



## 2013 North American Superconductor Technology for MRI Technology Innovation Award



FROST & SULLIVAN



50 Years of Growth, Innovation & Leadership

## **Technology Innovation Leadership Award Superconductor Technology for MRI North America, 2013**

### **Frost & Sullivan's Global Research Platform**

Frost & Sullivan is in its 50th year in business with a global research organization of 1,800 analysts and consultants who monitor more than 300 industries and 250,000 companies. The company's research philosophy originates with the CEO's 360-Degree Perspective™, which serves as the foundation of its TEAM Research™ methodology. This unique approach enables us to determine how best-in-class companies worldwide manage growth, innovation and leadership. Based on the findings of this Best Practices research, Frost & Sullivan is proud to present the 2013 North American Technology Innovation Leadership Award in superconductor technology for MRI to Cutting Edge Superconductors, Inc.

### **Significance of the Technology Innovation Leadership Award**

#### **Key Industry Challenges Addressed by Cutting Edge Superconductors, Inc.'s superconductor technology for MRI**

Magnetic resonance imaging (MRI) can be defined as an imaging technology that employs superconducting magnets to produce the image. The quality of the image depends directly on the strength of the magnetic field. MRI is an important technique in medical diagnosis, but its application faces the following challenges:

- High cost: previous techniques of MRI involved superconducting technology based on niobium-titanium (NbTi), which necessitates the use of liquid helium cryogen in order to operate at a very low temperature. This would result in high operation and maintenance costs, which would ultimately translate into high expenditure for the customer or patient.
- Inappropriate for claustrophobic patients: superconducting technology based on niobium-titanium involved imaging in a closed space, which is inconvenient for claustrophobic patients.
- Poor quality of image: magnesium diboride high-transition temperature superconductors have been explored and found to be quite effectual for MRI. This was found to have potential for the development of low-cost cryogen-free MRI. Magnesium diboride wires were utilized for the development of the first cryogen-free 0.5T next-generation MRI. This MRI technology addressed a significant number of challenges associated with the previous MRI technologies such as imaging in a closed space, which was inconvenient for claustrophobic patients. However, the associated magnetic field was of considerably low magnitude, i.e. 0.5T, which resulted in poor-quality images produced, since the image quality depends on the square of the

magnetic field.

- Difficulty in improving current-carrying property: enhancing the current-carrying properties of magnesium diboride wires in order to employ them for 1.5T and 3.0T MRI could be considered as one of the major challenges associated with the high-performance magnesium diboride superconducting wires.

The proprietary technology of Cutting Edge Superconductors, Inc. (CES, Inc.) addressed these challenges by adding both magnetic and nonmagnetic impurities to magnesium diboride wires. This enabled the much-required improvement of critical currents of superconducting magnesium diboride wires, thus driving high performance and industrially viable next-generation cryogen-free 1.5T and 3.0T MRI. The worldwide patented technology based on magnesium diboride superconducting, wire-enhanced next-generation MRI, would bring down the MRI scan cost by up to 40% and still provide the same quality of image as the commercialized MRI scan. This reduction in price is contributed by the cost-effectiveness of the CES, Inc. technology and its maintenance-free operation.

### **Key Benchmarking Criteria for Technology Innovation Leadership Award**

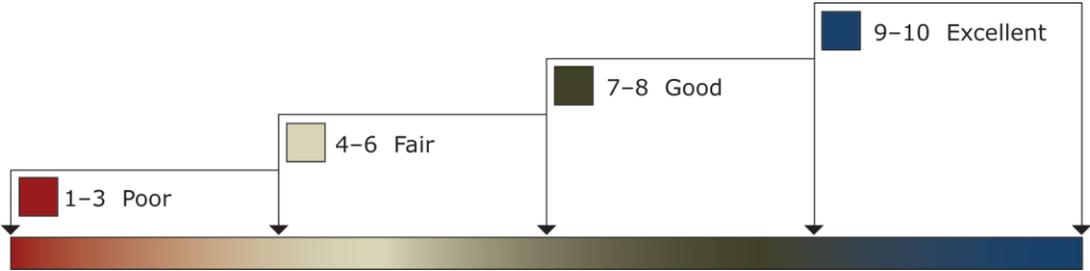
For the Technology Innovation Leadership Award, the following criteria were used to benchmark Cutting Edge Superconductors, Inc.'s performance against key competitors:

