Boston, 25-30 Nov 2001
E1: New Superconductors I – MgB_2

Potential Electric Power Applications for MgB_2

Paul M. Grant
Science Fellow
EPRI

Power Device Req'mts

	T (K)	H (T)	J_c (A/cm^2)
Motors/ Generators	30	4	100,000
Transformers	30	2	80,000
Current Limiters	30	2	80,000
Cables	77	0.5	70,000

Dick Blaugher, NREL

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Nature, 1 March 2001

How was it ever missed!

Superconductivity at 39 K in magnesium diboride

Jun Nagamatsu*, Norimasa Nakagawa*, Takahiro Muranaka*, Yuji Zenitani* & Jun Akimitsu*†

* *Department of Physics, Aoyama-Gakuin University, Chitosedai, Setagaya-ku, Tokyo 157-8572, Japan*
† *CREST, Japan Science and Technology Corporation, Kawaguchi, Saitama 332-0012, Japan*

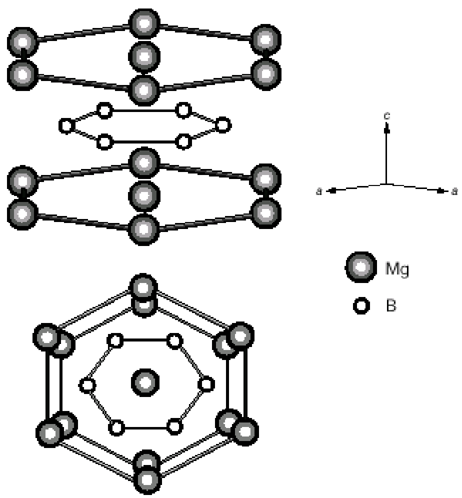

Figure 2 Crystal structure of MgB_2.

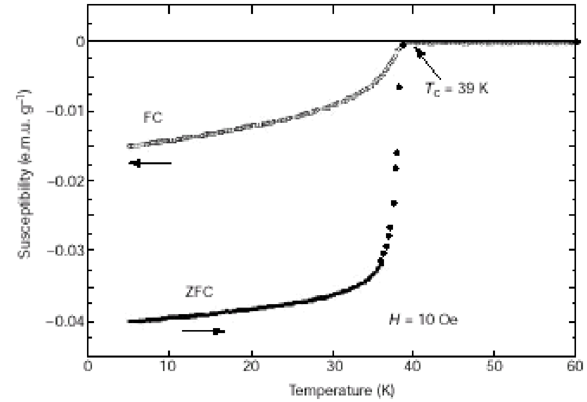

Figure 3 Magnetic susceptibility χ of MgB_2 as a function of temperature. Data are shown for measurements under conditions of zero field cooling (ZFC) and field cooling (FC) at 10 Oe.

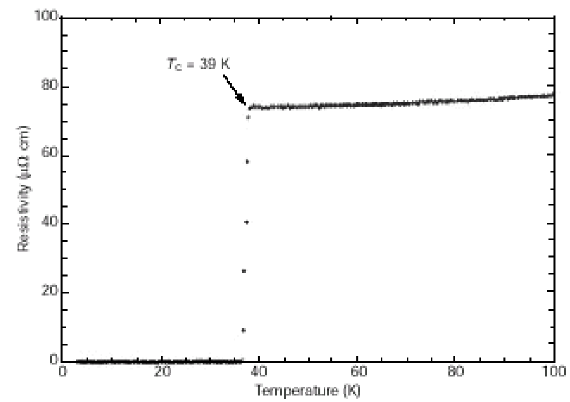

Figure 4 Temperature dependence of the resistivity of MgB_2 under zero magnetic field.

Maybe It Wasn't Missed!

