

Legal Statement

Cu

The purpose of the information in this presentation is to guide ICA programs and provide members with information to make independent business decisions.

Antitrust Guidelines for Copper Industry Trade Association Meetings

Cu

The following guidelines with respect to compliance with antitrust laws of the United States, Japan and European Community¹ are intended to govern the conduct of participants in copper industry trade association meetings, both at the meeting itself and in informal discussions before or after the formal meeting.

Price: Competitors should not discuss future prices (including terms of sale) of their products. There is no blanket prohibition against the mention of or reference to current or past prices but limits must be observed. Such references or mentions should occur only when necessary in connection with the development of association programs. For example, reference to a particular price level in comparing the cost of a copper product to a competing product is permitted. Whenever possible, such references should be discussed in advance with legal counsel.

Competitive Information: Competitors should not discuss the market share of a particular copper producer or copper fabricator's products. Furthermore, nothing should be said at a meeting which could be interpreted as suggesting prearranged market shares for such products or producer production levels. The overall market share of copper products may be discussed with regard to competition with non-copper products and general market acceptance.

New Products: Competitors should not encourage or discourage the introduction of a new product by another competitor or reveal a particular copper company's plans to change the production rate of an existing product or to introduce a new product. No company should disclose to another company whether it is in a position to make or market a new product. New products may be discussed in a technical manner or from the standpoints of competition with non-copper products and general market acceptance. In addition, proposed methods for and results of field and laboratory testing can be considered.

The Role of Legal Counsel: Legal counsel attends association meetings to advise association staff and other meeting attendees regarding the antitrust laws and to see that none of the matters discussed or materials distributed raise even the appearance of antitrust improprieties. During the course of a meeting, if counsel believes that the discussion is turning to a sensitive or inappropriate subject, counsel will express that belief and request that the attendees return the discussion to a less sensitive area.

A paper entitled 'Copper Industry Trade Associations and Antitrust Laws' is available upon request.

10/92, 5/93, 10/10

1. Other foreign competition laws apply to International Copper Association, Ltd. (ICA)'s activities worldwide.



International Copper
Association
Copper Alliance

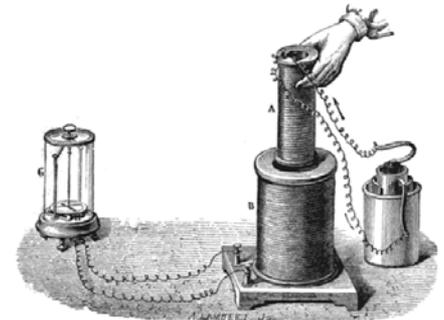
Future for super conductors and ultra-conductive copper

Hal Stillman – Director, Technology Development and Transfer

We live in an increasingly electric world

Cu

- Scientific discoveries starting in the 1820's set the stage for applications of electricity...and copper
- Our world is electrifying further – due to the expansion of renewable energy, power grids, electromobility, communications, computing, and energy storage
- And yet, at the core of these advances is understanding how electrons, those unseeable entities behaving as particles and waves, travel through metal wires
- Conductivity is essential for all applications of electricity
- Improved conductors would have lower resistance, higher ampacity, lighter weight, smaller size, insensitivity to temperature
- The quest for better conductors is continuing



