Silicon versus germanium – A historical perspective

- The first transistor was made of germanium (Ge).
- However, discrete transistors soon transitioned from Ge to Si.

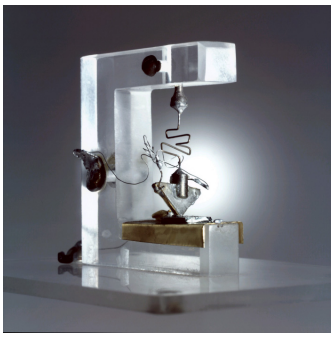
Advantages of Ge:

- Crystal growth possible at lower temperatures.
- Substantially higher electron and hole mobility indicating potential for higher-speed devices.

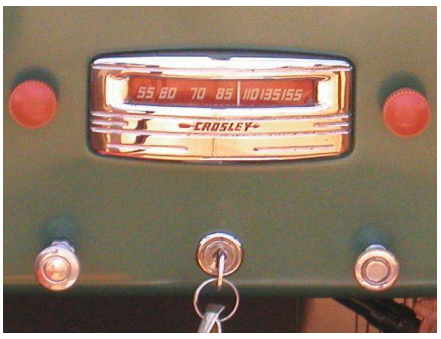
Advantages of Si:

- Stable and strong material with same crystal structure as diamond.
- Excellent oxide (SiO_2). Thermal oxide forms an excellent interface with Si; the interface has a very low interface-state density (~ 10^{10} cm^{-2} eV^{-1}). Note that *deposited* SiO_2 does *not* produce the excellent interface that the thermal oxide forms. Also note that this advantage has less significance for FETs using high-ε_r (high k) gate dielectric materials (e.g. HfO_2).
- Si has a larger bandgap and thus becomes intrinsic at higher temperatures.
- Si is less expensive due to the greater abundance of element. The major raw material for Si wafer fabrication is *sand* and there is lots of sand (SiO_2) available.

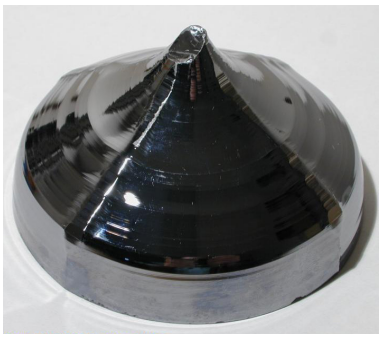
The following story illustrates as to why the transition from Ge to Si was necessary: The first transistor and the first commercial transistors were bipolar junction transistors and they were made of Ge. Motorola Corporation was a manufacturer of car radios. Motorola was one of the first companies to make transistor radios. Naturally the transistors were made of Ge. However, if a car was parked in the sun on a really hot summer day, the radio no longer worked. Why? Because Ge had become became intrinsic; this caused the n-type and p-type regions to lose their distinct properties and, as a result, the bipolar junction transistors no longer worked. This gave Motorola a strong motivation to replace Ge bipolar transistor with Si bipolar transistors.



First transistor (1948)



Early "Motorola Chrome Nose" radio



Si wafer boule