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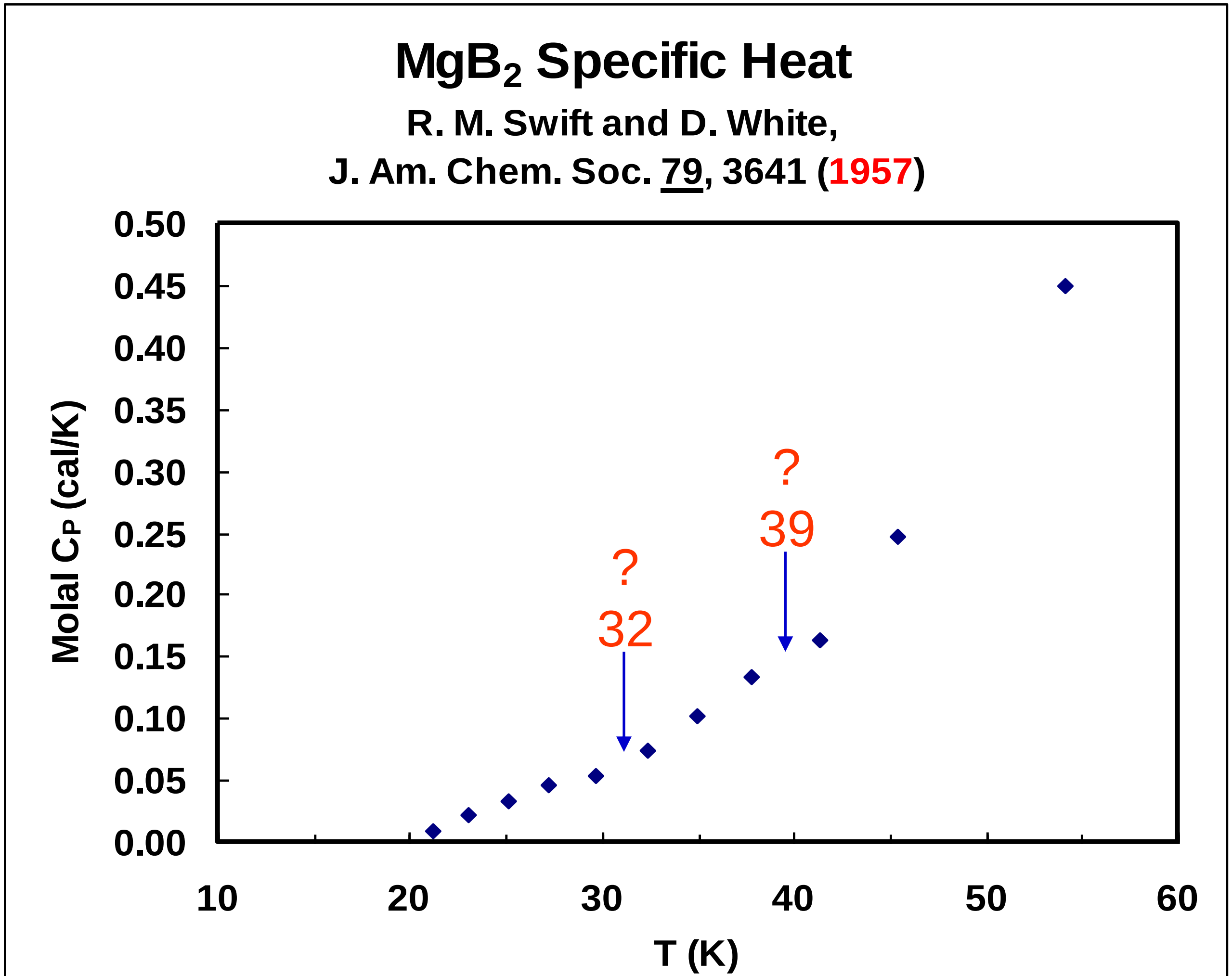

Paul M. Grant
26 November 2001

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Nature, 31 May 2001

Superconductivity

Rehearsals for prime time

Paul Grant

Superconductivity seems to have been forever waiting in the wings. Although superconducting power cables are about to go live, will the newest material, magnesium diboride, become the class act of the future?