- Uniqueness of Technology
- Impact on New Products/Applications
- Impact on Functionality
- Impact on Customer Value
- Relevance of Innovation to Industry

### **Decision Support Matrix and Measurement Criteria**

To support its evaluation of best practices across multiple business performance categories, Frost & Sullivan employs a customized Decision Support Matrix (DSM). The DSM is an analytical tool that compares companies' performance relative to each other with an integration of quantitative and qualitative metrics. The DSM features criteria unique to each Award category and ranks importance by assigning weights to each criterion. The relative weighting reflects current market conditions and illustrates the associated importance of each criterion according to Frost & Sullivan. Fundamentally, each DSM is distinct for each market and Award category. The DSM allows our research and consulting teams to objectively analyze each company's performance on each criterion relative to its top competitors and assign performance ratings on that basis. The DSM follows a 10-point scale that allows for nuances in performance evaluation; ratings guidelines are shown in Chart 1.

**Chart 1: Performance-Based Ratings for Decision Support Matrix**



This exercise encompasses all criteria, leading to a weighted average ranking of each company. Researchers can then easily identify the company with the highest ranking. As a final step, the research team confirms the veracity of the model by ensuring that small changes to the ratings for a specific criterion do not lead to a significant change in the overall relative rankings of the companies.

**Chart 2: Frost & Sullivan’s 10-Step Process for Identifying Award Recipients**



**Best Practice Award Analysis for Cutting Edge Superconductors, Inc.**

The Decision Support Matrix, shown in Chart 3, illustrates the relative importance of each criterion for the Technology Innovation Leadership Award and the ratings for each company under evaluation. To remain unbiased while also protecting the interests of the other organizations reviewed, we have chosen to refer to the other key players as Competitor 1 and Competitor 2.

**Chart 3: Decision Support Matrix for Technology Innovation Leadership Award**

<i>Measurement of 1-10 (1 = lowest; 10 = highest)</i>	<b>Award Criteria</b>					
	Uniqueness of Technology	Impact on New Products/Applications	Impact on Functionality	Impact on Customer Value	Relevance of Innovation to Industry	<b>Weighted Rating</b>
<b>Relative Weight (%)</b>	<b>20%</b>	<b>20%</b>	<b>20%</b>	<b>20%</b>	<b>20%</b>	<b>100%</b>
Cutting Edge Superconductors Inc.	8.5	9.0	9.0	9.5	9.0	9.0
Competitor 1	8.0	8.0	7.0	7.5	8.0	7.7
Competitor 2	7.0	7.0	7.5	7.5	7.5	7.3

### **Criterion 1: Uniqueness of Technology**

CES, Inc. developed a proprietary technology based on magnesium diboride superconducting wire, which enabled cryogen-free 1.5T and 3.0T MRI. The technology has been developed with the help of magnesium diboride superconducting wires with innovative customizations in the chemistry of the material. The innovative material thus developed and turned into a superconducting wire that features the addition of both magnetic and nonmagnetic impurities to magnesium diboride. This improved the critical currents of superconducting magnesium diboride wires, thus enabling 1.5T and 3.0T MRI with image qualities similar to the currently available 1.5T MRI at much reduced operation and maintenance costs. This results in the reduced cost encountered by the patients, which is almost 40% of the present cost associated with MRI.

### **Criterion 2: Impact on New Products/Applications**

The innovative technology by CES, Inc. is based on utilizing magnesium diboride superconducting wires for next-generation, cost-effective, cryogen-free 1.5T and 3.0T MRI. It could be expected that this state-of-the-art technology would benefit the superconducting magnet domain, which would lead to significant developments in superconducting wires, such as magnesium diboride, niobium-titanium, and niobium-tin wires.

