Present status of MgB₂ wire manufacturing
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Giovanni Grasso
MgB$_2$ has opened a new frontier in the physical properties and application of SC. The limit of $T_c$ in metallic superconductors was considered equal to 30 K and this unexpected discovery of high $T_c$ in this simple binary intermetallic compound has produced a huge interest around the world, with thousands of papers published on MgB$_2$. 
Which HTS superconducting solutions are available today?

<table>
<thead>
<tr>
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<th>MgB$_2$</th>
<th>BSCCO – 1G</th>
<th>YBCO – 2G</th>
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</thead>
<tbody>
<tr>
<td><strong>Wire type</strong></td>
<td>Round wire or tape with Nickel-alloy sheath</td>
<td>Silver sheathed tape</td>
<td>Thin film on metallic substrate with biaxial texture</td>
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<tr>
<td><strong>$T_c$ (K)</strong></td>
<td>39 K</td>
<td>108 K</td>
<td>90 K</td>
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<tr>
<td><strong>Current carrying capability at 20 K</strong></td>
<td>$\approx 1000$ A</td>
<td>$\approx 1000$ A</td>
<td>$\approx 1000$ A</td>
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<tr>
<td><strong>Superconducting splices</strong></td>
<td>YES</td>
<td>NO</td>
<td>NOT YET</td>
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<tr>
<td><strong>Low cost (&lt;6 €/m)</strong></td>
<td>YES</td>
<td>NO</td>
<td>NOT YET (not likely within 5 years)</td>
</tr>
<tr>
<td><strong>Long length (&gt;6 Km)</strong></td>
<td>YES</td>
<td>NO</td>
<td>NOT YET (likely within 5 years)</td>
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</table>
Columbus has been founded in 2003 as a start-up originated from the Italian National Research Council (CNR)

- The actual plant is fully operational for MgB$_2$ wire production and is completing scaling up
- MgB$_2$ compound production is now also fully implemented
- Wire unit length today up to 2-4 Km in a single piece -length
- It is scaled up to 20 Km together with the full scale up of the plant with capacity exceeding 4’000 Km/year
- Columbus MgB$_2$ production for MRI has exceeded 700 Km of fully tested and qualified wires
- Total plant area 4’400 m$^2$ after being increased by further 1’000 m$^2$ in September 2012 - 40 employees today
Columbus Superconductors plant

- 39 new machines
- 15 existing machines will be still used over 21,
- 10 main upgrades to the technical infrastructures
- 1 new 2 floors building
- 2.280 m² of covered workshop area
- 20 direct production units
• SEM with EDX
• very fast XRD
• Laser particle size analyzer
• Eddy currents defect detector
• Optical stereomicroscopes
• Laser wire size and shape online monitor
• Industrial video cameras for surface defect detection
• Additional cryo-free critical current testing system under construction
Production Process

**Chemical Phase**

- **Mixing**
- **Synthesis**
  - 700-1000°C in Ar
- **MgB$_2$**
- **Planetary Ball Milling**

**Metallurgical Phase**

- **Tube Filling**
- **Drawing**
- **Cold rolling**
- **Sintering**
  - 900-1000°C in Ar

**Materials**

- **B** 95-97% pure
- **Mg** 99% pure

Columbus Superconductors
There are 3 different wire formats: Round, Flat and Sandwich

**Flat tape**

- The flat tape architecture has been the work-horse for Columbus in the past years and it has been the preliminary choice of our customers to start to understand the potential of our material
- Flat tape conductor is mainly used in small bore magnets and low current devices

**Sandwich conductor**

- This architecture is our solution for future magnet and winding applications
- It allows the maximum flexibility in the control of the wire absolute performance and in the amount of Cu stabilization
- Being the Cu stabilizer not subjected to the thermomechanical treatment of the MgB$_2$ conductor, it’s soldered to it in its optimal mechanical and electrical condition

**Round wire**

- MgB$_2$ is currently the only no low-Tc superconductor that can be easily produced in round wire shape with significant transport properties, multifilamentary structure and excellent reliability over long lengths
- Round wires present several advantages, particularly concerning easier solenoid and more complex magnet winding, and absence of anisotropy
Outer sheath of Monel 400 surrounding 37 MgB2 filaments protected by a Nb barrier and embedded in a Ni 201 alloy matrix

The unit piece is already 3.5 Km.
The scaling up will lead to a 20 Km unit piece length
MROpen has been developed employing the flat tape architecture.

- Unique fully dry superconducting MRI system currently on the market.
- Based on Columbus MgB$_2$ technology.
- Unique superconducting open-sky MRI system currently on the market.
- Very attractive because of its features (scanning with/no load, children, no claustrophobia, very easy installation and running, ..).
- More than a dozen systems produced so far.
- Also highly suitable for remote installation because electricity is the only requirement to setup/start/run the system – not suffering from scattered power outages because of large heat capacity.

First commercial systems already installed and fully operational in hospitals and private clinics in EU and North America.
Superconducting Generators

• could offer several cost and reliability improvements over conventional wind turbine drivetrains when scaled up to high capacity (5 MW and larger) and when used in direct drive systems: they do not require a gearbox

• less mass and less volume than conventional as well as PM generators, resulting in an overall reduction in turbine capital costs

• cost advantages produced by such weight savings are most likely to be realized initially in large turbines

• should increase drivetrain reliability by allowing a larger air gap tolerance between rotor and stator as compared to PM generators

• hold the potential of providing high torques in a smaller size and with smaller weight than conventional technologies

10 MW power:
150 tons MgB$_2$ generator
300 tons for PM and
500+ tons for conventional
• MgB₂ development and production is progressing well
• We believe that MgB₂ cables will represent a very important development for our products
• Dedicated MRI projects are ongoing in several countries
• Total body MRI companies are also starting the implementation of MgB₂ in future commercial systems in order to move to cryogenic-free systems
• New industrial products and research related applications will further help to boost MgB₂ production
Thanks for your attention