High critical currents in iron-clad superconducting MgB_2 wires

S. Jin, H. Mavoori, C. Bower & R. B. van Dover

Agere Systems/Lucent Technologies, Murray Hill, New Jersey 07974, USA

	4.2 K	25 K
J_C @ 1 T (A/cm^2)	150,000	35,000

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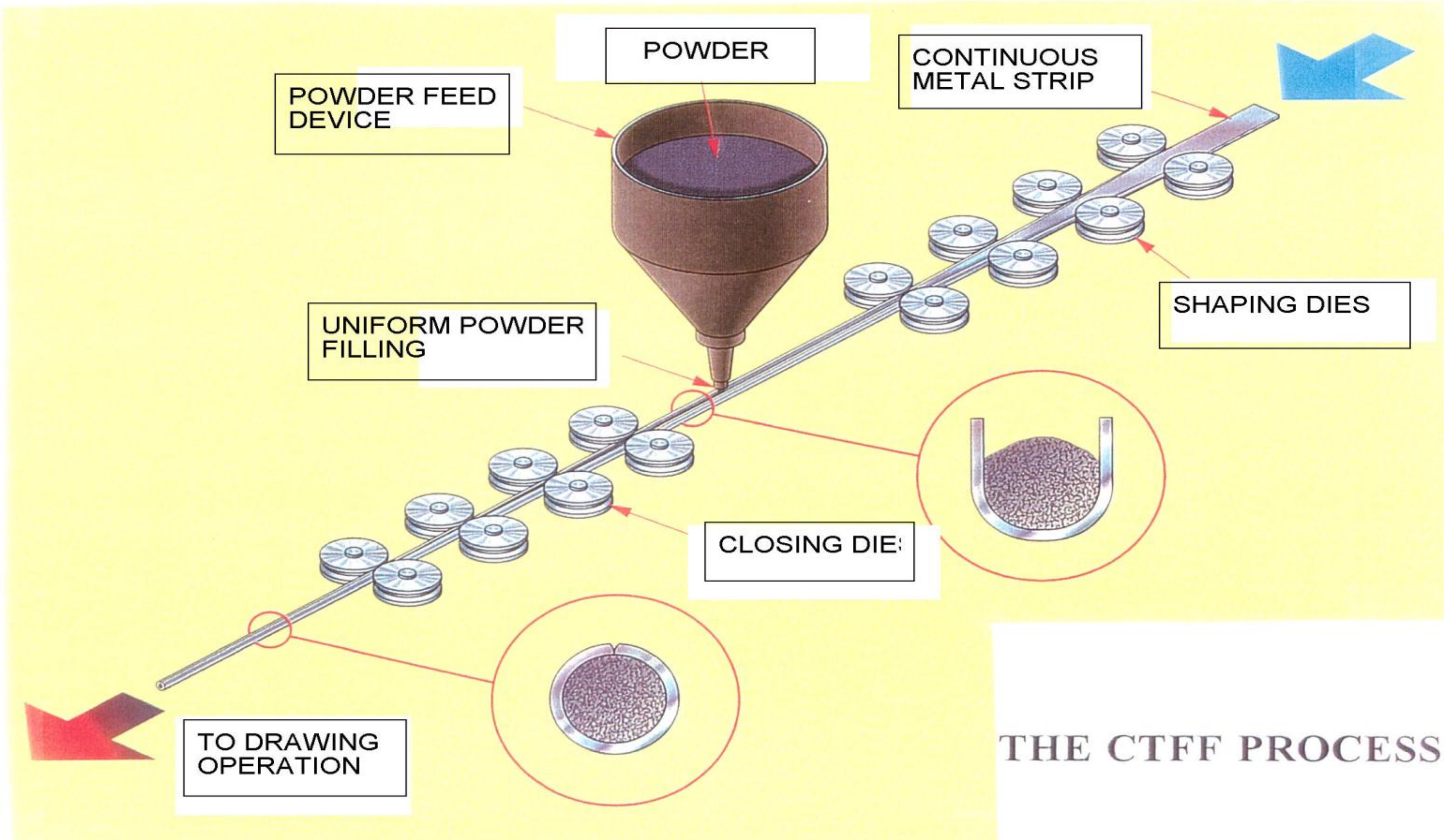
HyperTech CTFF for MgB_2

CONTINUOUS TUBE FORMING AND FILLING (CTFF)