Electrical conductivity and copper

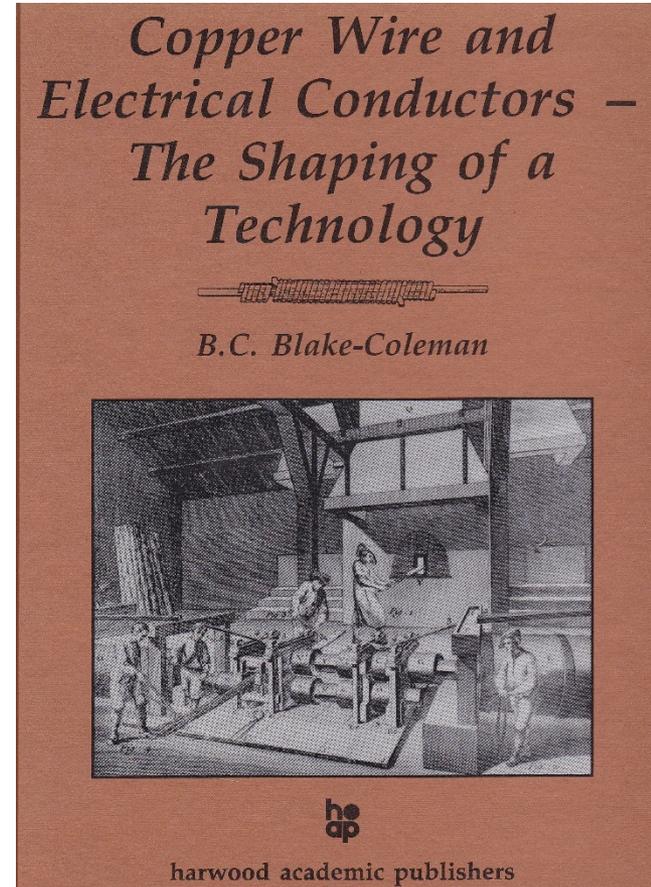
Cu

- The combination of copper's excellent electrical conductivity and physical properties has driven enormous demand for the metal
- The first electrolytically refined copper was produced in 1865
- In 1913, the International Annealed Copper Standard (IACS) was set as a method of defining the conductivity of copper wires. Copper was set at 100% at 20°C
 - Copper today reaches 103% IACS at 99.99999 purity
- Identifying copper-based materials with a higher % IACS at room temperature has the potential to significantly impact both the market and society in general
- In addition, as a metal heats up, conductance drops. Electrical equipment runs hotter than 20°C; copper is about 70% IACS at 100°C

Copper's electrical conductivity evolved through technology development

Cu

- Book examines the events which influenced the evolution of copper wire as a crucial component in electrical technology
- Describes the technological advances that improved conductivity and quality
- Explains how entrepreneurs increased copper wire production from 60 tonnes in 1865 to millions of tonnes today



Three major scientific discoveries to improve electrical conductivity

Cu

Superconductivity

- Discovered in 1911
- Zero resistance mechanism not fully understood
- Requires cryogenic temperature: liquid nitrogen cooling at -196°C ; or lower
- Copper is in superconductor materials; also for strength and circuit protection
- Major application areas: magnets, short transmission lines, special motors and generators

Carbon Nanotubes

- Discovered around 1991
- CNTs show new type of “ballistic” conduction in pure and perfect condition
- Do not mix with copper - many routes have been explored with limited success to date
- Major application area: lightweight CNT cable for electric ships and aircraft

