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EXPERIMENTAL WORKSHOP ON HIGH TEMPERATURE SUPERCONDUCTORS & RELATED MATERIALS (BASIC ACTIVITIES)

12 - 30 MARCH 1990

CRITICAL CURRENTS
Part II

RENE FLÜKIGER

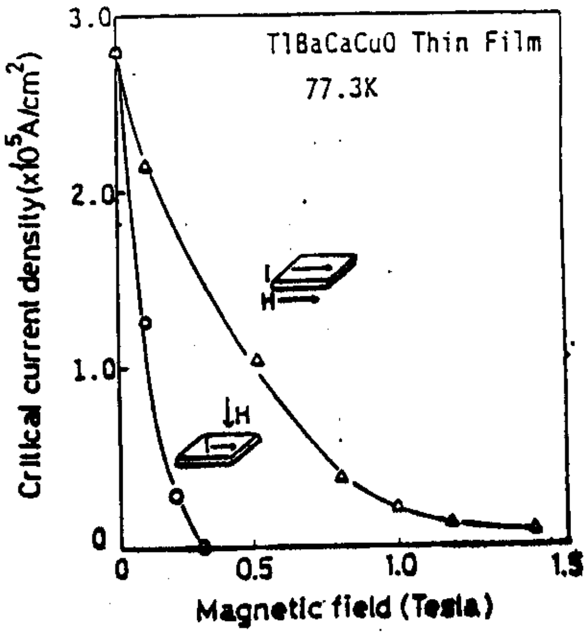
Kernforschungszentrum Karlsruhe
Institut Fur Technische Physik
7514 Eggenstein - Leopoldshafen
Karlsruhe 7500
Federal Republic of Germany

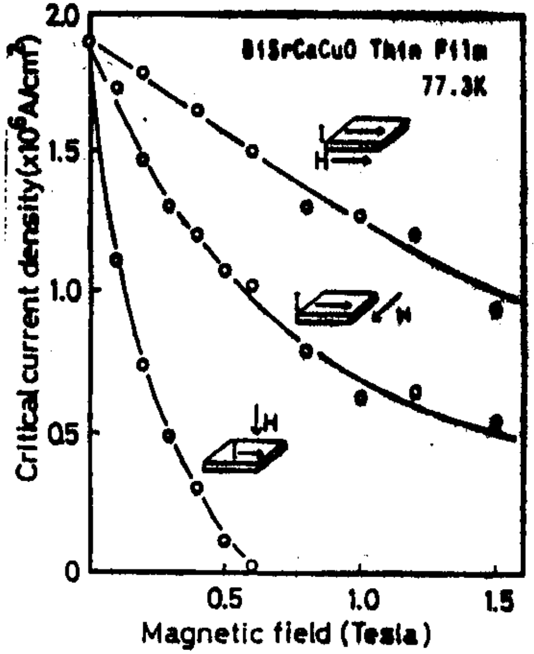
Preparation and properties of Bi-Pb-Sr-Ca-Cu-O bulk samples and tapes

2212 : $Bi_2 Sr_2 Ca_1 Cu_2 O_8$

2223 : $Bi_2 Sr_2 Ca_2 Cu_3 O_{10}$
or
$(Bi_{1-x} Pb_x)_2 Sr_2 Ca_2 Cu_3 O_{10}$

Properties comparable to Tl-Ca-Ba-Cu-O
(not discussed here)





Goal :- Preparation of single-phased, homogeneous 2223 phase of $Bi_{1.65}Pb_{0.35}Sr_2Ca_2Cu_3O_{13}$ in view of tape fabrication

Way : - Systematical work comprising
- composition
- sintering time
- sintering temperature
- cold pressing parameters

- Solid State Processes

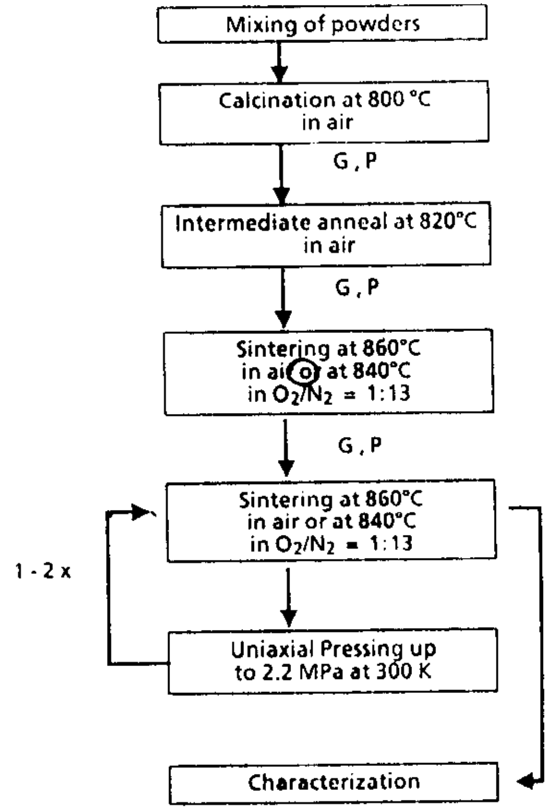
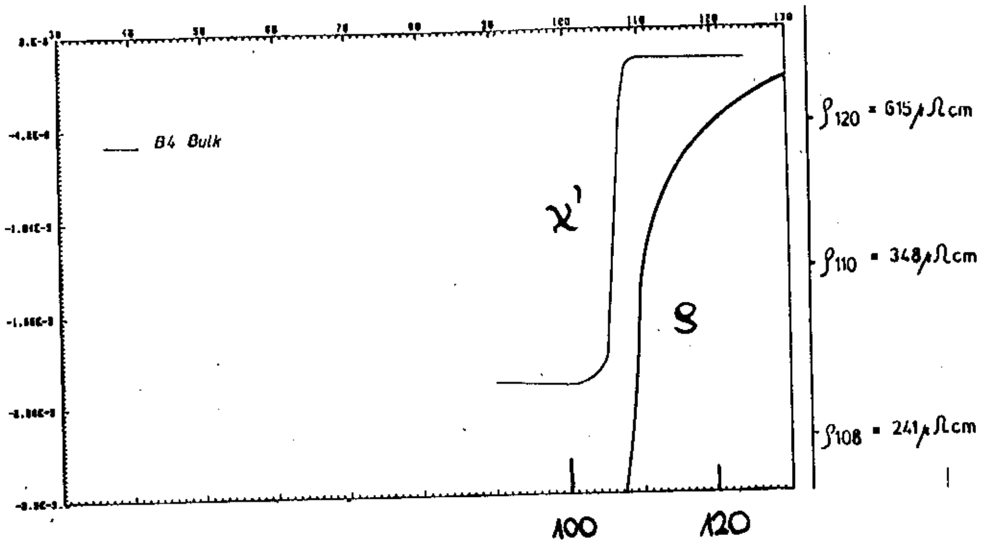
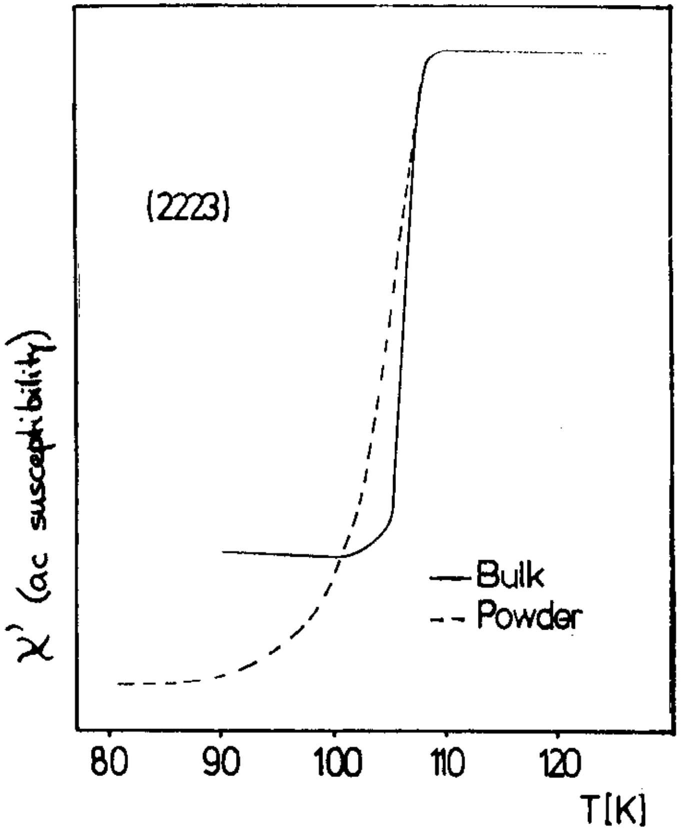


Fig. 1.