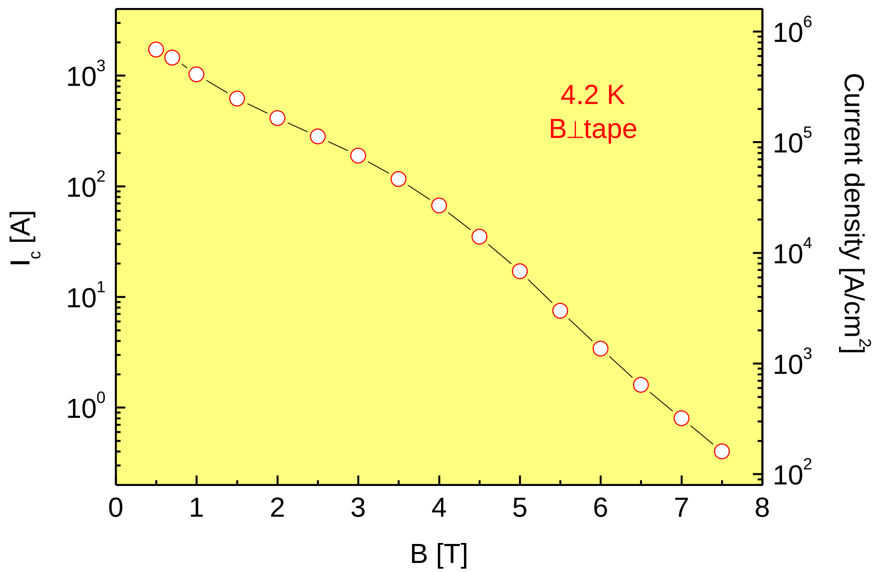


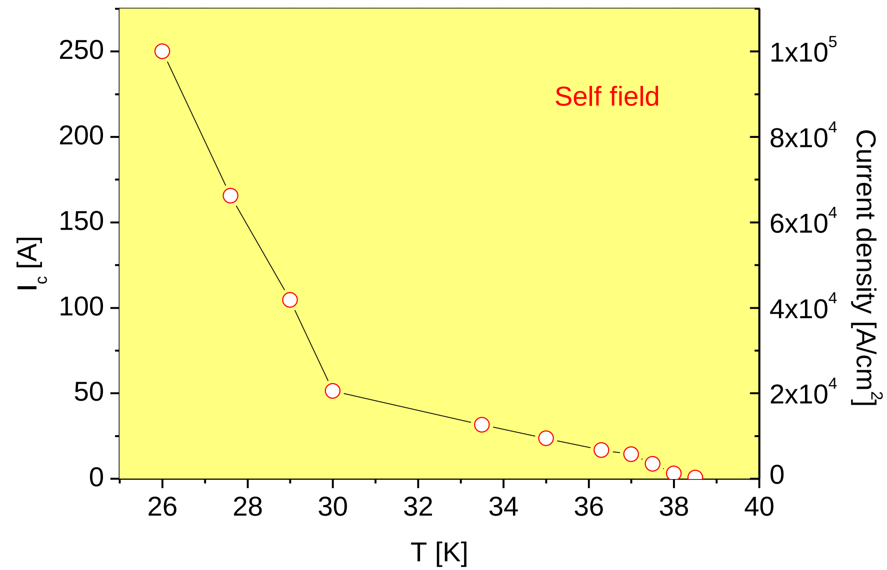
Madison, 18 July 2001

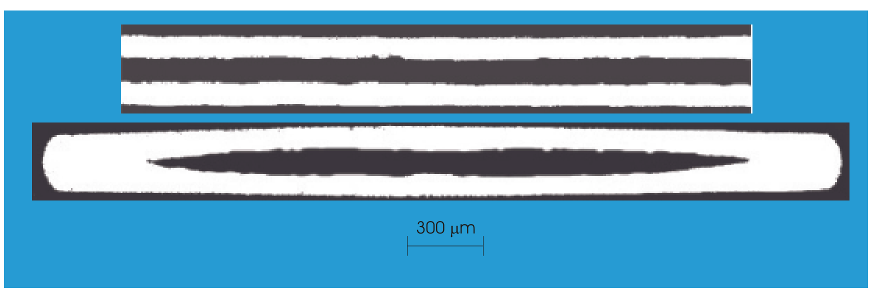
J_C @ 1 T (A/cm^2)

Group	4.2 K	25 K
Geneva	250,000	100,000
Wollengong		59,000
Karlsruhe	100,000	37,000
Grasso (10 m!)	100,000	50,000
Ames	500,000!	(200,000?)