The technology by CES, Inc. could be expected to influence a wide spectrum of industries, such as electrical power (generation, transmission, and distribution), healthcare, defense, and many more involving applications such as high-performance cryogen-free magnets for scientific nuclear magnetic resonance (NMR), accelerators, and fusion reactors. The

technology developed by CES, Inc. could be expected to support the development of financially viable, high-quality, portable MRI.

The technology could be readily employed in applications in the military and the airport screening of potentially dangerous materials such as liquid explosives. Also, the technology would benefit small hospitals in economically unstable nations in the form of low-cost, high-quality portable MRI. Magnesium diboride superconducting wires could be utilized in power system applications such as electric power transmission, and superconducting fault current limiters and generators, as well as motors. Thus, the improved current-carrying capacity of superconductors would also benefit a range of applications across industries.

### **Criterion 3: Impact on Functionality**

The proprietary technology by CES, Inc. leads to the development of superior quality magnesium diboride bulk samples and wires, which could be employed for next-generation cryogen-free 1.5T and 3.0T MRI, which presently has been limited to only 0.5T cryogen-free MRI with the existing technical enhancements.

The patented technology of CES, Inc. revolves around the application of the new phenomena based on the effects of magnetic impurity in superconductors. The innovative concept of adding both magnetic and nonmagnetic impurities to the superconductor projects significant improvement of high magnetic field properties. This in turn opens the door to a wide spectrum of functionalities, such as converting ordinary superconductors into magnetic superconductors featuring exceptionally high field properties, thus making magnetic superconductors inimitable for magnetic applications. This could be expected to drive the superconducting magnet technology a step forward with respect to high performance and economic viability in applications such as MRI, scientific NMR, accelerators, as well as fusion reactors.

### **Criterion 4: Impact on Customer Value**

The proprietary technology by CES, Inc. based on magnesium diboride powders comprises a unique amalgamation of magnetic and nonmagnetic impurities, the influence of which brings superior and critical current properties into superconducting magnesium diboride wires. This enables high-performance, next-generation cryogen-free 1.5T and 3.0T MRI that would be much more cost-effective than the presently commercialized cryogen-free 0.5T MRI. This cryogen-free 0.5T MRI projects images of average quality as compared to 1.5T MRI, since the quality of image is directly dependent on the strength of the magnetic field. On the other hand, the present 1.5T MRI technology is cryogenic, which involves the usage of cost-intensive liquid helium, thus increasing the cost of maintenance, operation, as well as initial cost. This increase in cost is ultimately passed on to the patient who undergoes the MRI.

The next-generation cryogen-free 1.5T and 3.0T MRI technology offered by CES, Inc. promises a significant reduction in the MRI scan cost by up to 40%. This is contributed by

the financial viability and simplicity of the MRI equipment, which could be developed with the help of the innovative superconducting technology by CES, Inc. This cost-effectiveness is achieved by maintaining a higher operating temperature of 20 degrees K, with the help of a cryocooler, thus avoiding the use of expensive liquid helium. Also, the customer benefits from a maintenance-free operation with significant equipment longevity of 10 to 20 years. Alternatively, the presently available MRI employs superconducting NbTi wires that operate at a temperature of 4 degrees K, which necessitates cooling with the help of 1,700 liter of liquid helium cryogen. This makes the apparatus complex and the maintenance cost very high, in the range of about \$1 million for a lifetime of 5 to 7 years, thus affecting its affordability.

### **Criterion 5: Relevance of Innovation to Industry**

The patented technology by CES, Inc. is capable of supporting various industries such as healthcare, energy and power, defense, and many more. The technology is based on enhanced magnesium diboride superconducting wire, which could be employed to develop next-generation, cost-effective, cryogen-free 1.5T and 3.0T MRI.

MRI could be represented as a painless diagnostic procedure carried out with the help of a large magnet and radio waves, enabling physicians to visualize the internal structures of the patient's body without using X-rays, by detailed images. MRI could clearly project the difference between healthy and diseased tissue, provide important information about the brain, spine, joints, and internal organs, making early detection and treatment of disease possible. The technology by CES, Inc. is directed to improve the current-carrying capacity and thus, the magnetic field strength of the mentioned magnet. On the one hand, this makes the device more industrially viable and simple, and, on the other hand, supports the development of a range of applications across industries. The technology would bring down the cost of MRI by 40% and provide the same quality of image as compared to its presently available cryogenic counterpart. The technology has been based on improving the current-carrying properties and magnetic fields of superconducting wires, which in turn could be utilized to develop high-performance cryogen-free magnets ideal for scientific NMR, accelerators, and fusion reactors.