B4 Bulk
χ'
ϱ
ϱ120 = 615 μΩcm
ϱ110 = 348 μΩcm
ϱ108 = 241 μΩcm
100
120


(2223)
χ' (ac susceptibility)
—Bulk
-- Powder
80
90
100
110
120
T[K]

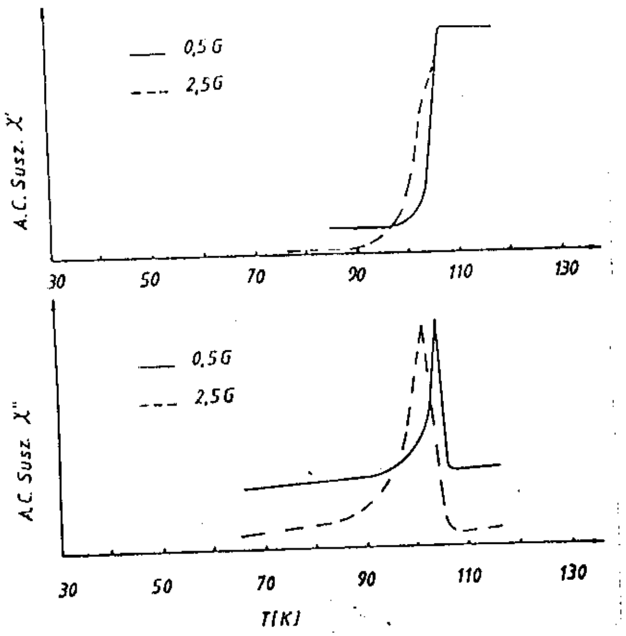

0,5 G
2,5 G
A.C. Susz. χ'
30
50
70
90
110
130
0,5 G
2,5 G
A.C. Susz. χ''
30
50
70
90
110
130
T[K]

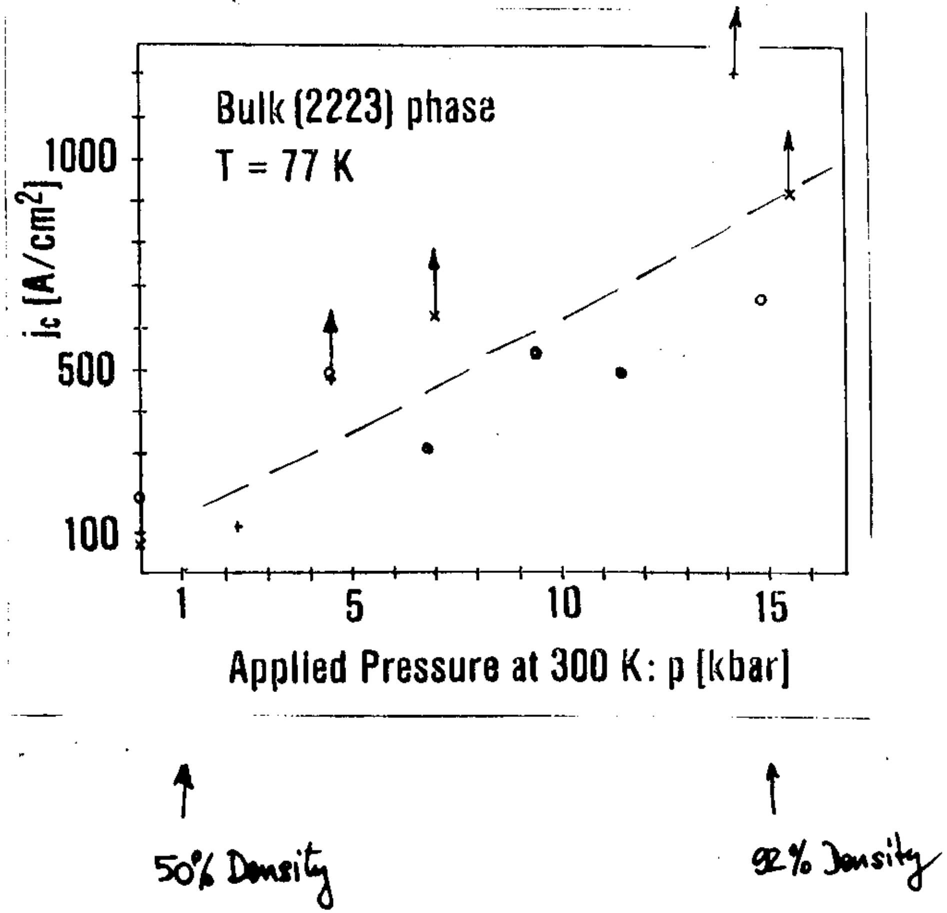
Fig.4.

Density and j_c in Bi-Pb cuprate (2223 phase)

Sample	Density (g/cm^3)	j_c(77K,B=0) (A/cm^2)
C2	3.3	76
C10	3.6	468
C14	4.3	487
C16	4.5	664
C15	4.6	621#
C13	5.6	↑1195#
C17	5.9	904#

Probe verbrannt

(# means burning of the sample, j_c was higher)



sintering temperature: 860°C /air

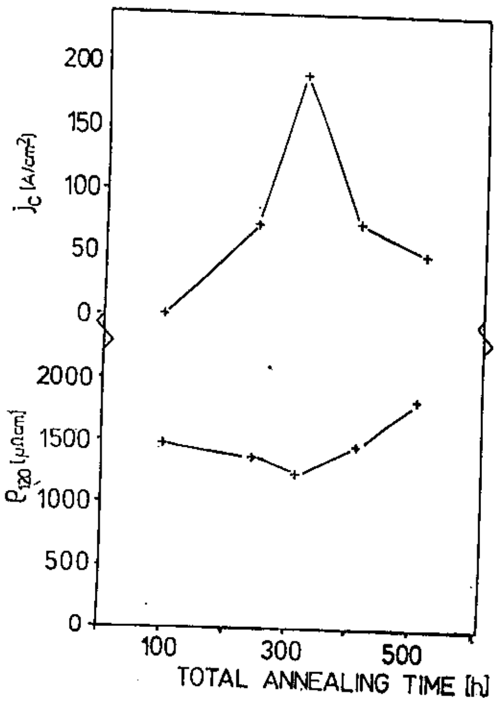


Fig. 8.

zwischen den Körnern hin.