INFM-Genova
Ni-Sheathed MgB_2 Tape



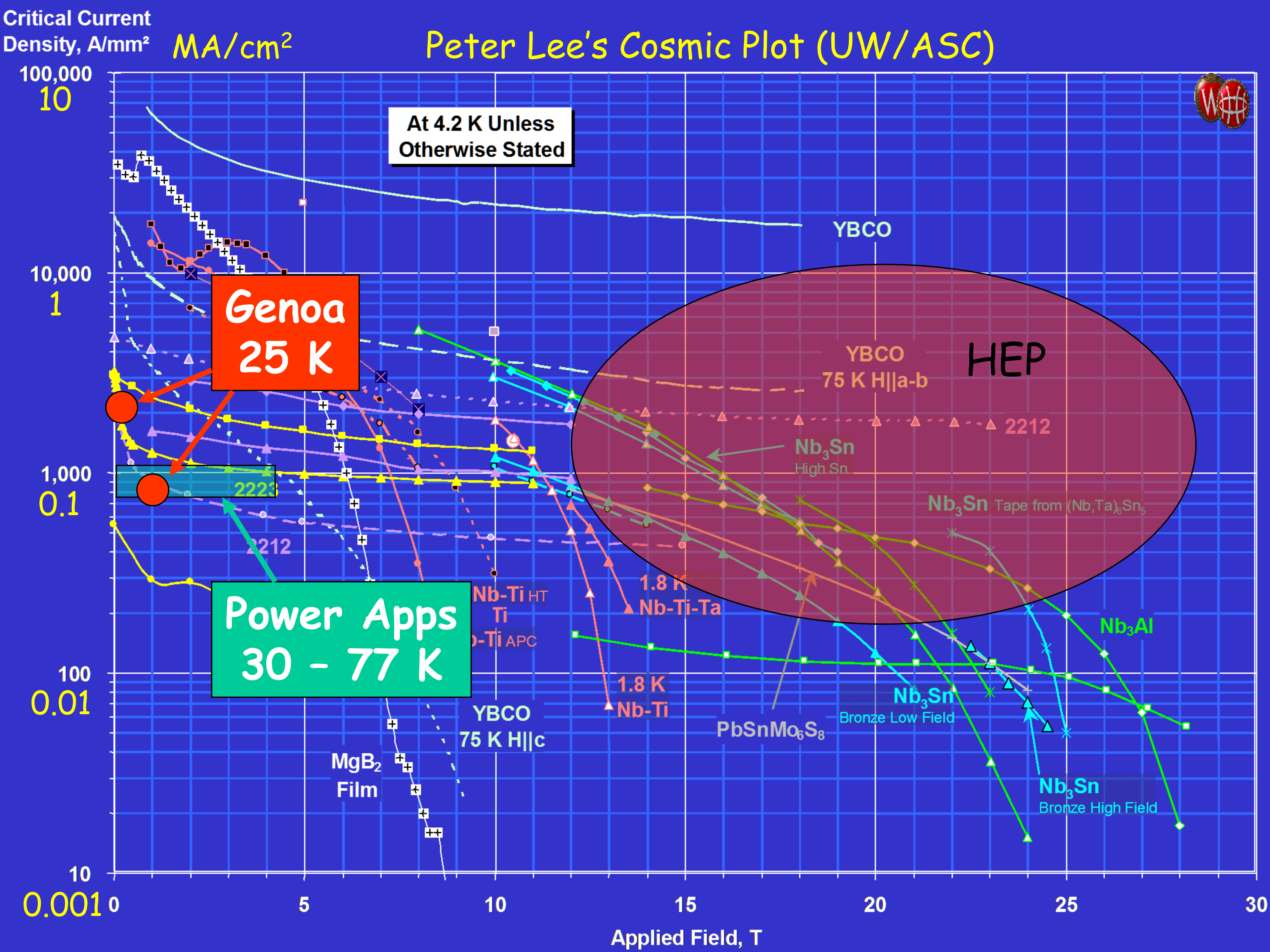




Ex-Situ Sintered

Tape dimensions: 3.5 mm x 0.35 mm
Filling factor 20%
Treated at 900°C for 2 hours in Ar

INFM-Genova, G. Grasso, A. Malagoli, V. Braccini, S. Roncallo, and A.S. Siri, Italy


Peter Lee's Cosmic Plot (UW/ASC)
Critical Current Density, A/mm²
MA/cm²
At 4.2 K Unless Otherwise Stated
100,000
10
10,000
1
1,000
0.1
100
0.01
10
0.001
0
5
10
15
20
25
30
Applied Field, T
YBCO
Genoa
25 K
HEP
YBCO
75 K H||a-b
2212
Nb₃Sn
High Sn
2223
Nb₃Sn Tape from (Nb,Ta)₆Sn₅
2212
Power Apps
30 – 77 K
Nb-Ti HT
Ti
-Ti APC
1.8 K
Nb-Ti-Ta
Nb₃Al
1.8 K
Nb-Ti
YBCO
75 K H||c
PbSnMo₆S₈
Nb₃Sn
Bronze Low Field
MgB₂
Film
Nb₃Sn
Bronze High Field