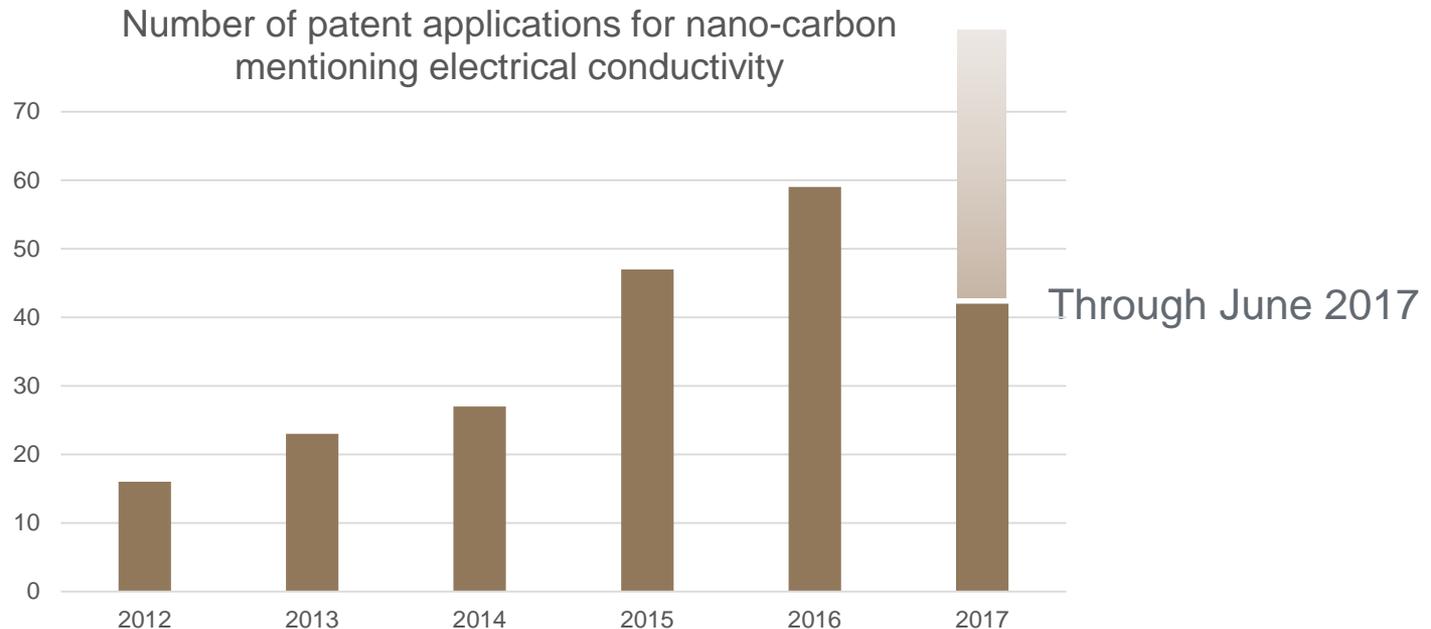
Graphene

- Discovered in 2004
- Graphene is more conductive than copper...in defect-free condition in a vacuum
- Does not mix with copper
- Major application area: research

An attractive innovation target

Cu

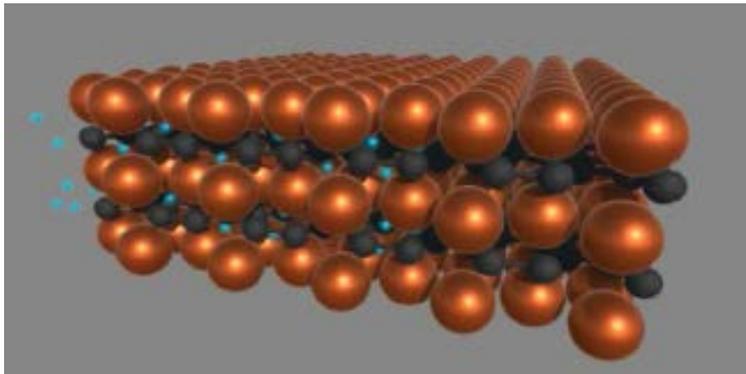
- We have noticed a global uptick in R&D and patenting concerning improvements in the conductivity of copper
- **Now reporting on two significant developments**



Copper + graphene: a potential breakthrough

Cu

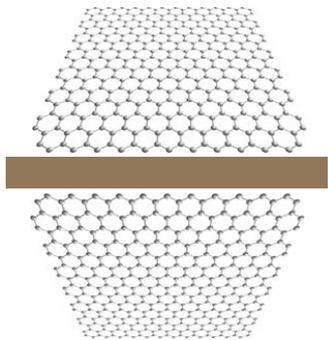
- ICA-funded research at Shanghai Jiao Tong University (SJTU) achieved a verified breakthrough performance of 116% IACS conductivity at room temperature
- A bulk material combining 99.99+% copper with graphene
- Layered copper/graphene/copper structure
- Discovery of low resistance electron-path channels



