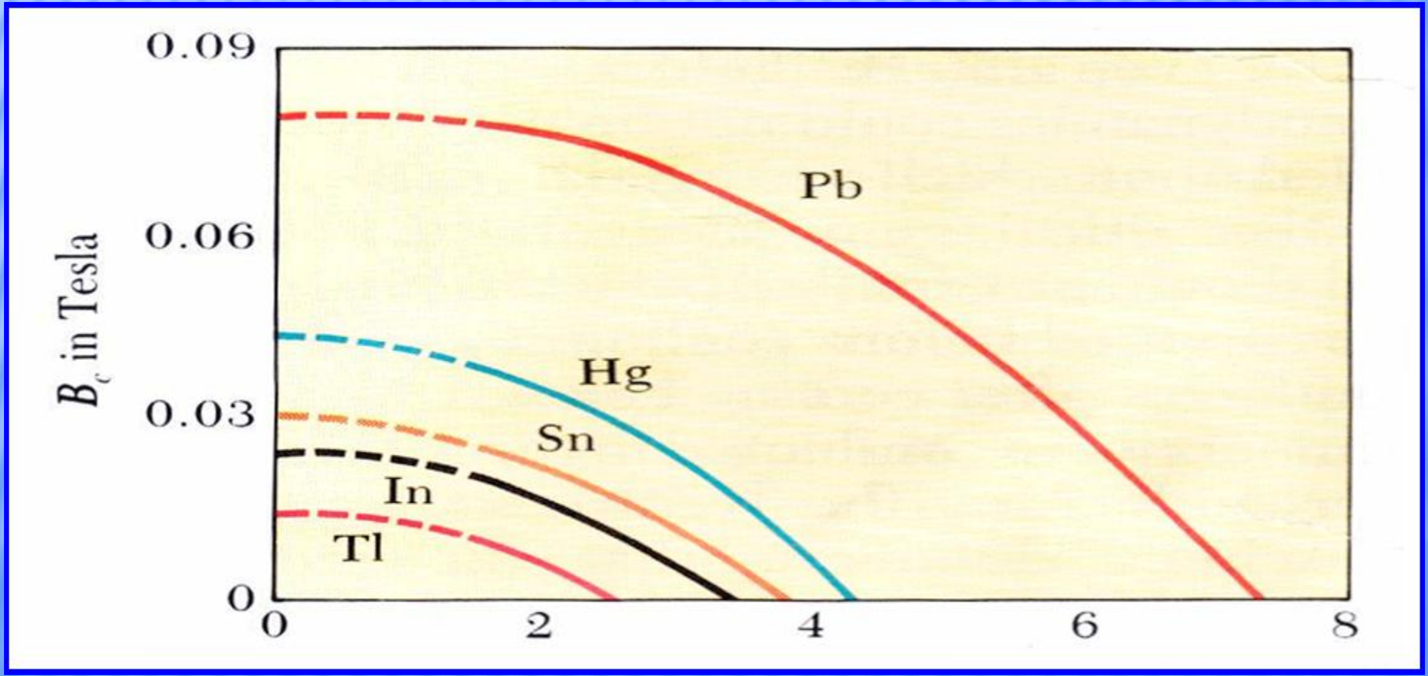
- We can also notice that, values for the critical field B_c for type I superconductors are quite low, less than 0.2 T as shown in the Table.

- For this reason, Type I superconductors cannot be used to construct high-field magnets, called superconducting magnets.

- **The critical magnetic field varies with temperature according to the following approximate expression:**

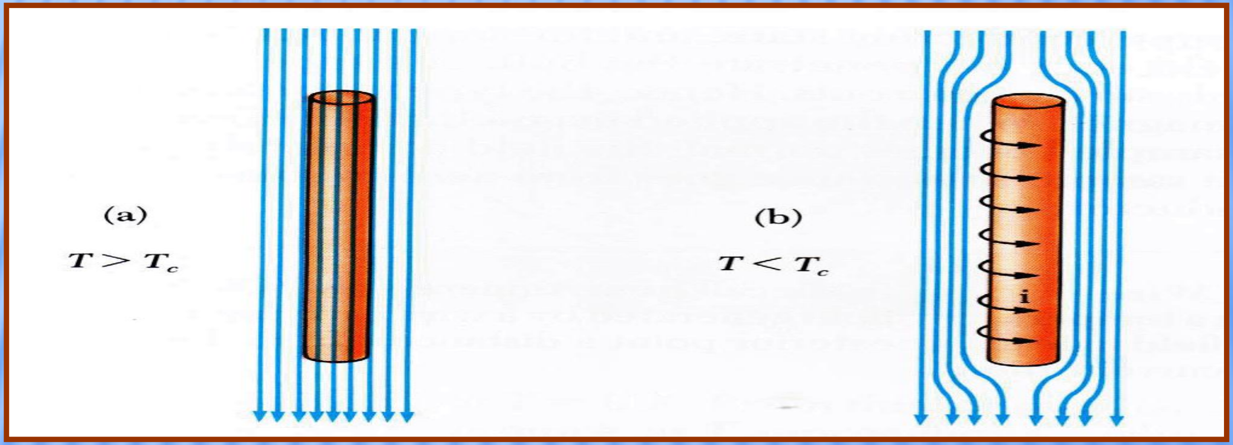
$$B_C(T) = B_C(0)\left[1 - \left(\frac{T}{T_C}\right)^2\right]$$