Wire Cost Issues

Merit Factor for Superconducting Wire:
C/P = $/kAmp × meters

Wire	C/P	Cost Driver
NbTi (4.2 K, 2 T)	0.90	Materials (Nb)
Nb_3Sn (4.2 K, 10 T)	10	Materials (Nb)
Bi-2223 (25 K, 1 T)	20	Materials (Ag)
Y-123 (25 K, 1 T)	4	Capital Plant

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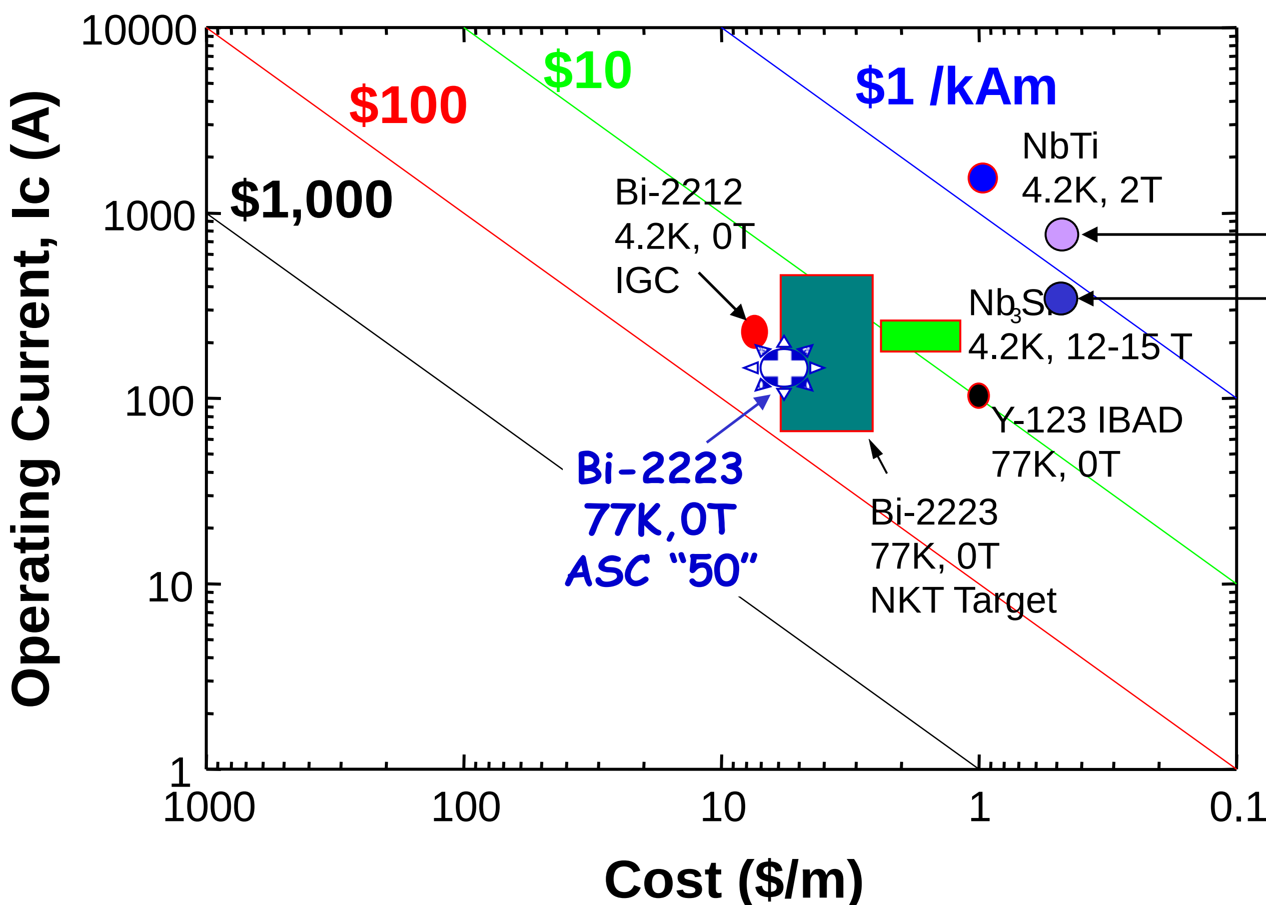
MgB_2 on the SokPlot

"Sokolowski Plot" of HTSC Wire Performance and Cost

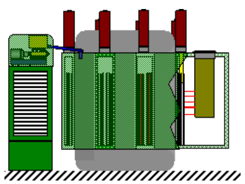


MgB_2 Wire HyperTech 12-24 mos.