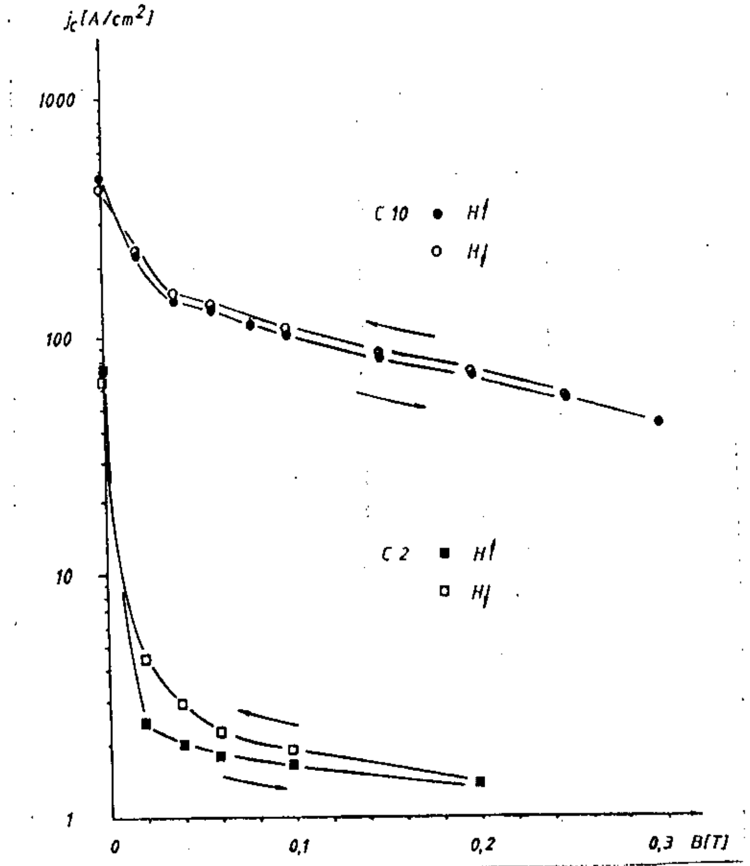
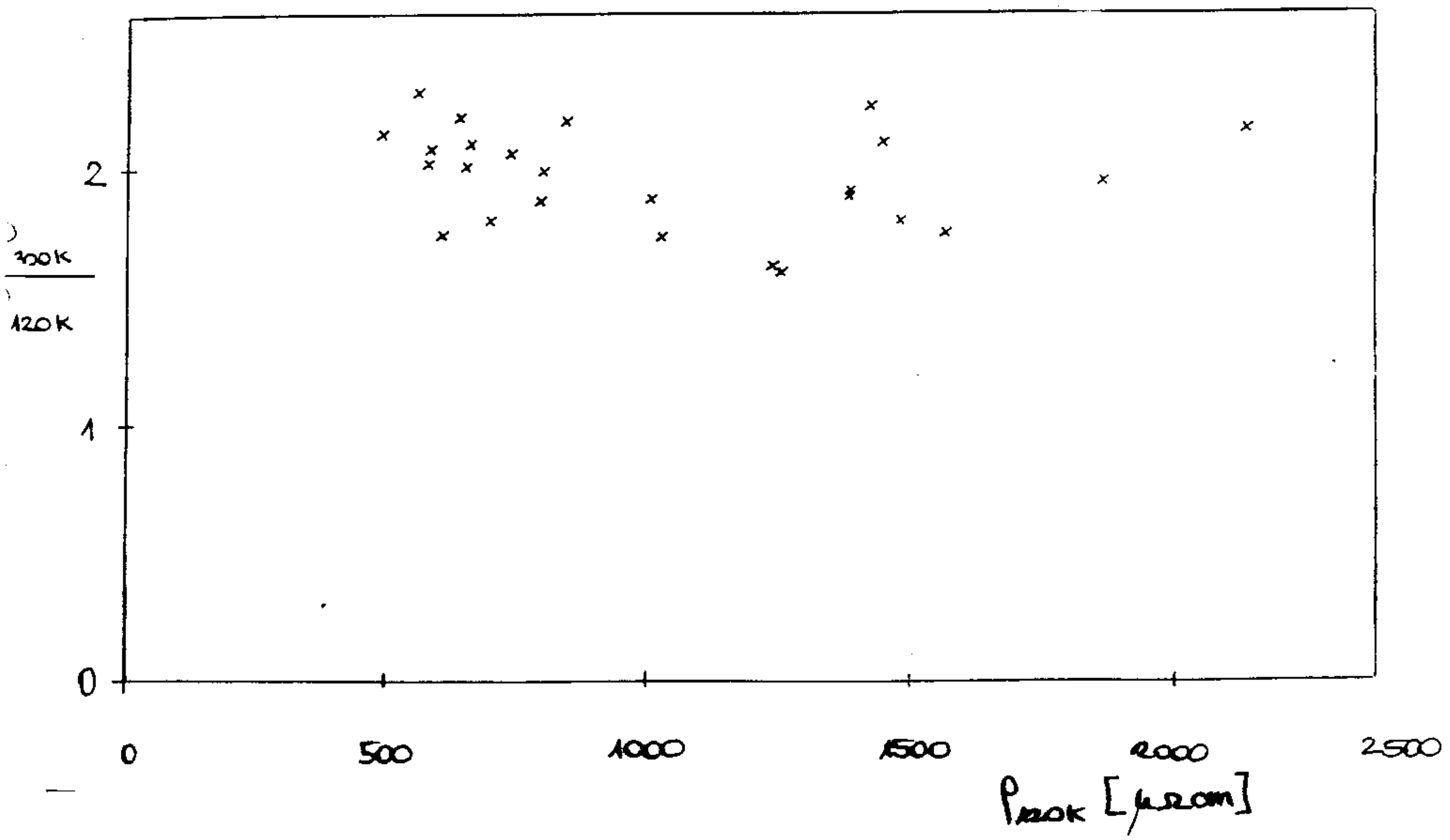
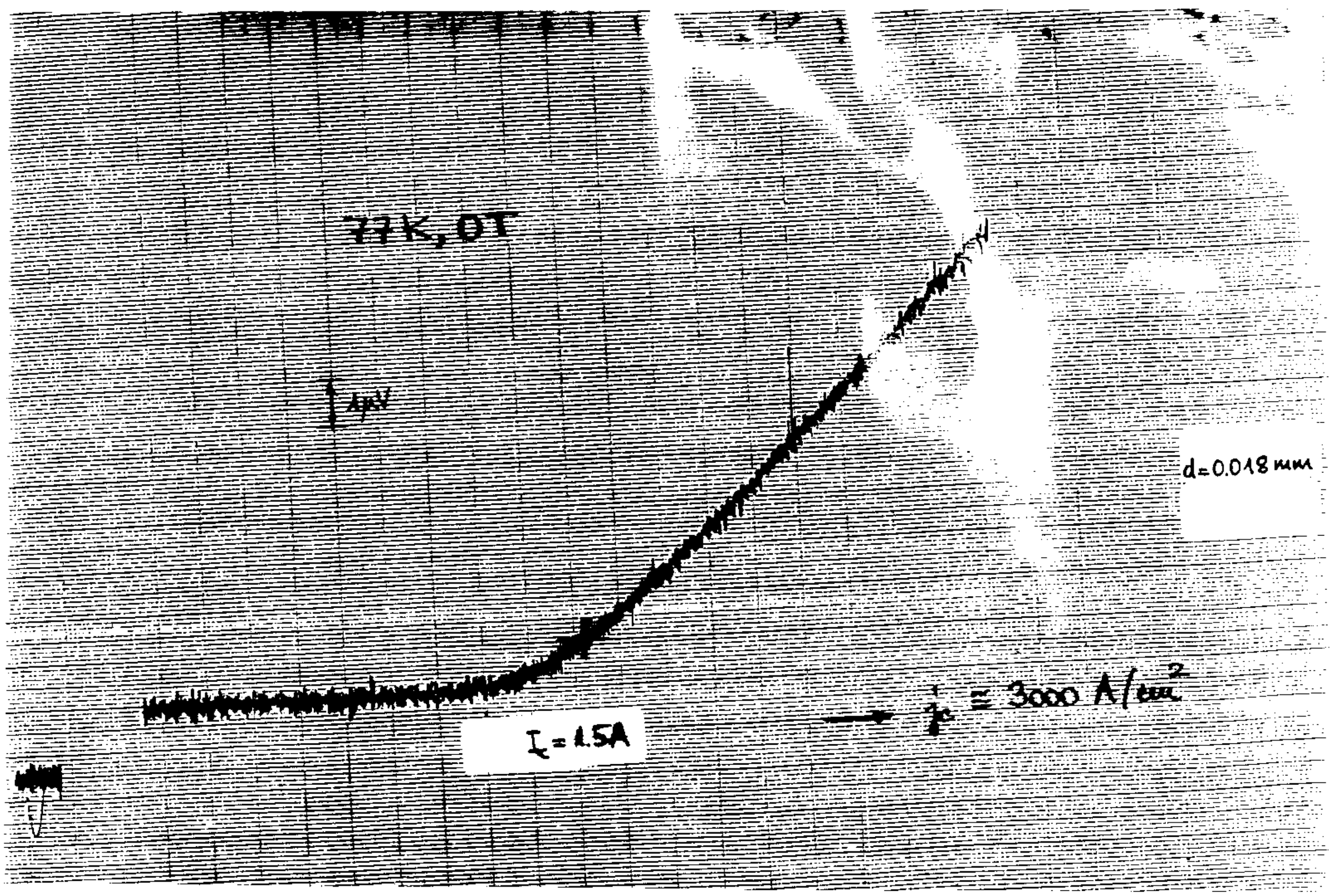


Abbildung 60. Hysteresis für nachgepreßte (C10) und Sinterprobe (C2)



2
1
0
ρ300K
ρ120K
0
500
1000
1500
2000
2500
ρ120K [μΩcm]



77K, 0T
1μV
d=0.018 mm
I = 1.5A
→ jc ≅ 3000 A/cm²

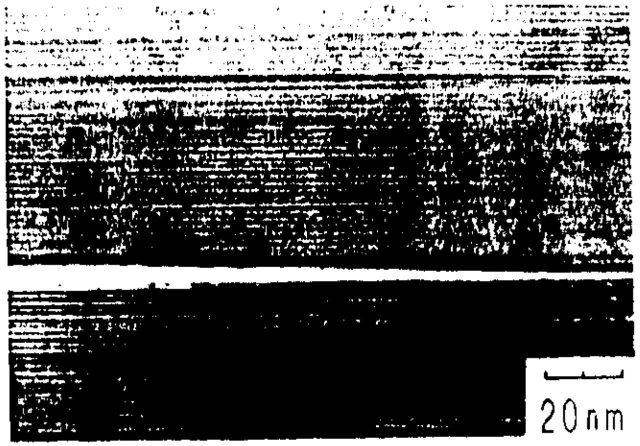


Fig. 4. TEM image viewed along the plane of the BiPbSrCaCuO wire.

Fig. 5. TEM image viewed along the plane of the BiPbSrCaCuO wire.