The value of $B_c(0)$ is found by determining B_c at some finite temperature, and extrapolating back to *0 K*, which cannot be achieved.



Magnetic properties of Type I Superconductor

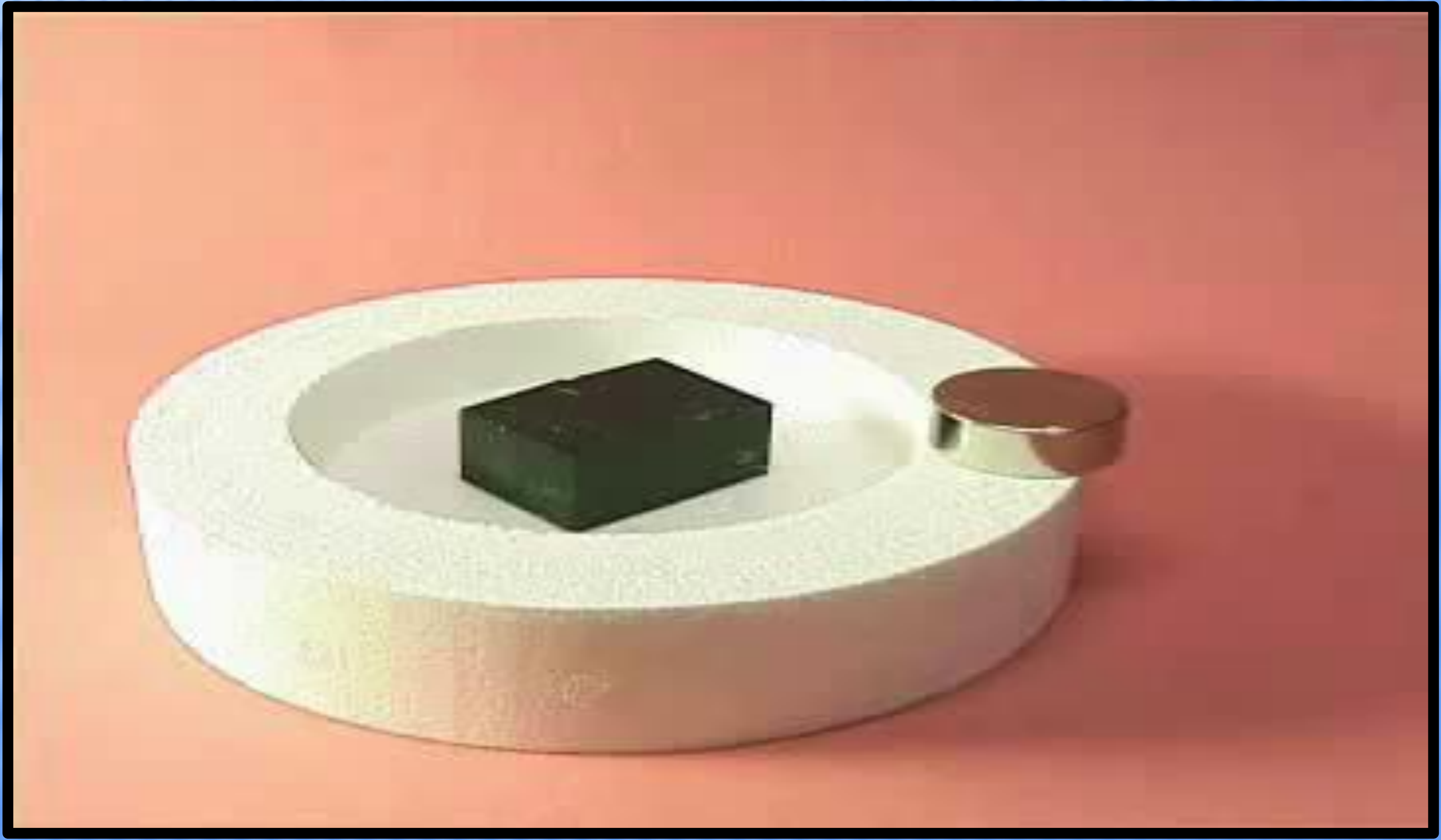
- **In 1933, Meissner and Ochsenfeld discovered that when a metal becomes superconducting in the presence of a weak magnetic field, the field lines are spontaneously expelled from the interior of the superconductor, by the induction of surface currents, so that *B = 0* everywhere interior (Meissner effect).**



