3.4 Identify that the use of germanium in early transistors is related to lack of ability to produce other materials of suitably purity –

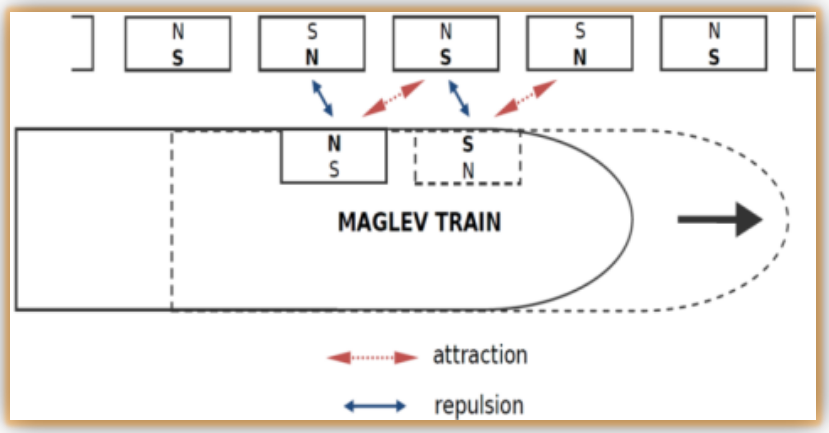
- **Transistors are semiconducting devices used to amplify or switch electric current**
- **Germanium is a metalloid & was the 1st element used in transistors as it was the only element that could be purified to the high level required for semiconductor devices**
- **But Germanium had many disadvantages:**
  i. **As it gets hot, it becomes a relatively good conductor allowing too much current to pass through components, which can damage equipment**
  ii. **It is a rare element and is thus costly and finite**
- **Silicon eventually replaced Germanium as the semiconducting material of choice in transistors as it overcame the problems in Germanium:**
  i. **Can be extracted from silicon dioxide (sand) → abundant and cheap**
  ii. **Retains its semiconducting properties at relatively high temperatures**
  iii. **Forms thin oxide layers that can be doped with impurities for use in transistor technology e.g. microchips and microprocessors**
  iv. **Techniques have been developed to produce very pure, single crystal forms of silicon that have uniform structure hence consistent properties**
  v. **Can carry a higher current for longer periods of time compared to Germanium**

Describe how superconductors and the effects of magnetic fields have been applied to develop a maglev train –

- **Maglev Trains utilise superconducting electromagnets in the train and electromagnets in the guideway track. (superconducting magnets make the B field stronger)**
- **Operation: use superconductors on the train to create a magnetic field that interacts with magnetic fields created by currents flowing in the track to levitate, control and accelerate the train (levitation and propulsion are the two concepts involved → not MIESSNER EFFECT!)**

Levitation of Train:

- **Magnets in the guideway simultaneously push and pull on those in the train to levitate it.**
- I.e. Superconducting magnets and electromagnets on track have same pole thus exert a repulsive force, enabling the levitation of the train.



Acceleration of Train:

- **Train is accelerated by a repulsion and attraction force between the train's superconducting magnet and the guideway magnets, which are powered by an AC so that their polarity changes as the train moves along.**
- I.e. as magnets on train and in front of train on the track have AC polarities, the train is attracted and pulled forward. Likewise, magnets on train and magnets behind train have same polarity, causing repulsion from the magnet behind, pushing train forward. Acceleration is achieved through changing the polarities of the magnets on the track with greater frequency.

Deceleration of Train:

- **Deceleration is achieved by reversing the polarity of the propulsion coils in the guideway to slow the train's motion. Back-up aerofoils on the top of the train, and disc brakes on the supporting wheels, can also be used to slow it.**

Advantages of Maglev Trains	Disadvantages of Maglev Trains
• **Quieter, faster, more energy efficient opposed to normal trains** ✓ **Powerful electromagnets made from Superconductors use less energy than conventional electromagnets to keep Maglev Trains suspended** ✓ **Currents can be produced and maintained with negligible heat loss** • **Less frictional drag thereby improving max. speed and minimising maintenance costs (train does not make any physical contact with the track)** • **Less air and noise pollution** • **Unaffected operation in ice and rain**	• **Superconductors require low temperatures and huge amounts of electricity are needed to produce the strong magnetic fields required → expensive to run and strong magnetic fields can damage passengers with pacemakers and magnetic storage devices** • **Low temperatures are difficult to achieve & maintain** • **Tracks are expensive to build and requires new infrastructure** • **Difficulty in integrating networks with existing systems**