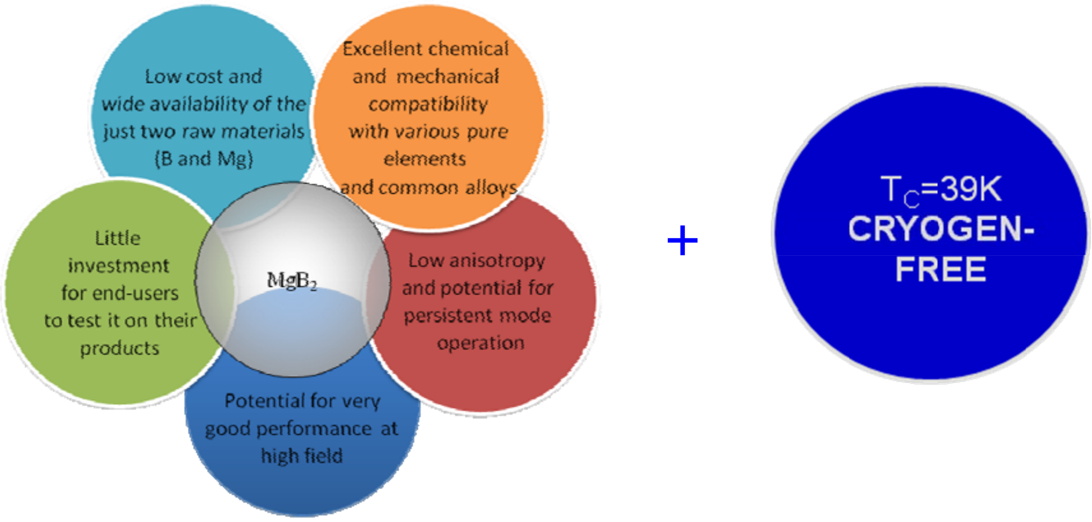
MgB_2 is the binary compound with the highest critical temperature known so far (about 39K). It is also very popular between researchers because of its peculiar ‘two-gap’ superconductivity. Although not mandatory, MgB_2 is usually produced by reaction of fine Magnesium and Boron powders, thoroughly mixed together and heated at a temperature around or above the melting point of pure Magnesium (> 600 °C). Following this process, the resulting MgB_2 phase presents a powderish nature, with particle size distribution related to the size of the precursors mixture, and typically lying in the range 0.1 – 10 microns. MgB_2 wires and tapes are therefore realized by means of the so-called Powder-In-Tube method (PIT).

In the PIT method, powders are packed inside a metallic tube, which is directly cold worked into long conductors, whose complexity can be adapted to the particular needs of any targeted application. Columbus Superconductors exploits the PIT production process in its *ex-situ* version, in which the metallic tube is filled with pre-reacted MgB_2 and then cold worked. It differs from PIT *in-situ*, in which the metallic tube is filled with boron and magnesium, cold worked and then heat treated in order to make the reaction between precursors possible. One of the most important advantages obtained thanks to the use of PIT ex-situ technique concerns mechanical properties of the growing out product. Columbus’ MgB_2-based conductors can be used for making winding once they have already been heat treated and this is what the superconductivity community called *react and wind* (R&W) technology. It differs from the wind & react technology, in which the conductors, because of their worse mechanical properties, have to be first winded, then the final heat treatment has to be performed o the whole winding.



Driving forces for MgB_2

MgB_2 shows a good chemical and mechanical compatibility with the large majority of the metals that can be cold worked into wires, except for Copper. Copper is usually requested to electrically and thermally protect a superconducting wire in the unlikely event of a sudden loss of the superconductivity for any technical reason. In Columbus Superconductors’ MgB_2 wires, Copper is usually present, but is not placed in direct contact to the superconductor.

The superconductivity of MgB_2 is greatly influenced by the way it is realized. In its simplest form, MgB_2 presents useful transport properties only at moderate magnetic fields (generally up to 5

Tesla). However, much better performance at higher magnetic fields can be achieved, and has been already demonstrated in MgB_2 thin films, bulk, and wires. Currently, the highest known value of critical field for MgB_2 exceeding 60 Tesla has been reached in thin films. In bulk materials and wires, critical fields in the range 20-40 Tesla have been also achieved by controlling the particle size distribution, the Carbon doping, and the nanoparticles addition. Nowadays, improved conductors are carrying critical currents of about 10’000 A/cm^2 in a magnetic field of 13 Tesla. Research is underway in a number of worldwide laboratories to study the mechanisms to further improve the properties of MgB_2 conductors at high fields.

Thanks to the higher operating temperatures, MgB_2 systems can be cooled by modern cryocooling devices, that do not require costly, problematic and hazardous use of liquid helium for cooling. This is substantial, considering that helium is a natural resource available in poor quantity and that it is already not easy to be found in the quantities necessary for scientific and industrial applications. This will be a big bottleneck to any major industrial development using superconductivity and MgB_2 can represent the major solution to that.

Considering wire costs, currently they are driven by external sheath. Replacing nickel or monel with stainless or low-carbon steel will help in dropping the cost down to the same level of NbTi when production will exceed 10000 km/year (NbTi: 150000 km/year).