- **Type I Superconductor has the important property of:**
- **Zero dc Resistance (R = 0)**
- **Perfect Diamagnet (B = 0).**

- **Demnstration of the Meissner effect is the Magnetic Levitation.**

MEISSNER EFFECT



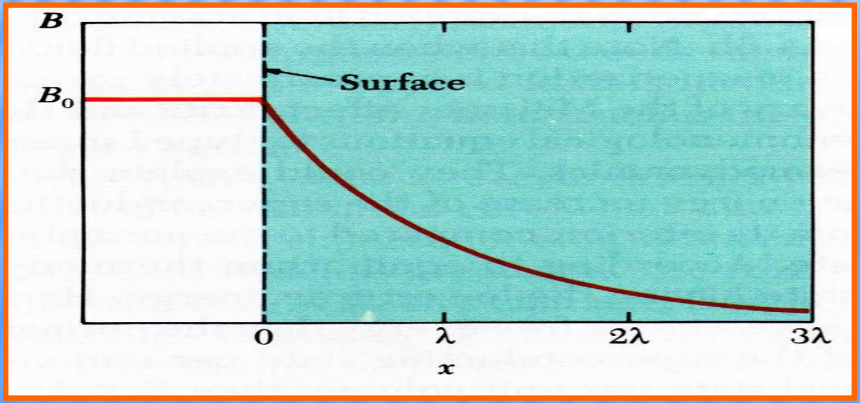
- **Penetration Depth,** due to the formation of surface currents within thin layer (10 ~ 100 nm), the magnetic field ***B*** inside a **type *I*** superconductor is:

$$B(x) = B_0 \, e^{-x/\lambda}$$

X : is the distance from the surface, and **λ :** is the penetration depth (~ 10-100 nm), **B_0 :** is the value of the magnetic field at the surface.

- **The penetration depth varies with temperature according to the empirical expression:**

$$\lambda(T) = \lambda_0 \left[1 - \left(\frac{T}{T_c} \right)^2 \right]^{-1/2}$$



λ_0 : is the penetration depth at T=0 K.

- **Magnetization,** **when a bulk sample is placed in an external magnetic field B, the sample acquires magnetization M. The magnetic field B_{in} inside the sample is:**

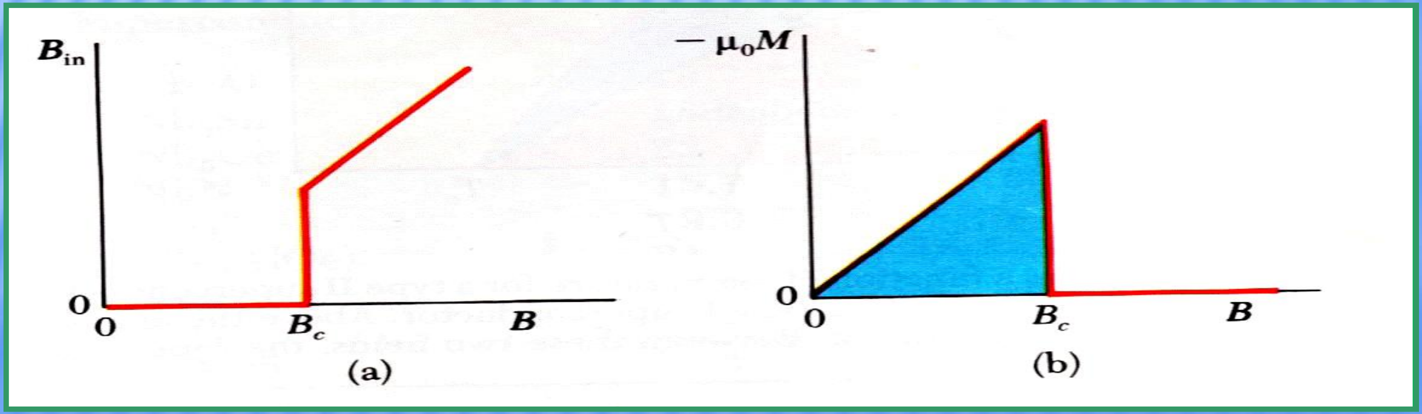
$$B_{in} = B + \mu_0 M$$

- **When the sample is in superconducting state, $B_{in} = 0$; therefore the magnetization is given by:**

$$M = -\frac{B}{\mu_0} = \chi B$$

where $\chi = -1/\mu_0$, is the magnetic susceptibility.

- **Therefore,** ***a type I superconductor exhibits perfect diamagnetism, which is an essential property of the superconducting state.***



Superconductive Elements