

# Advancements in Superconductors: Promising Applications

## Research Prompt

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"What is the current state of the art in superconductors and what are the most promising applications?"

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# Search Results

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## Introduction to Superconductors

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Search terms:

- *Definition of superconductors*
- *Properties of superconductors*
- *Types of superconductors*

### Definition of superconductors

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Relevant Excerpt	Citation Source
... So let's start with the definition of superconductors and superconductivity. <b>what is a superconductor?</b> A state of the material in which it has zero resistivity is called superconductivity....	<a href="#">Superconductivity   Properties of superconductivity   Types of ... (easyelectronics.co.in)</a>

### Properties of superconductors

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Relevant Excerpt	Citation Source
... Type II superconductors can be penetrated by a magnetic field, whereas type I cannot. <b>Superconductor Properties</b> The superconducting materials exhibit some unique properties necessary for current technology....	<a href="#">Superconductor - Working, Properties, Superconductor Types, FAQs (byjus.com)</a>
The research is still going on to understand and utilise these extraordinary properties of superconductors in various fields of technology. <b>Such properties of superconductors are listed below- Zero Electric Resistance (Infinite Conductivity)</b> Meissner Effect: Expulsion of magnetic field Critical Temperature/Transition Temperature Critical Magnetic Field Persistent Currents Josephson Currents Critical Current Zero Electric Resistance or Infinite Conductivity In Superconducting state, the superconducting material shows the zero electric resistance (infinite conductivity)....	<a href="#">Properties of Superconductors   Electrical4U (electrical4u.com)</a>
... The research on these properties is still going on to utilise these properties in various fields. <b>The four most important properties of superconductors are listed</b>	<a href="#">Superconductor - Working, Properties,</a>

Relevant Excerpt	Citation Source
below: Infinite Conductivity A material has zero resistance in the superconducting state. When the temperature of the material is below the critical temperature, its resistance abruptly lowers to zero....	<a href="#">Superconductor Types, FAQs (byjus.com)</a>
... However, if you want to cool huge parts & all the transmission wires within the plant to complete zero, probably you will waste more energy. Properties of Superconductor The superconducting materials show some amazing properties which are essential for current technology. The research on these properties is still going on to recognize and utilize these properties in various fields which are listed below....	<a href="#">Superconductor : Types, Materials, Properties and Its Applications (elprocus.com)</a>
... Superconductor Properties The superconducting materials exhibit some unique properties necessary for current technology. The research on these properties is still going on to utilise these properties in various fields....	<a href="#">Superconductor - Working, Properties, Superconductor Types, FAQs (byjus.com)</a>

## Types of superconductors

Relevant Excerpt	Citation Source
... c) Type I superconductors perfectly obey the Meissner effect. d) Example of Type I superconductors: Aluminum ( $H_c = 0.0105$ Tesla), Zinc ( $H_c = 0.0054$ ) 2) Type II or Hard superconductors: The following is the definition and Properties of Type II or Hard Superconductors: a)...	<a href="#">Type I and Type II superconductors   Winner Science (winnerscience.com)</a>

# Current State of Superconductors

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- [High-Temperature Superconductors](#)
- [Novel Superconducting Materials](#)

## High-Temperature Superconductors

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Search terms:

- *Advancements in high-temperature superconductors*
- *Applications of high-temperature superconductors*