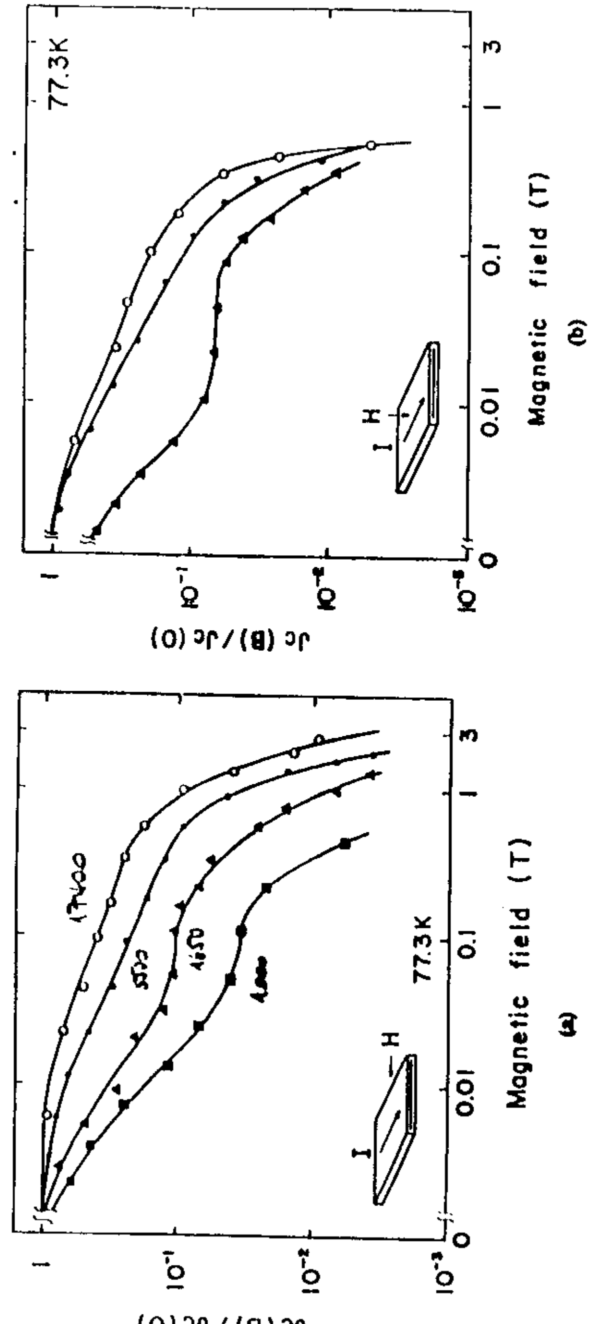
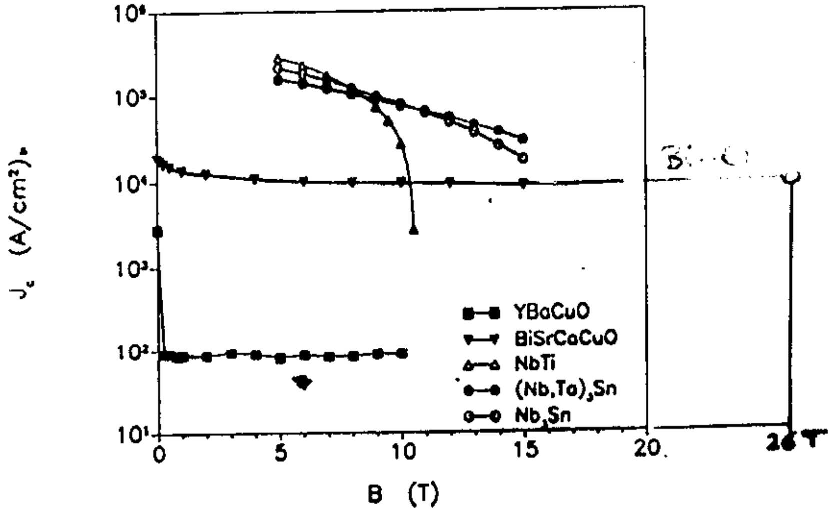
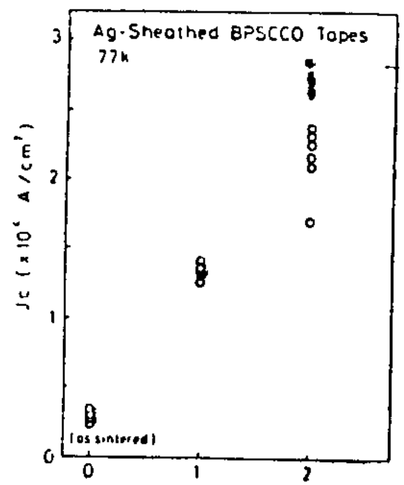


Fig. 1. Magnetic field dependence of critical current density of each specimen with J_c=1,000A/cm^2 (■), 1,650A/cm^2 (▲), 5,500A/cm^2 (●) and 17,400A/cm^2 (○) in a zero magnetic field, which are normalized by J_c(0 T). (a) H parallel to a wide plane of the specimens. (b) H perpendicular to a wide plane of the specimens.

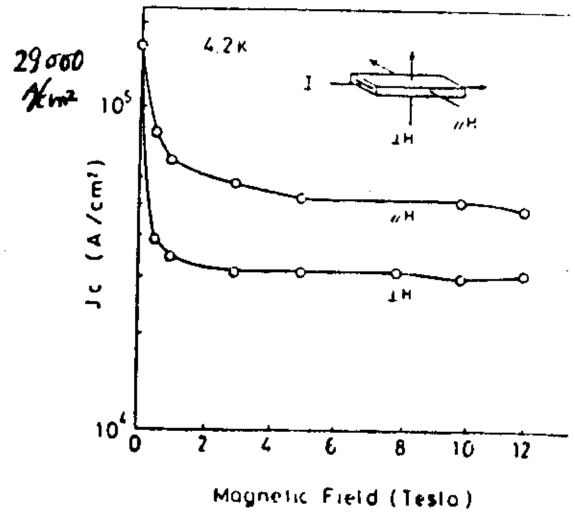
At 4.2K, Wires



10^5
10^4
10^3
10^2
10^1
10^0
0
5
10
15
20.
26 T
B (T)
J_c (A/cm²)
YBaCuO
BiSrCaCuO
NbTi
(Nb,Ta)$_3$Sn
Nb$_3$Sn



Ag-Sheathed BPSCCO Tapes
77K
(as sintered)
0
1
2
3
Jc (x10⁴ A/cm²)



29000 A/cm²
4.2K
I
⊥H
//H
10^5
10^4
0
2
4
6
8
10
12
Jc (A/cm²)
Magnetic Field (Tesla)

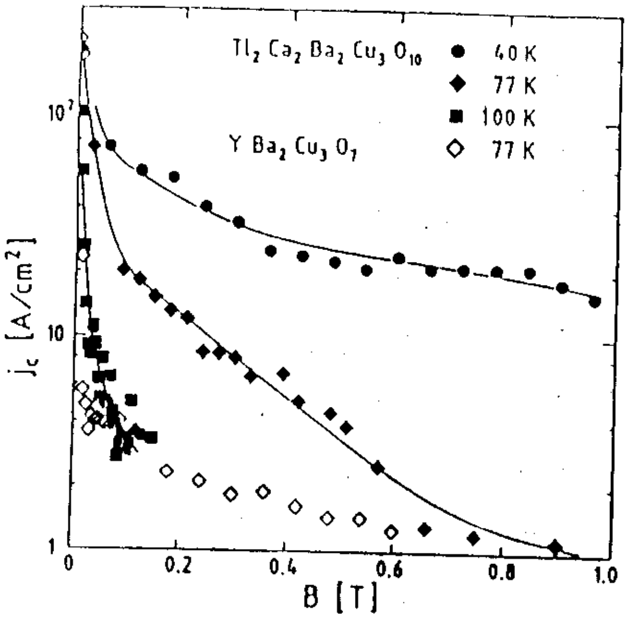


Fig. 5. Critical intergrain current densities' dependence on field measured inductively in bulk $Tl_2Ca_2Ba_2Cu_3O_{10}$

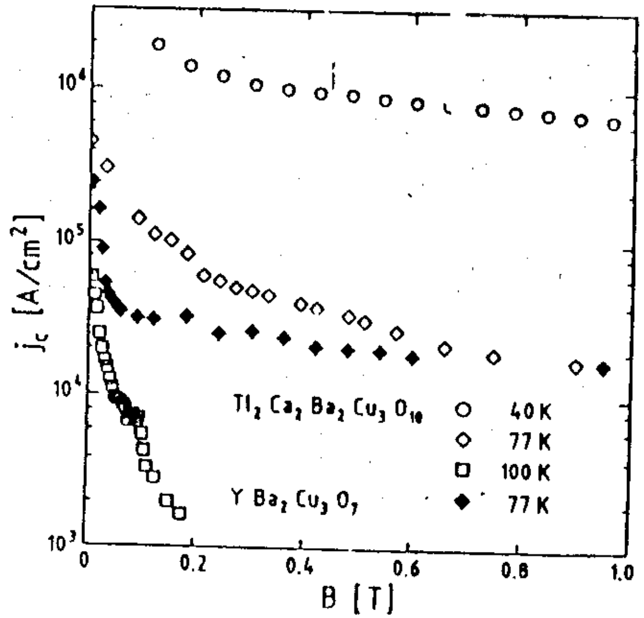


Fig. 6. Critical intragrain current densities' dependence on field measured inductively in bulk $Tl_2Ca_2Ba_2Cu_3O_{10}$