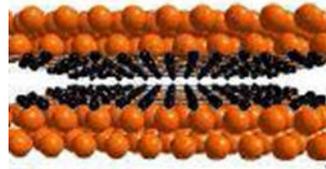
Graphene-based Ultraconductive Copper

Cu

- Electron-path channels show 100 times lower resistance than copper
- Effect only occurs in copper due to lattice matching and electron doping



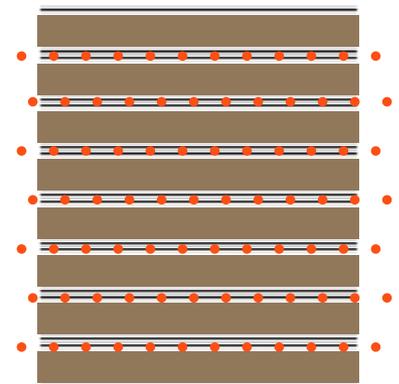
Apply graphene to copper foil...



Sandwich copper with graphene...



Stack and press layers...

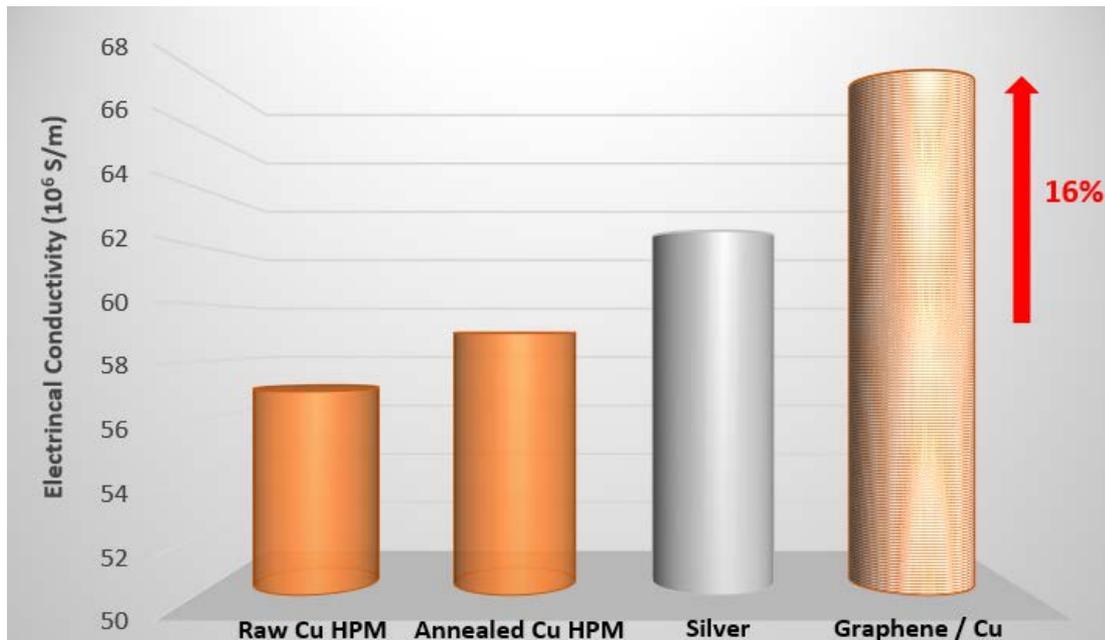


Creating electron-path channels

The most conductive bulk material ever produced

Cu

- Experimental results show dramatic increase in electrical conductivity with 6 layers