## Advancements in high-temperature superconductors

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Relevant Excerpt	Citation Source
Organized by M. Parans Paranthaman (chair), Amit Goyal, and Ron Feenstra of Oak Ridge National Laboratory, USA; Teruo Izumi of ISTE, Japan; and Venkat Selvamanickam of IGCSuperPower, USA, the international workshop presented research to 100 attendees from a group of 50 scientists from industry, national laboratories, and academia who are key players in the field of high-temperature superconductivity. <b>Major advances have been made in the last 15 years in high-temperature superconductor (HTS) research, resulting in increasing use of HTS materials in commercial and pre-commercial applications.</b> HTSs are expected to be useful for numerous electric-power applications, including transmission cables, transformers, superconducting magnetic-energy storage (SMES), current limiters, motors, and generators....	<a href="#">MRS Superconductivity Workshop Explored Issues Related to Second-Generation YBCO-Coated Conductors (semanticscholar.org)</a>
... Unfortunately, most materials must be in an extremely low energy state (very cold) in order to become superconductive. <b>Research is underway to develop compounds that become superconductive at higher temperatures.</b> Currently, an excessive amount of energy must be used in the cooling process making superconductors inefficient and uneconomical....	<a href="#">What Is A Superconductor? (uaf.edu)</a>
... Prior to this point, the understanding was that superconductivity manifested only when cooled to near absolute zero, but using an oxide of barium, lanthanum, and copper, they found that it became a superconductor at approximately 40 degrees Kelvin. <b>This initiated a race to discover materials that functioned as superconductors at much higher temperatures.</b> In the decades since, the highest temperatures that had been reached were about 133 degrees Kelvin (though you could get up to 164 degrees Kelvin if you applied a high pressure)....	<a href="#">Superconductor Definition, Types, and Uses (thoughtco.com)</a>
... The largest use of superconductors is currently for manufacturing superconducting magnets used for medical MRI machines and for scientific	<a href="#">Scientists closer to solving a</a>

Relevant Excerpt	Citation Source
applications such as particle accelerators. <b>For the potential applications of superconducting materials to be fully realized, developing superconductors that maintain their properties at higher temperatures is crucial for scientists.</b> The cuprate superconductors currently exhibit relatively high transition point temperatures and therefore give scientists an opportunity to study what makes higher temperature superconductivity possible....	<a href="#">superconducting puzzle with ... (phys.org)</a>
... Presently, excessive energy must be used in the cooling process, making superconductors uneconomical and inefficient. <b>A study is underway to design compounds that become superconductive at higher temperatures.</b> Superconductor Definition "A superconductor is defined as a substance that offers no resistance to the electric current when it becomes colder than a critical temperature....	<a href="#">Superconductor - Working, Properties, Superconductor Types, FAQs (byjus.com)</a>

## Applications of high-temperature superconductors

Relevant Excerpt	Citation Source
... Assuming the magnetic charge in the cube/ball is opposite that of the superconductor, the two repel each other. <b>How are superconductors used?</b> Superconductors have been used in, or proposed for use in, a wide variety of applications....	<a href="#">What is superconductivity? – TechTarget Definition (techtarget.com)</a>
... How are superconductors used? <b>Superconductors have been used in, or proposed for use in, a wide variety of applications.</b> Examples include high-speed magnetic-levitation trains, magnetic resonance imaging equipment, ultra-high-speed computer chips, high-capacity digital memory chips, alternative energy storage systems, radio frequency filters, radio frequency amplifiers, sensitive visible light and infrared detectors, miniaturized wireless transmitting antennas, systems to detect submarines and underwater mines and gyroscopes for earth-orbiting satellites....	<a href="#">What is superconductivity? – TechTarget Definition (techtarget.com)</a>
... The application of this has not been previously demonstrated due to the large magnetic fields required (on the order of Tesla), which for conventional technologies would demand exceptionally heavy and power-hungry electromagnets. <b>Hightemperature superconductors (HTS) have reached a level of industrial maturity sufficient for them to act as a key enabling technology for this application.</b> Thanks to superior current densities, HTS coils can offer the necessary low weight and compactness required for space applications, with the ability to generate the strong magnetic fields needed re-entry protection....	<a href="#">MAGNETOHYDRODYNAMIC ENHANCED ENTRY SYSTEM FOR SPACE TRANSPORTATION (MEESST) AS A KEY ELEMENT FOR HUMAN SPACEFLIGHT MISSIONS (semanticscholar.org)</a>
... In August 2015, a paper published in the journal Nature reported the discovery of superconductivity at a temperature of 203 degrees Kelvin when under high pressure. <b>Applications of Superconductors Superconductors are used in a variety of applications, but most notably within the structure of the Large Hadron Collider.</b> The tunnels that contain the beams of charged particles are surrounded by tubes containing powerful superconductors....	<a href="#">Superconductor Definition, Types, and Uses (thoughtco.com)</a>

# Novel Superconducting Materials

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Search terms:

- *Emerging superconducting materials*
- *Properties of novel superconductors*

## Emerging superconducting materials

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Relevant Excerpt	Citation Source
... Superconductors are characterized by the absence of any kind of resistance to the flow of electrons whatsoever. <b>Since the discovery of superconductivity, research has identified many materials that can be turned into superconductors.</b> However, the transition temperature varies for each material....	<a href="#">What is superconductivity? – TechTarget Definition (techtarget.com)</a>
... In 1986, scientists discovered a new class of copper-oxide materials that exhibited superconductivity, but at much higher temperatures than the metals and metal alloys from earlier in the century. <b>These materials are known as high-temperature superconductors.</b> While they still must be cooled, they are superconducting at much warmer temperatures-some of them at temperatures above liquid nitrogen (-321 degrees F)....	<a href="#">DOE Explains...Superconductivity   Department of Energy (energy.gov)</a>
... And that, in turn, could have implications for quantum computing and more. <b>The material is also expected to become an important tool for plumbing the secrets of unconventional superconductors.</b> This may be useful for new quantum technologies....	<a href="#">New material could be two superconductors in one   MIT News ... (mit.edu)</a>
... (Good explanations of superconductivity and the latest news about room temperature superconductors and other advances in the field). <b>Superconducting Magnets.</b> Wikipedia, The Free Encyclopedia....	<a href="#">Superconductive magnet design - Questions and Answers in MRI (mriquestions.com)</a>
... Even though a complete understanding of the quantum mechanism is yet to be discovered, scientists have found ways to enhance superconductivity (increase the critical temperature and critical current) and have discovered many new families of high-temperature superconducting materials. <b>Each new superconducting material offers scientists an opportunity to get closer to understanding how high-temperature superconductivity works and how to design new superconducting materials for advanced technological applications.</b> Superconductivity Facts Superconductivity was discovered in 1911 by Heike Kamerlingh-Onnes....	<a href="#">DOE Explains...Superconductivity   Department of Energy (energy.gov)</a>

# Superconducting Devices and Applications

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- [Superconducting Magnets](#)
- [Superconducting Electronics](#)
- [Superconducting Power Transmission](#)

## Superconducting Magnets

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Search terms:

- *Applications of superconducting magnets*
- *Superconducting magnets in medical imaging*

## Applications of superconducting magnets

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Relevant Excerpt	Citation Source
... Large scale applications of superconducting magnets became possible also thanks to the remarkable progress in cryogenics, superconducting composite industrialization, and engineering of cryogenic electrical systems. Applications of superconducting magnets include particle accelerators and detectors, fusion and energy storage (SMES), laboratory magnets, magnetic resonance imaging (MRI), high speed transportation (MagLev), electrical motors and generators, magnetic separators, etc. This paper presents the overview of practical superconducting materials, being used in various superconducting magnets, magnet designs and operation features, and the most remarkable examples of superconducting magnets....	<a href="#">Superconducting Magnets - Principles, Operation, and Applications (semanticscholar.org)</a>
... The best examples of these are NbN and Babi3. These superconductors are applicable for strong field superconducting magnets. Superconductivity Materials We know that there are a lot of materials available where some of them will superconduct....	<a href="#">Superconductor : Types, Materials, Properties and Its Applications (elprocus.com)</a>
... Superconducting technology can provide breakthroughs in spacecraft design and performance (many devices). Superconducting magnets find applications in the following areas: Magnets for nuclear fusion Magnets for high-energy physics Generators and motors Magnetically Levitated Transportation Superconducting magnets for energy storage Magnetic resonance imaging and other applications (in medicine)....	<a href="#">Superconductivity I Properties of superconductivity I Types of ... (easyelectronics.co.in)</a>
It provides an overview of materials aspects of high-temperature superconductors, combining introductory aspects, description of new physics, material aspects, and a description of the material properties This title is suitable	<a href="#">Physical Properties of High-Temperature</a>

Relevant Excerpt	Citation Source
for researchers in materials science, physics and engineering. Also for technicians interested in the applications of superconductors, e.g. as biomagnets	<a href="#">Superconductors (semanticscholar.org)</a>
These features are used in superconducting magnets to produce high fields, reduce magnet size and lower power consumption. Thanks to these features superconducting magnets are widely used in scientific research, industrial application, medicine, transportation, etc. Large scale applications of superconducting magnets became possible also thanks to the remarkable progress in cryogenics, superconducting composite industrialization, and engineering of cryogenic electrical systems....	<a href="#">Superconducting Magnets - Principles, Operation, and Applications (semanticscholar.org)</a>