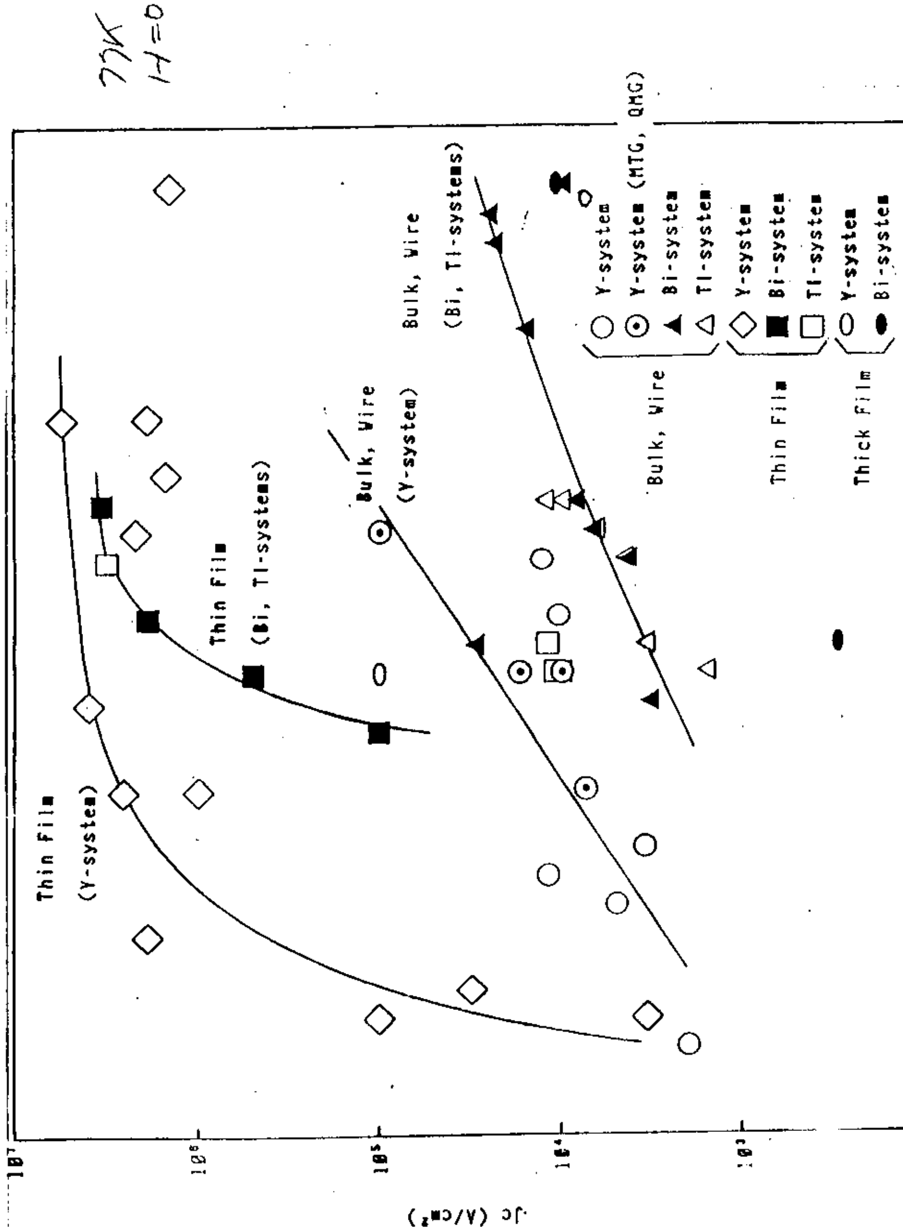
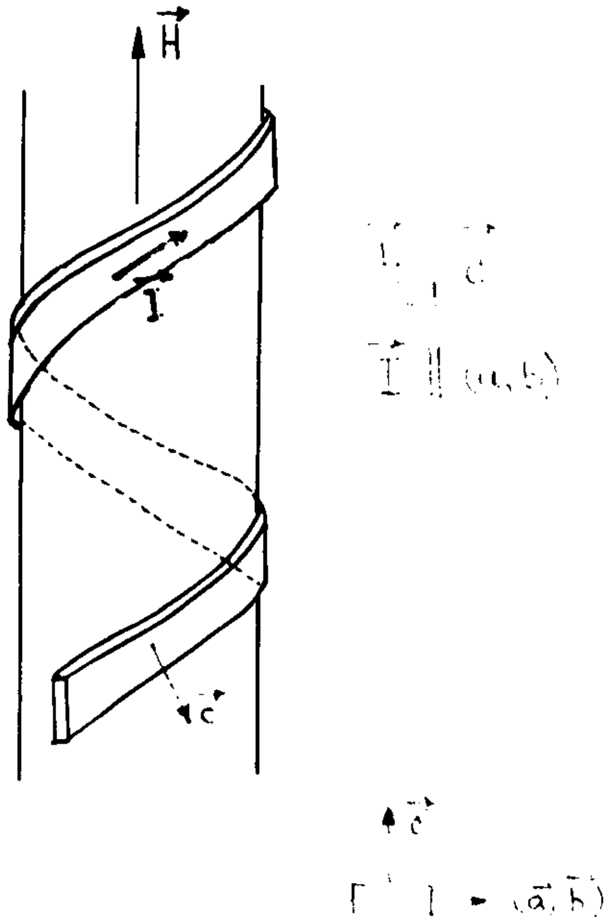


Fig.6 The Jc Calendar

NIKKEI SUPERCONDUCTORS

Preparation and properties of $YBa_2Cu_3O_{7-\delta}$ Tapes

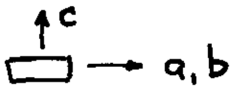


At both ends of the magnet:

$$B_\perp \neq 0$$

CONDITIONS FOR A $YBa_2Cu_3O_7$ WIRE

- LONG LENGTHS (> 1000 m)
- RECTANGULAR CROSS SECTION



- MECHANICAL STABILITY

  Bulk rupture strain : actually 0.05% (Bending!)

  → COMPOSITES : > 0.5%

  → FINE FILAMENTS → M/F

- THERMAL STABILITY

  → Ag sheath

  $\rho_{ab} < 100\ \mu\Omega cm$

  $\rho_c < 1000\ \mu\Omega cm$ | at 100 K

- CRITICAL CURRENT DENSITY

  $J_c \geq 10^5\ A/cm^2$ at $B > 10T$

- $J_c \neq J_c(t)$ FLUX CREEP!

- COSTS COMPARABLE TO Nb_3Sn .....

PREPARATION OF $YBa_2Cu_3O_7$ WIRES

"POWDER IN TUBE"

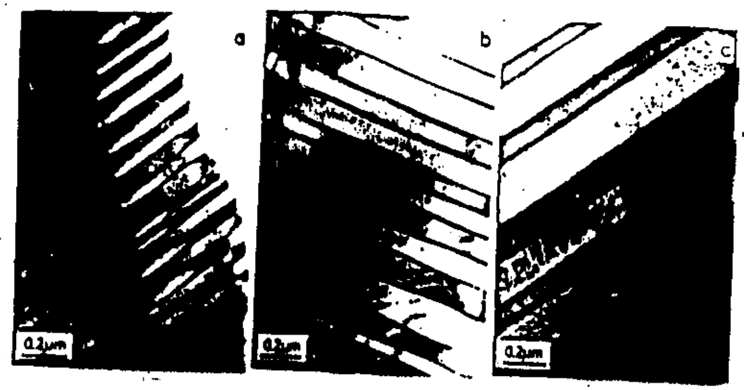
	T_c
1) OPTIMIZED $YBa_2Cu_3O_7$ POWDER (T_c = 93K) IN Ag TUBE	93K
2) COLD DEFORMATION TO WIRE (ϕ 0.5mm)	<77K
3) SINTERING AT 900 – 950°C (O_2) OR 900 – 920°C (air)	<77K
4) OXIDATION AT ~ 550°C (O_2) ~	93K