### **Conclusion**

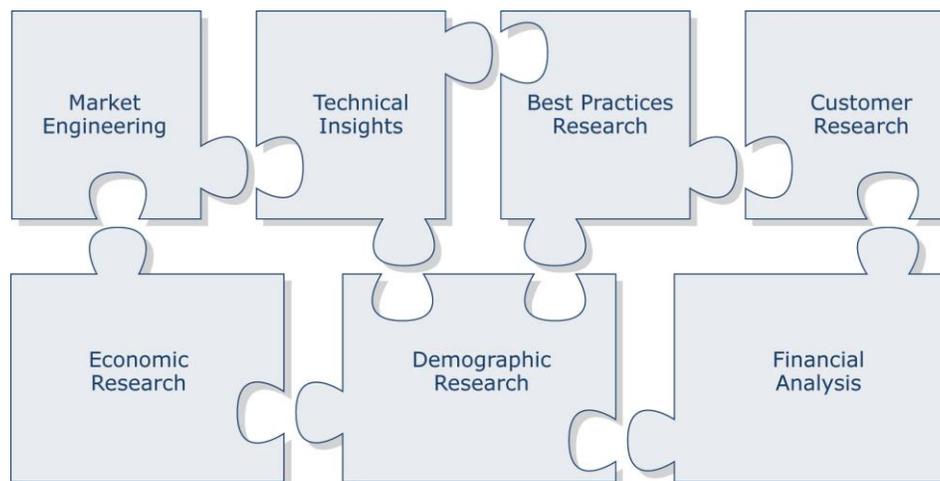
The technology developed by CES, Inc. is able to eliminate the root of challenges generally faced by modern MRI technologies (which are the cryogenic 1.5T MRI and cryogen-free 0.5T MRI). CES, Inc. improves the superconducting properties of magnesium diboride superconducting wires by improving the current-carrying capacity by a unique amalgamation of magnetic impurities in the chemical composition of the wires. This provides high-quality images similar to the presently available cryogenic 1.5T MRI and reduces the cost by 40%. Also, the technology boosts the equipment lifetime to 10 to 20 years from the present longevity of 5 to 7 years of its cryogenic counterparts and offers a hassle-free and maintenance-free operation. Last but not least, the improved

superconducting properties could be employed for the development of high-performance cryogen-free magnets ideal for scientific NMR, accelerators, and fusion reactors. Analyzing the above factors, CES, Inc. could be considered as a worthy award recipient.

### Critical Importance of TEAM Research

Frost & Sullivan's TEAM Research methodology represents the analytical rigor of our research process. It offers a 360-degree view of industry challenges, trends, and issues by integrating all seven of Frost & Sullivan's research methodologies. Our experience has shown over the years that companies too often make important growth decisions based on a narrow understanding of their environment, leading to errors of both omission and commission. Frost & Sullivan contends that successful growth strategies are founded on a thorough understanding of market, technical, economic, financial, customer, best practices, and demographic analyses. In that vein, the letters T, E, A and M reflect our core technical, economic, applied (financial and best practices) and market analyses. The integration of these research disciplines into the TEAM Research methodology provides an evaluation platform for benchmarking industry players and for creating high-potential growth strategies for our clients.

**Chart 4: Benchmarking Performance with TEAM Research**



### About Frost & Sullivan

Frost & Sullivan, the Growth Partnership Company, enables clients to accelerate growth and achieve best-in-class positions in growth, innovation and leadership. The company's Growth Partnership Service provides the CEO and the CEO's Growth Team with disciplined research and best-practice models to drive the generation, evaluation and implementation of powerful growth strategies. Frost & Sullivan leverages 50 years of experience in partnering with Global 1000 companies, emerging businesses and the investment community from more than 40 offices on six continents. To join our Growth Partnership, please visit <http://www.frost.com>.