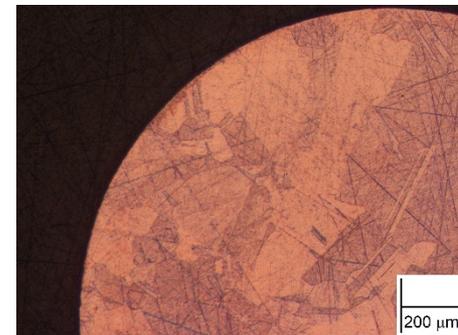


HPM = Hot Pressed Multilayer

Another UCC development

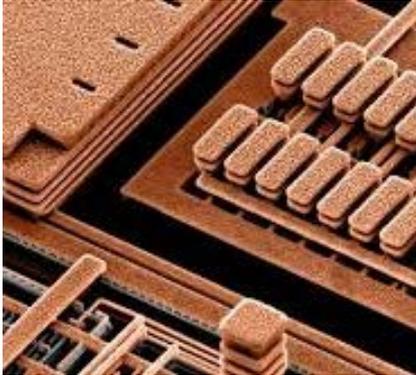
Cu

- Building on investigations funded by ICA, researchers at Ohio University have found a way to produce Cu/graphene nano-alloyed wire (12 AWG/2.05mm) with 102.9% IACS conductivity
- Wire produced with a special hot extrusion alloying process
- Probably can not match the very high performance potential of electron-path channels
- May provide a near-term production technology