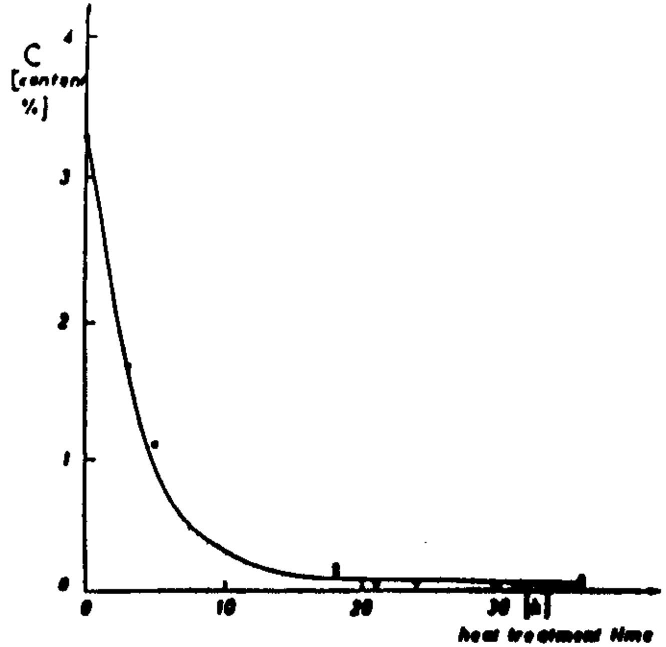
SHEATH MATERIAL :— Ag

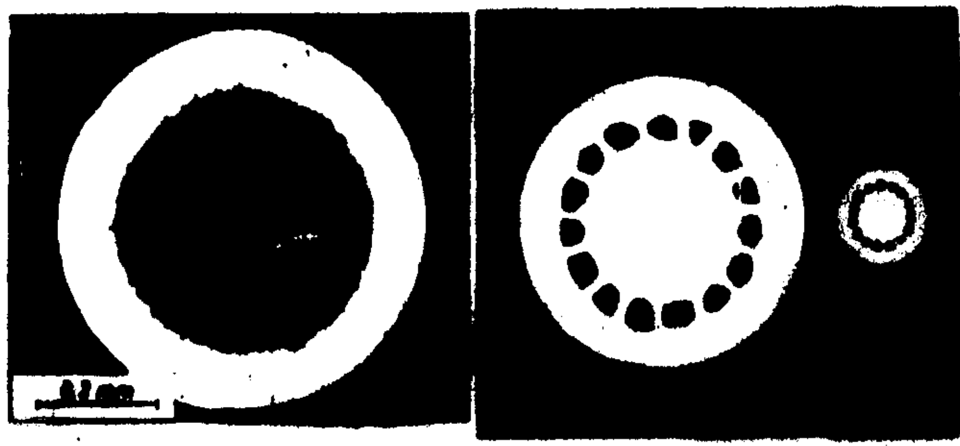
— Ag–Pd (<5%Pd

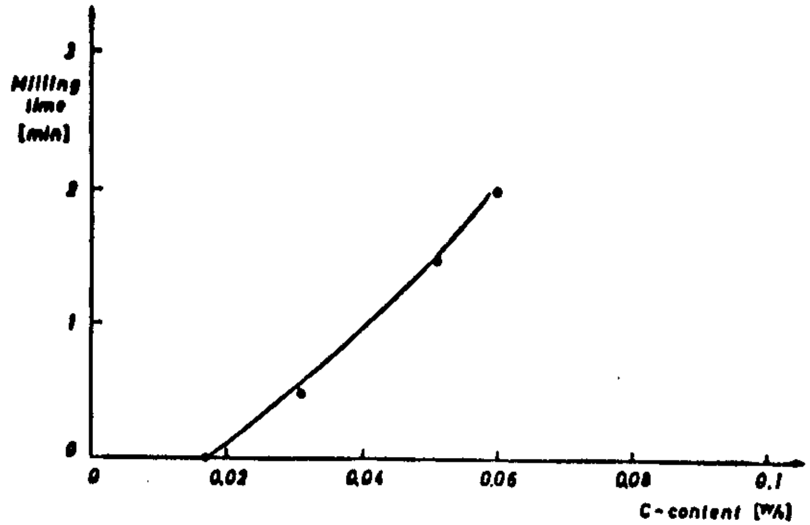
Ag : $T_F = 961°C \longrightarrow 938°C$ in O_2

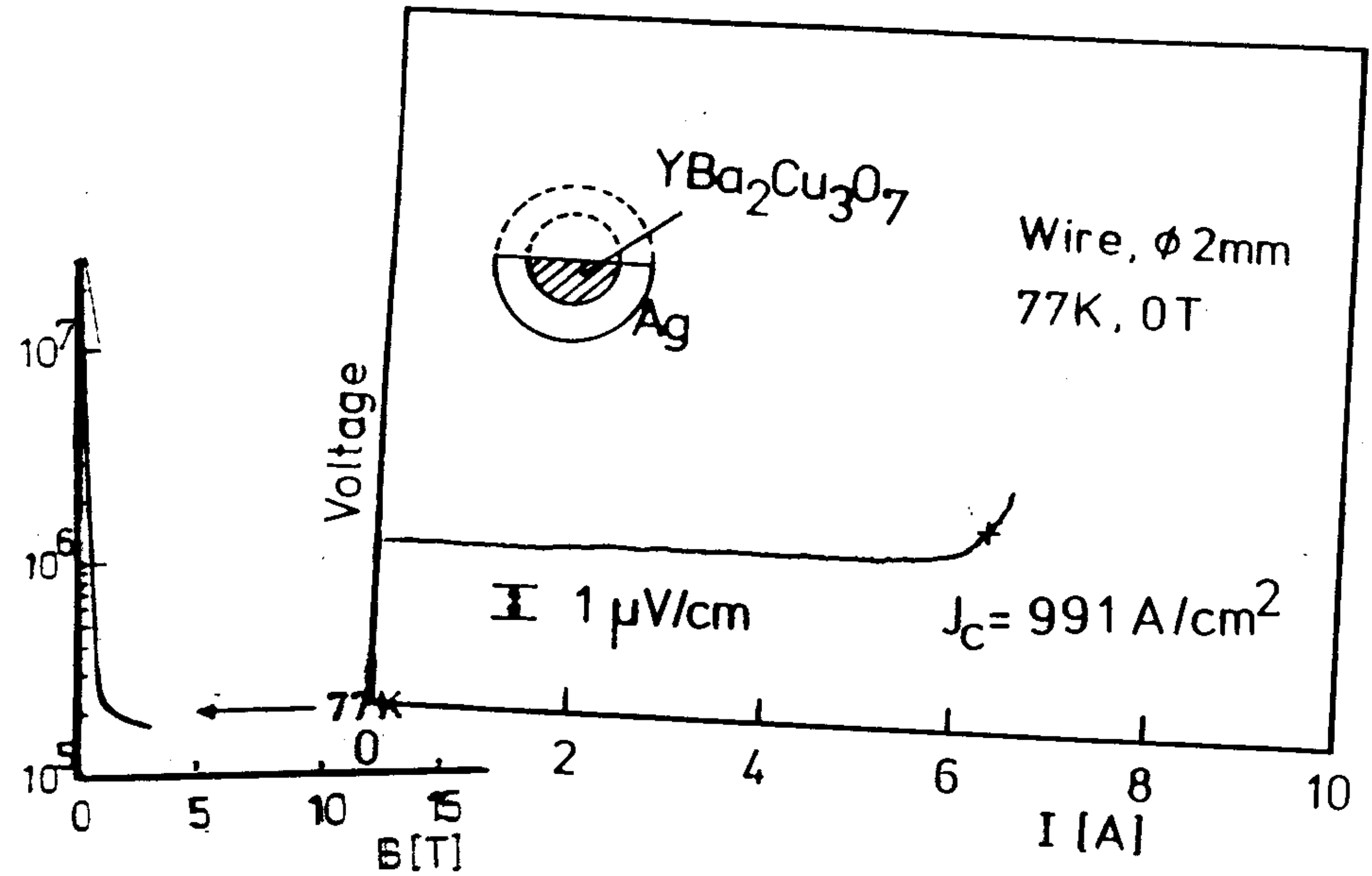
THIS WORK $\longrightarrow$ Ag-Pd : $\Delta T_F \cong +9°C$ /at.% Pd.