## Superconducting magnets in medical imaging

Relevant Excerpt	Citation Source
... NMR imaging may well provide the first large-scale use of superconducting magnet technology by society as a whole. This paper describes the role of superconducting magnets in NMR imaging. The design criteria for superconducting magnets suitable for whole-body imaging of humans are presented....	<a href="#">THE ROLE OF SUPERCONDUCTING MAGNETS IN NMR MEDICAL IMAGING (semanticscholar.org)</a>
... Site preparation can frequently run into several \$100,000s including room radiofrequency (RF) shielding, possible magnetic shielding, floor reinforcement, vibration mitigation and a very reliable uninterruptible power supply (UPS). Superconducting magnets at 1.5 T and above allow functional brain imaging, MR spectroscopy and superior SNR and/or improved time and spatial resolution....	<a href="#">Magnets (types)   Radiology Reference Article   Radiopaedia.org (radiopaedia.org)</a>
... Technologically, wires opened whole new uses for superconductors, including wound coils to create powerful magnets. In the 1970s, scientists used superconducting magnets to generate the high magnetic fields needed for the development of magnetic resonance imaging (MRI) machines. More recently, scientists introduced superconducting magnets to guide electron beams in synchrotrons and accelerators at scientific user facilities....	<a href="#">DOE Explains...Superconductivity   Department of Energy (energy.gov)</a>
... This paper describes the role of superconducting magnets in NMR imaging. The design criteria for superconducting magnets suitable for whole-body imaging of humans are presented....	<a href="#">THE ROLE OF SUPERCONDUCTING MAGNETS IN NMR MEDICAL IMAGING (semanticscholar.org)</a>
... NMR imaging can be particularly useful for the detection of cancer and certain cardiovascular diseases. NMR imaging may well provide the first large-scale use of superconducting magnet technology by society as a whole. This paper describes the role of superconducting magnets in NMR imaging....	<a href="#">THE ROLE OF SUPERCONDUCTING MAGNETS IN NMR MEDICAL IMAGING (semanticscholar.org)</a>



# Superconducting Electronics

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Search terms:

- *Advancements in superconducting electronics*
- *Superconducting electronics in quantum computing*

## Advancements in superconducting electronics

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Relevant Excerpt	Citation Source
<p>... The researchers at KTH, together with researchers from Stanford University, TD Lee Institute in Shanghai and AIST in Tsukuba, discovered that the magnetic flux produced by vortices in a superconductor can be divided up into a wider range of values than thought. That represents a new insight into the fundamentals of superconductivity, and also potentially can be applied in superconducting electronics. A vortex of magnetic flux happens when an external magnetic field is applied to a superconductor...</p>	<p><a href="#">Quantum Electronic Vortices in Superconductors: Unprecedented ... (scitechdaily.com)</a></p>
<p>... As we traverse through this inflection point, we call for topics in this special focus on Advances in Superconducting Logic which highlight recent leaps forward in several key technological areas. These include novel circuits and architectures, materials and Josephson junctions, new superconducting logic elements and memories, as well as the development of superconducting foundries and EDA (electronic design automation) tools. We look to also capture numerous applications in addition to general purpose computing including quantum computing control and readout, neuromorphic computing, digital signal processing and special purpose processing such as hashing algorithms....</p>	<p><a href="#">Advances in Superconducting Logic - AIP Publishing LLC (aip.org)</a></p>
<p>... Superconducting technology has the inherent ability to provide devices, components, and systems that can greatly reduce overall system weight, volume, and input power. Superconducting technology can provide breakthroughs in spacecraft design and performance (many devices)...</p>	<p><a href="#">Superconductivity   Properties of superconductivity   Types of ... (easyelectronics.co.in)</a></p>

## Superconducting electronics in quantum computing

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Relevant Excerpt	Citation Source
<p>... (Image credit: Getty Images/ Thomas Barwick) "One of the most interesting applications of superconductors is for quantum computers," said Alexey Bezryadin, a condensed matter physicist at the University of Illinois at Urbana-Champaign. Because of the unique properties of electrical currents in</p>	<p><a href="#">What is a superconductor?   Live</a></p>