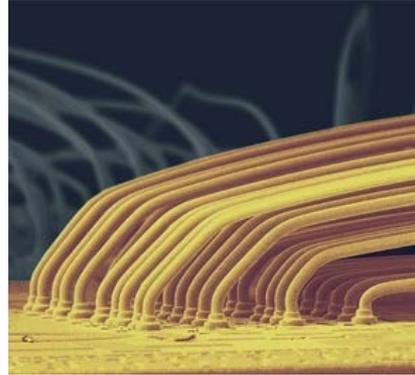


UCC technology has potential in all electrical applications

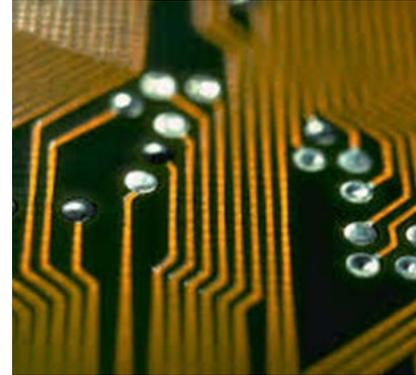
Cu



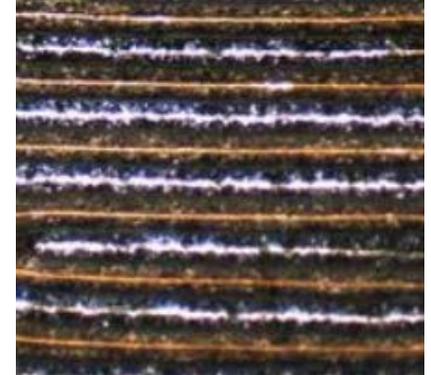
Chip-level connections



Bonding wire for lead frame to chip



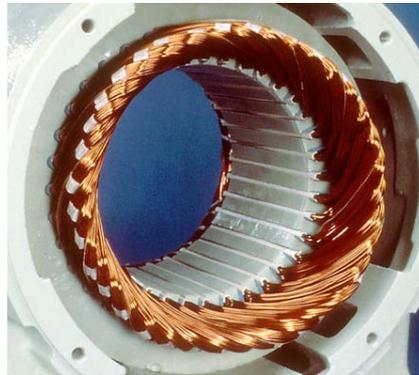
Circuit boards



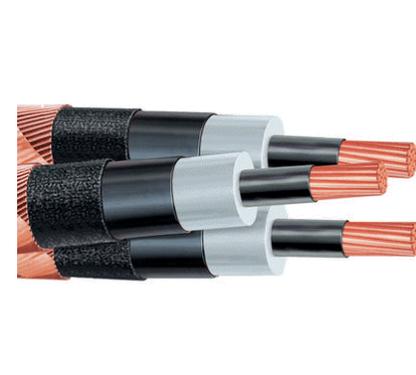
Copper foil in batteries



Data cable



Magnet wire in motor stators

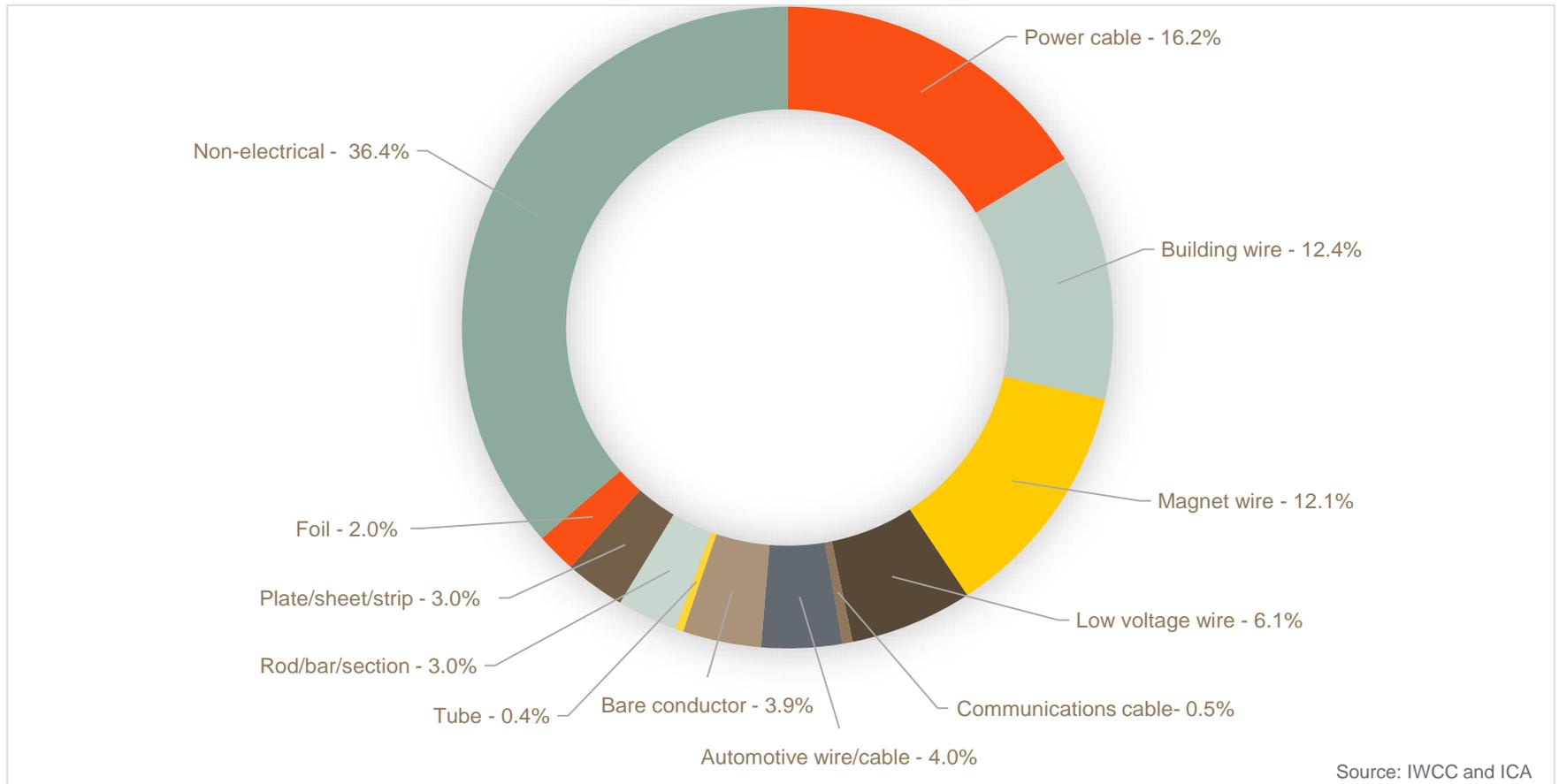


Power cable



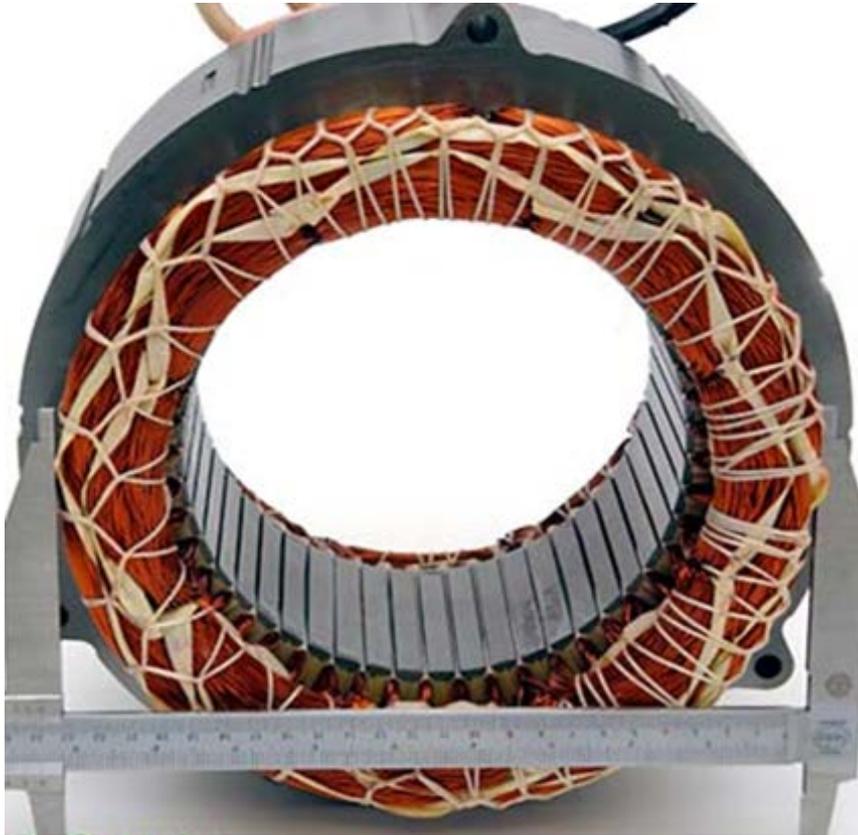
Power transmission cable

Why is this important? More than 60% of copper is used for electrical conductivity applications



Ultraconductive Copper applications: EV motor windings and small diameter cable

Cu



UCC enables lighter weight, more compact, more efficient aerospace and vehicle motors



UCC cables would deliver megawatts of power with smaller diameter and lower losses

Development path and expectations

Cu

-
- Patenting and peer-reviewed publications in progress
 - Technology will be free to apply to stimulate innovation and commercialization
 - One company currently being funded by Aurus Venture Fund (Santiago, Chile)
 - Anticipating process scale up in 3 years
 - We believe that this technology can move into commercialization and widespread deployment faster than superconductivity
 - **The ICA encourages interested parties to make contact and collaborate on further development of UCC**
 - More technical details are available at the Trends and Innovations section of www.copperalliance.org

Summing it up: Better wires for higher energy efficiency

Cu

- Researchers have developed a new class of conductive material based on combining tiny amounts of nano-carbon and copper
- Currently have recently achieved 118% IACS; **the best room temperature conductor ever recorded**
- Targeting wires with >140% IACS electrical conductivity of pure copper at room temperature; >10x may be possible
- Other properties improved: thermal conductivity, thermal coefficient of resistance
- Only works with copper due to lattice match
- **This has the potential to be a game-changing technology**

Thank you

For more information please contact
hal.stillman@copperalliance.org

Copper. Makes the world work better.



International Copper
Association
Copper Alliance