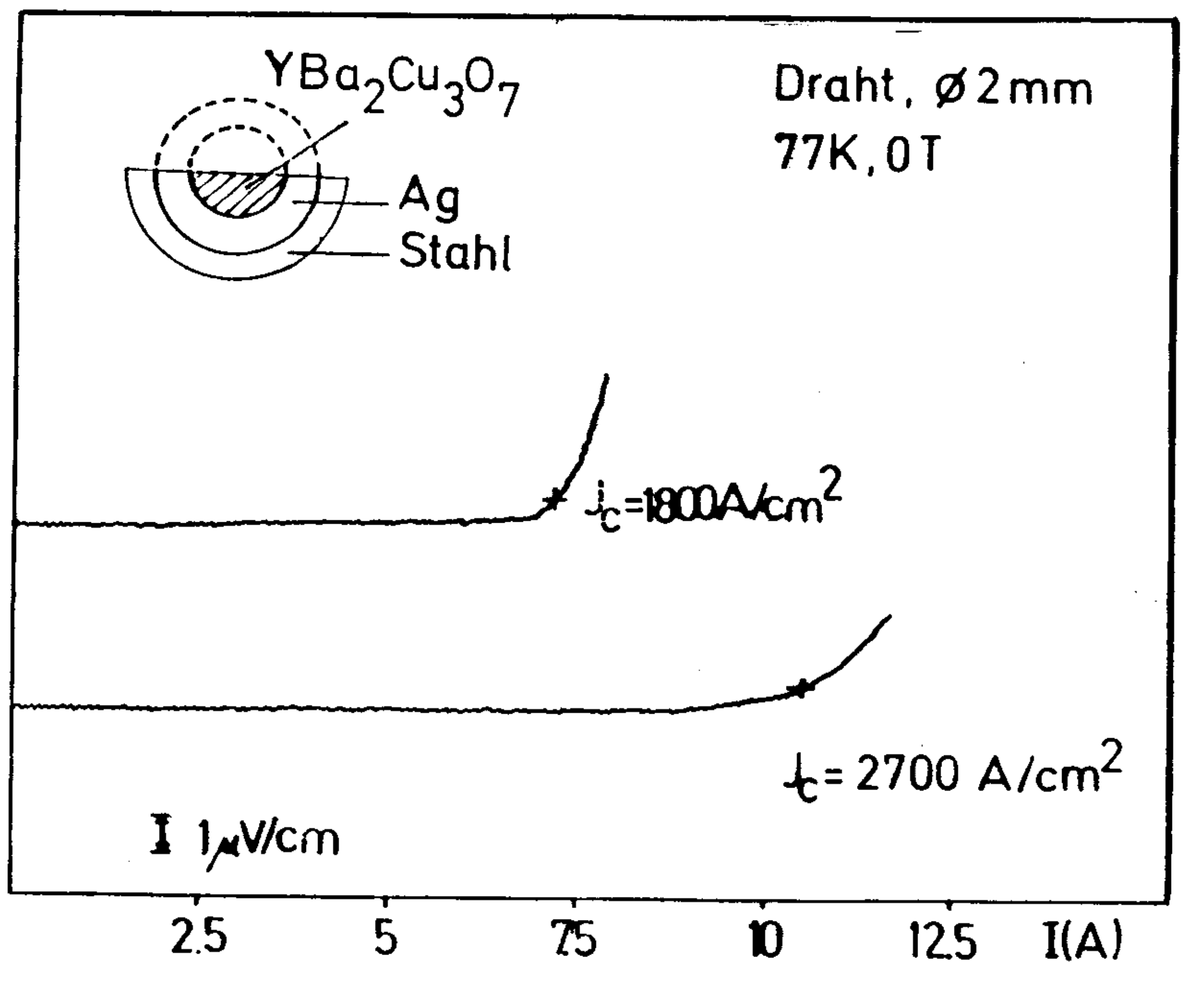

C
[content %]
4
3
2
1
0
0
10
20
30 [h]
heat treatment time


0,2 mm

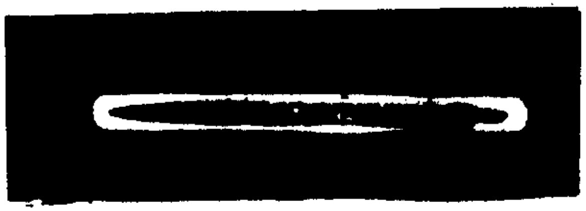

Milling time [min]
3
2
1
0
0
0,02
0,04
0,06
0,08
0,1
C-content [W%]



$YBa_2Cu_3O_7$
Ag
Wire, ϕ 2mm
77K, 0T
Voltage
1 μV/cm
J_c = 991 A/cm^2
77K
10^7
10^6
10^5
0
5
10
15
B [T]
0
2
4
6
8
10
I [A]

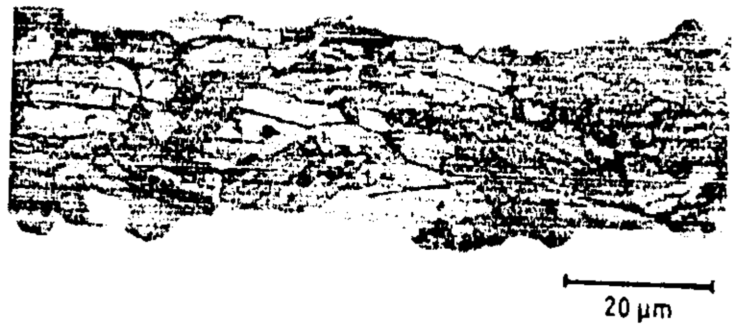


$YBa_2Cu_3O_7$
Ag
Stahl
Draht, ∅ 2mm
77K, 0T
j_c=1800A/cm^2
j_c= 2700 A/cm^2
1 μV/cm
2.5
5
7.5
10
12.5
I(A)