Transformers

Cost of Ownership: 1$/kW

Wire-Driven Costs: 2000 ABB SPI Phase I Analysis
Units: $/kA×m

	Cu (300 K) 300 A/cm^2	HTS (68 K)	MgB_2 (25 K)
Losses	60	5	5
Cryo	-	25	34
Wire	5	50	1
Total	65	80	40

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E1: New Superconductors I – MgB_2

1967 SC Cable !

PROCEEDINGS OF THE IEEE, VOL. 55, NO. 4, APRIL 1967

Superconducting Lines for the Transmission of Large Amounts of Electrical Power over Great Distances

R. L. GARWIN AND J. MATISOO

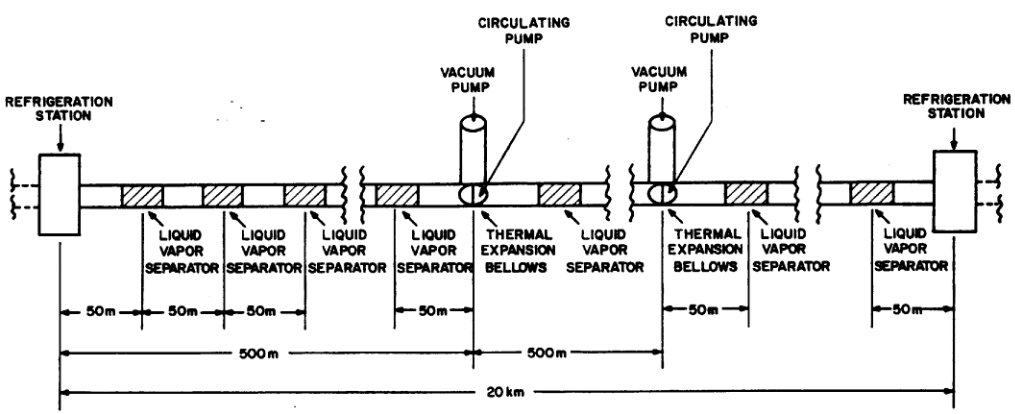

Fig. 2. A 20-km module of the 1000-km, 100-GW line.

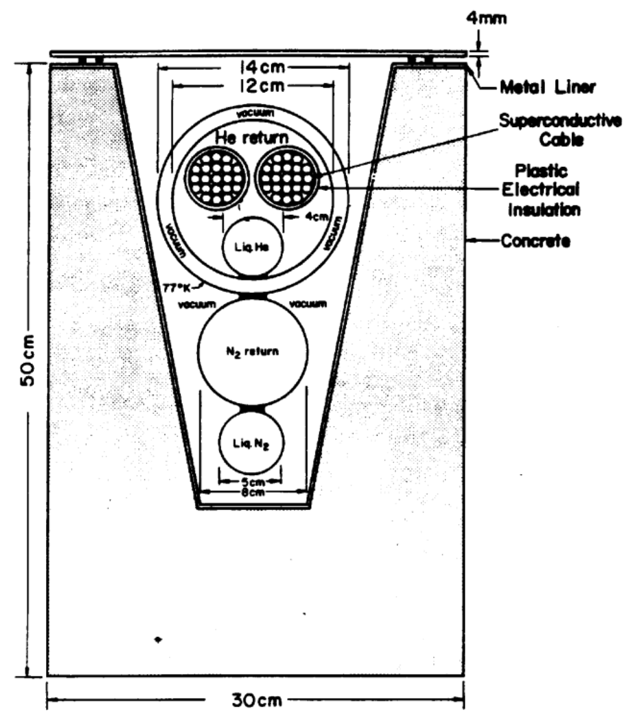

Fig. 1. Cross section of the 100-GW line.

100 GW dc, 1000 km !

"Fast Forward" 2015

- An Era of Global Accord Arrives
- World's Population Aspires to an American Standard of Living
- GHG-driven GCC Underway
- World Society Requires a Green, Sustainable Energy Supply
- A Safe, Robust, Non-intrusive Energy Delivery Infrastructure

"Boundary Conditions"

- Zero GHG emissions for energy production and personal transportation
- Least environmentally and visually invasive
- Optimal (minimal) utilization of land area for energy production and delivery
- Optimal (maximal) physical safety and security

The Challenge

Design a communal energy economy to meet the needs of a densely populated industrialized world that reaches all corners of Planet Earth.

Accomplish all this within the highest levels of environmental, esthetic, safety and security engineering practice possible.