Relevant Excerpt	Citation Source
superconductors, they can be used to construct quantum computers. "Such computers are composed of quantum bits or qubits....	<a href="#">Science (livescience.com)</a>
... Today, superconducting magnet technology is in the mature stage: many large magnets for nuclear fusion experiments have been constructed, the superconducting magnetic resonance imaging (MRI) market is going steadily, and an experimental magnetically levitated train is under development as a commercial transportation system. Superconductivity is also entering the field of electronics....	<a href="#">Superconductivity   Properties of superconductivity   Types of ... (easyelectronics.co.in)</a>
This breakthrough discovery, involving manipulating quantum vortices, opens up new potential applications in superconducting electronics and computing. Within superconductors little tornadoes of electrons, known as quantum vortices, can occur which have important implications in superconducting applications such as quantum sensors....	<a href="#">Quantum Electronic Vortices in Superconductors: Unprecedented ... (scitechdaily.com)</a>
... In this paper, superconducting digital circuits, such as single-flux quantum and adiabatic quantum flux parametron circuits are described, that are promising candidates for this purpose. After estimating their energy consumption and speed, a conceptual overview of the superconducting electronics for controlling a multiple-qubit system is provided, as well as some of its component circuits.	<a href="#">Superconducting Digital Electronics for Controlling Quantum Computing Systems (semanticscholar.org)</a>
In this issue, we take a look at the area of superconducting electronics (SCE) and its importance to quantum computing and design. Synopsys, working in collaboration with IARPA, is on the frontline of developing tools and flows to enable the design of circuits operating near 0...	<a href="#">EDA for Superconducting Electronics and Quantum Computing ... (synopsys.com)</a>

# Superconducting Power Transmission

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Search terms:

- *Applications of superconducting power transmission*
- *Superconducting power cables*

## Superconducting power cables

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Relevant Excerpt	Citation Source
<p>... Superconducting power cables will make it possible to expand the power grid in critical areas without having to dig up half the city, says Anders Jensen, Chief Technology Officer in NKT. The superconducting power cables is extremely compact compared to conventional cable technology and can become a key enabler of the transition to renewable energy in urban areas due to the high power-to-size ratio. The SuperLink is expected to have a power rating of 500 MW and will be installed between two substations in Munich using existing ducts to keep the construction work at a minimum....</p>	<p><a href="#">NKT is developing the prototype for the world's longest ... (nkt.com)</a></p>
<p>Cities will see the biggest increase in electricity demand, so finding ways to boost urban power supplies is a priority. Superconducting cables make it possible to transmit massive amounts of electricity in a very small space, making them the perfect candidate for congested urban grids. Our market-proven superconducting cables are transforming urban power....</p>	<p><a href="#">Superconductivity - Nexans (nexans.com)</a></p>
<p>The agencies have suggested using superconducting cables for the electric transmission to reduce heat losses. The limit of critical current has reached 134 K where Hg- based ceramic materials are available that can superconduct at this temperature range....</p>	<p><a href="#">Feasibility Analysis on Cryogenic Properties of Supercritical Nitrogen to be used in the Cooling of Hg-Based High Temperature Superconductors for Electric Aircraft Propulsion (semanticsscholar.org)</a></p>
<p>... The SuperLink is expected to have a power rating of 500 MW and will be installed between two substations in Munich using existing ducts to keep the construction work at a minimum. Facts: SuperLink Superconducting power cables enable power-dense transmission carrying a large amount of electric power in a very compact cable design</p>	<p><a href="#">NKT is developing the prototype for the world's longest ... (nkt.com)</a></p>
<p>... The SuperLink is a project-based solution adapted to the needs of Stadtwerke München, and we hope to prove the commercial viability of the technology in a situation of increasing grid congestion driven by urbanization, increased</p>	<p><a href="#">NKT is developing the prototype for the</a></p>

Relevant Excerpt	Citation Source
<p>electrification and more renewable energy entering the energy mix.</p> <p>Superconducting power cables will make it possible to expand the power grid in critical areas without having to dig up half the city, says Anders Jensen, Chief Technology Officer in NKT. The superconducting power cables is extremely compact compared to conventional cable technology and can become a key enabler of the transition to renewable energy in urban areas due to the high power-to-size ratio....</p>	<p><a href="#">world's longest ... (nkt.com)</a></p>