1 mm
thickness

0.5 mm
thickness

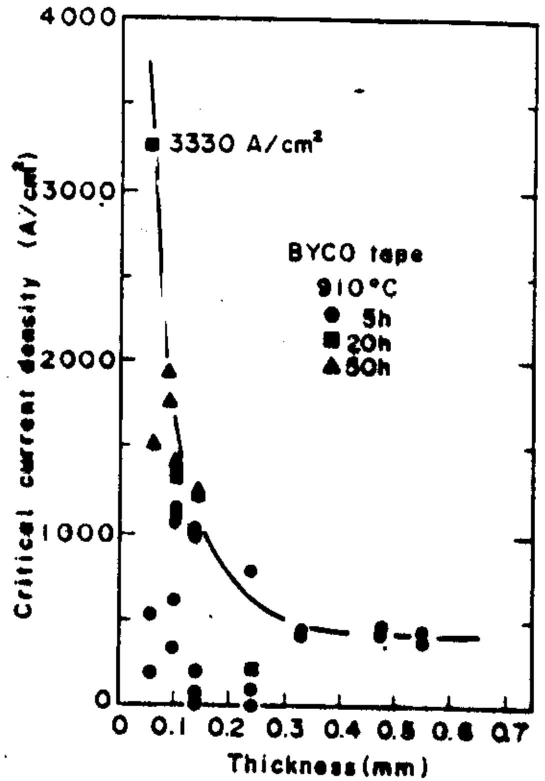


Rolling
$J_c = 347$ A cm^{-2}

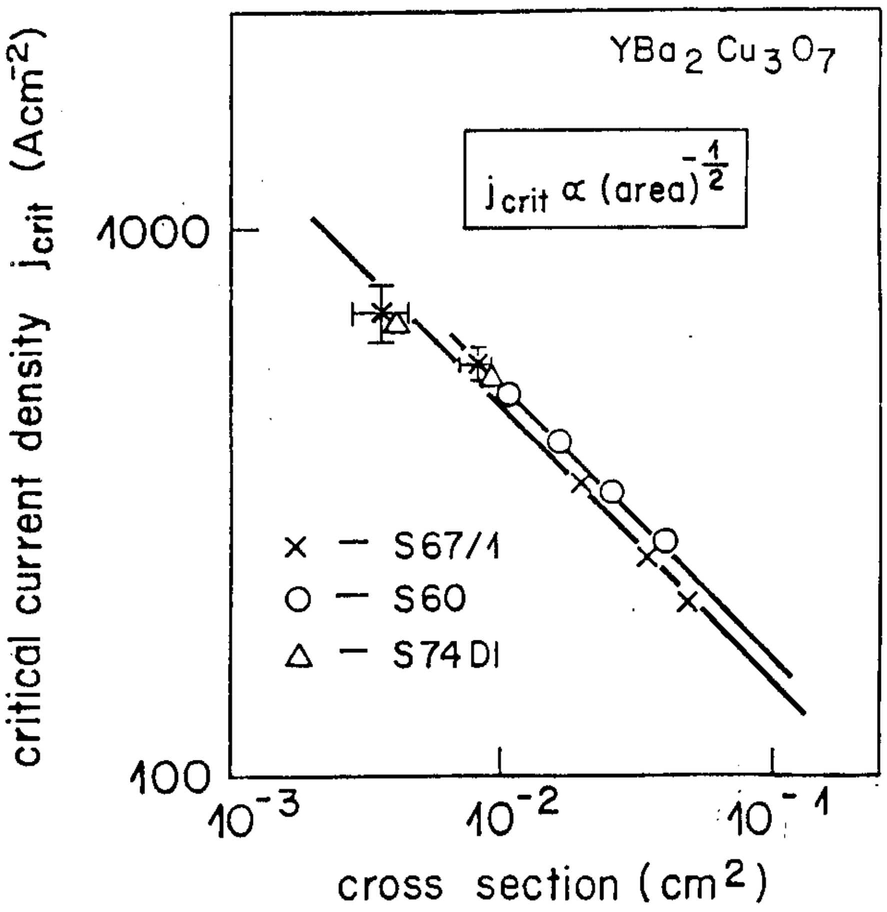
Pressing
$J_c = 2130$ A cm^{-2}

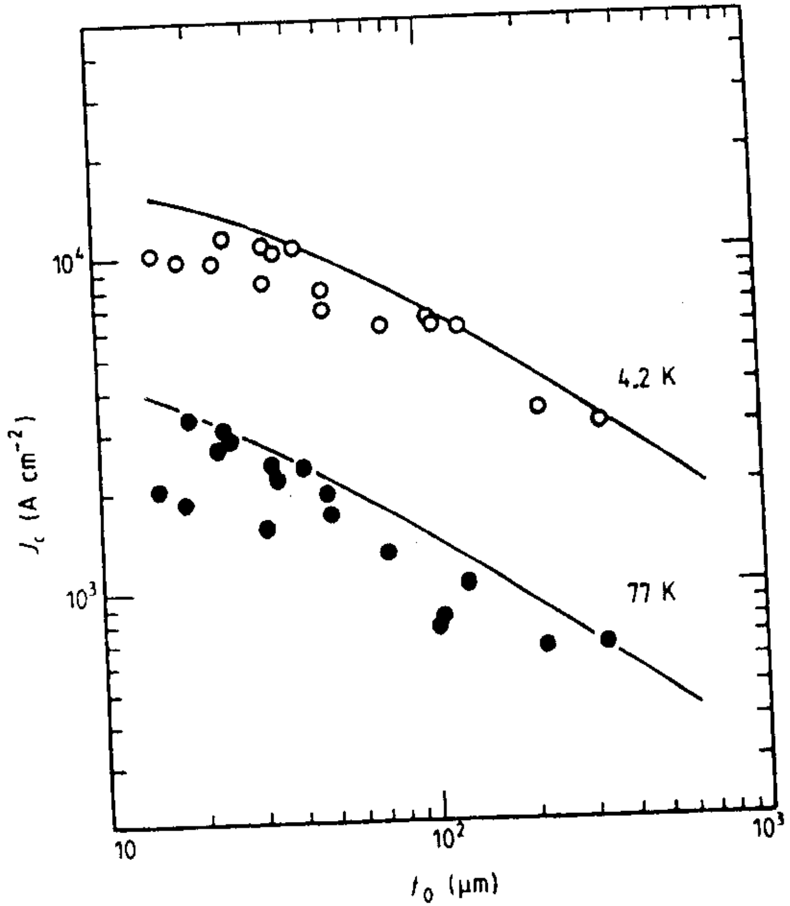
Microstructure of the cross-section parallel to the direction of current flow for the tapes made by cold-rolling and pressing. The measured value of critical current density at 77 K is given.

SELF-FIELD EFFECTS (?)

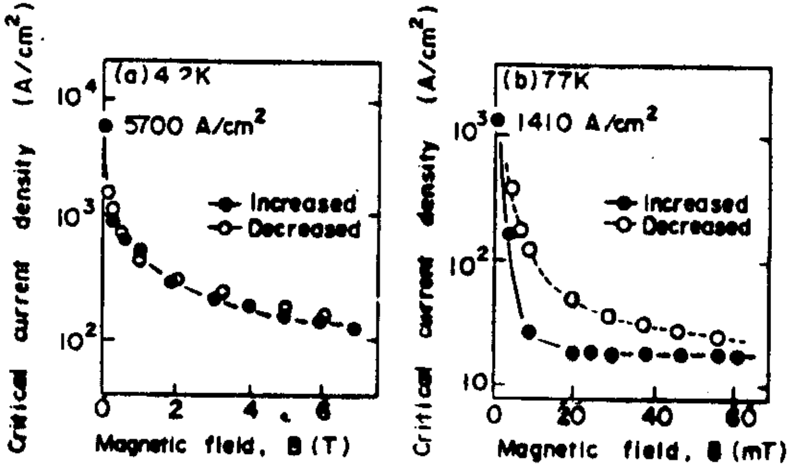


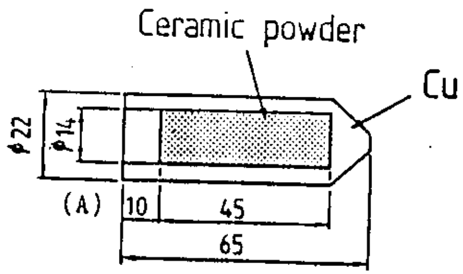
$YBa_2Cu_3O_7$ Tapes (KOHNO et al.)



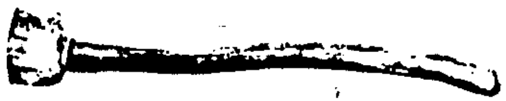


Change in critical current density as a function of oxide layer thickness for the tapes made by cold-pressing.

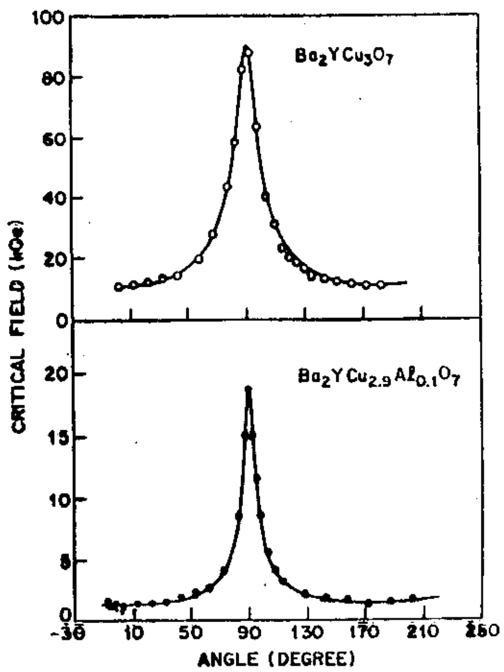


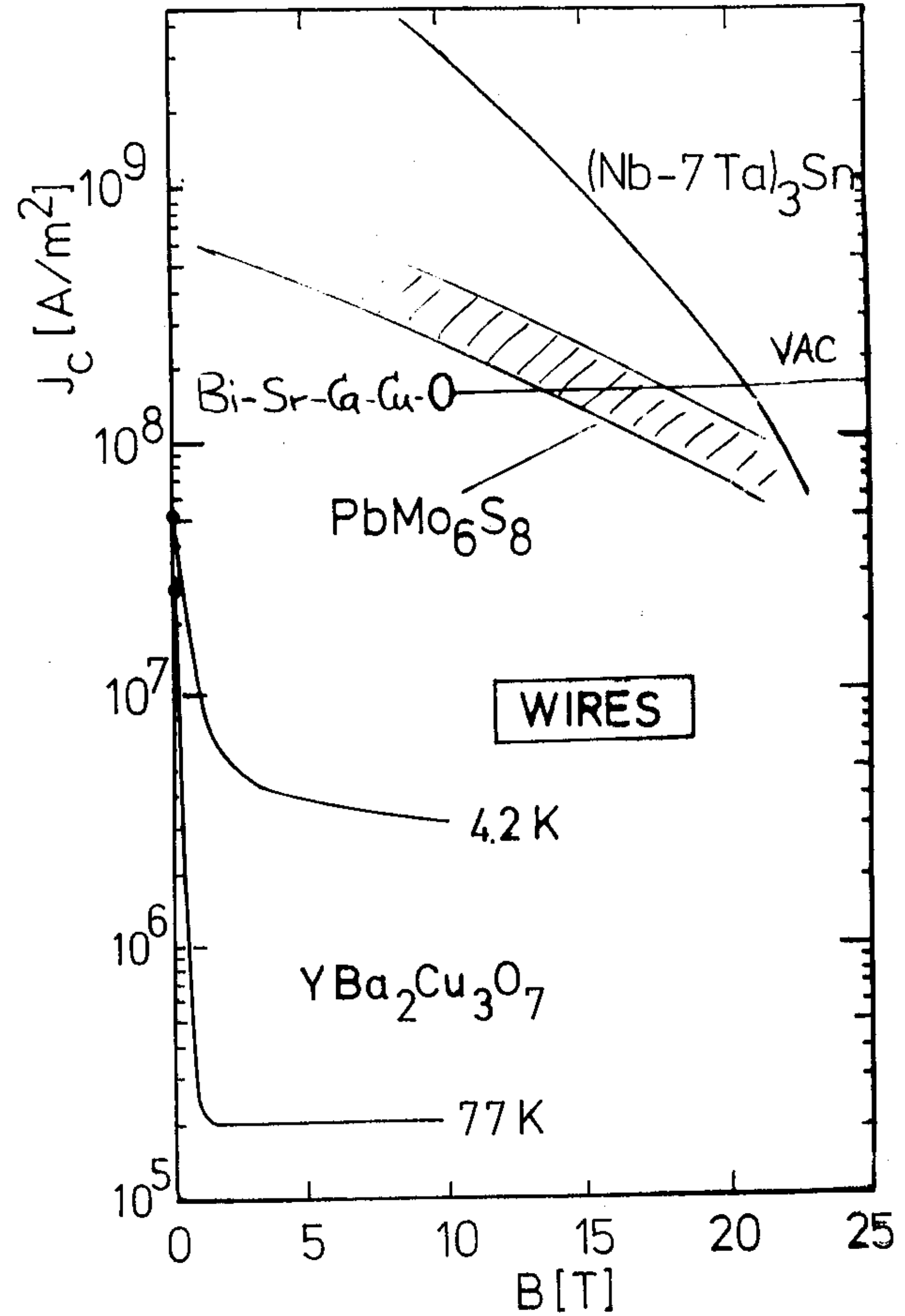


Before extrusion



After extrusion




J_c [A/m^2]
10^9
10^8
10^7
10^6
10^5
0
5
10
15
20
25
B [T]
$(Nb-7\,Ta)_3Sn$
VAC
Bi-Sr-Ca-Cu-O
$PbMo_6S_8$
WIRES
4.2 K
$YBa_2Cu_3O_7$
77 K