The Solution

- Generation
  - Nuclear-hydrogen, solar roofs
- Transmission
  - Underground (lvdcsc electricity and hydrogen)
- Distribution
  - Reversible fuel cell substations + H_2 storage
  - Local H_2 and electricity distribution for end use
- End Use
  - Appliances, Space Conditioning, Transportation

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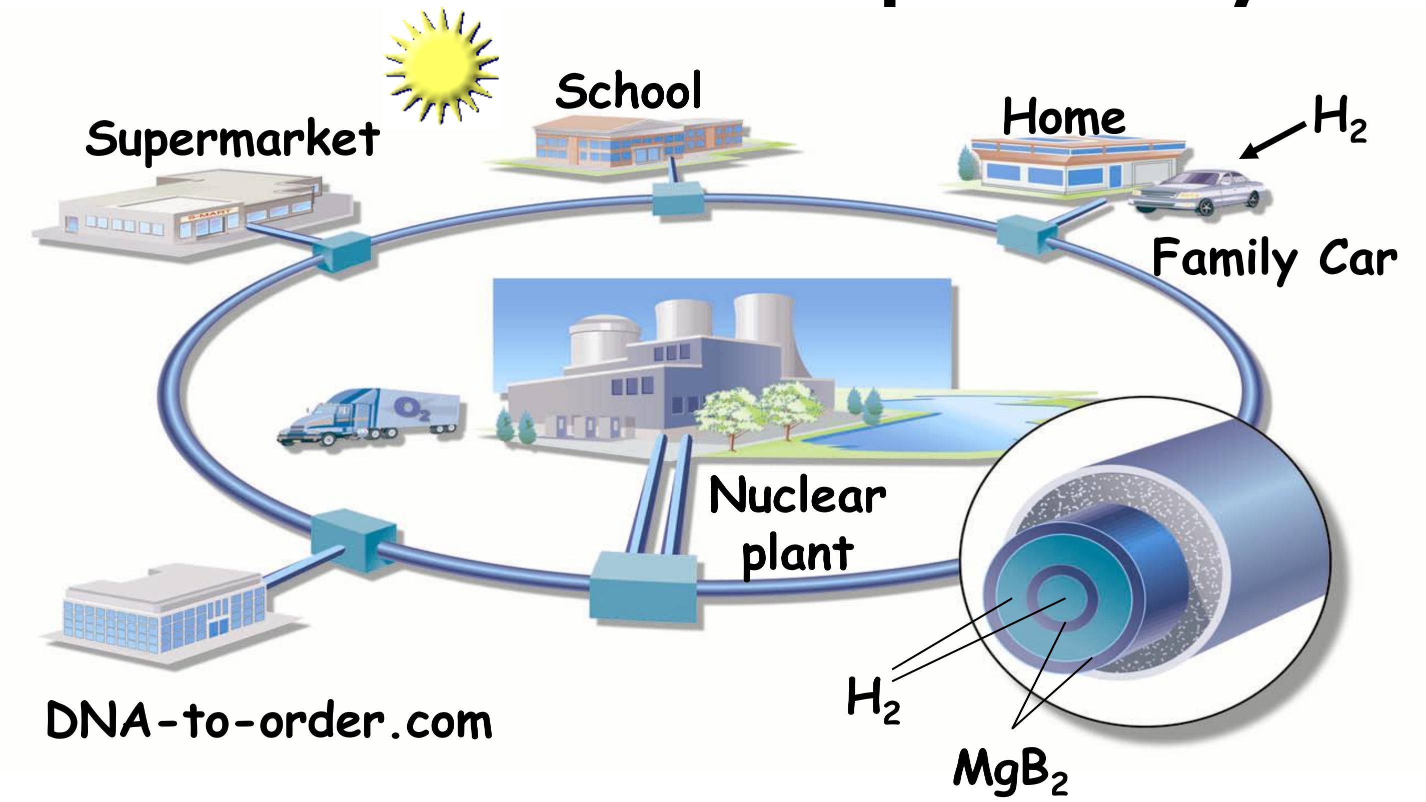
The Vision
"SuperCity"



National Climate Change Technology Initiative (NCCTI – "Necktie")
"Absolutely Zero GHG Emissions by 2050"
George W. Bush

P.M. Grant, The Industrial Physicist, Fall Issue, 2001

Where there is no vision, the people perish…

Proverbs 29:18

Paul M. Grant
26 November 2001