EXPERIMENTAL INVESTIGATION OF THE THERMAL RESISTANCE IN NIOBIUM SAMPLES FOR SUPERCONDUCTING RF CAVITIES

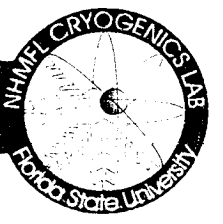
M.R. Smith
T. Zhang
Y. Xiang
S.W. Van Sciver
J.G. Weisend
P. Schmueser
M. Fouaddy

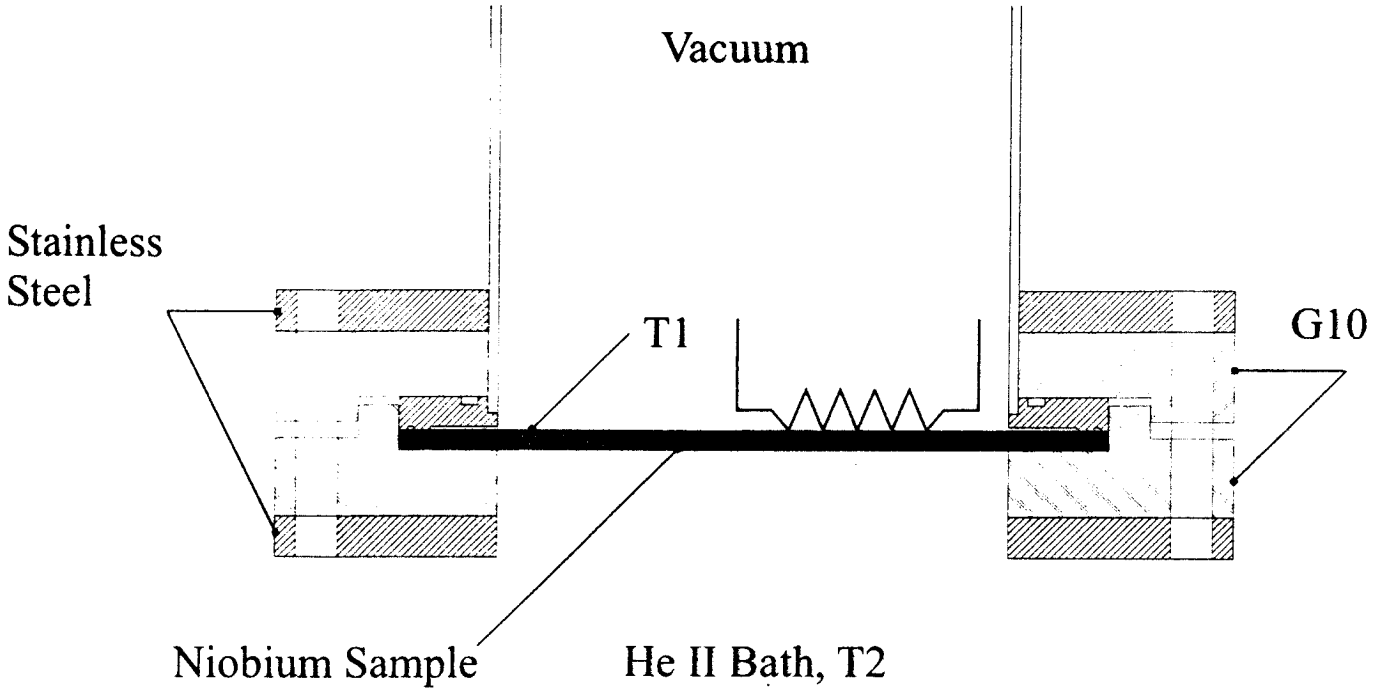
OUTLINE:

- EXPERIMENTAL SETUP
- RESULTS
- DISCUSSION OF COPPER COATING
- CONCLUSIONS

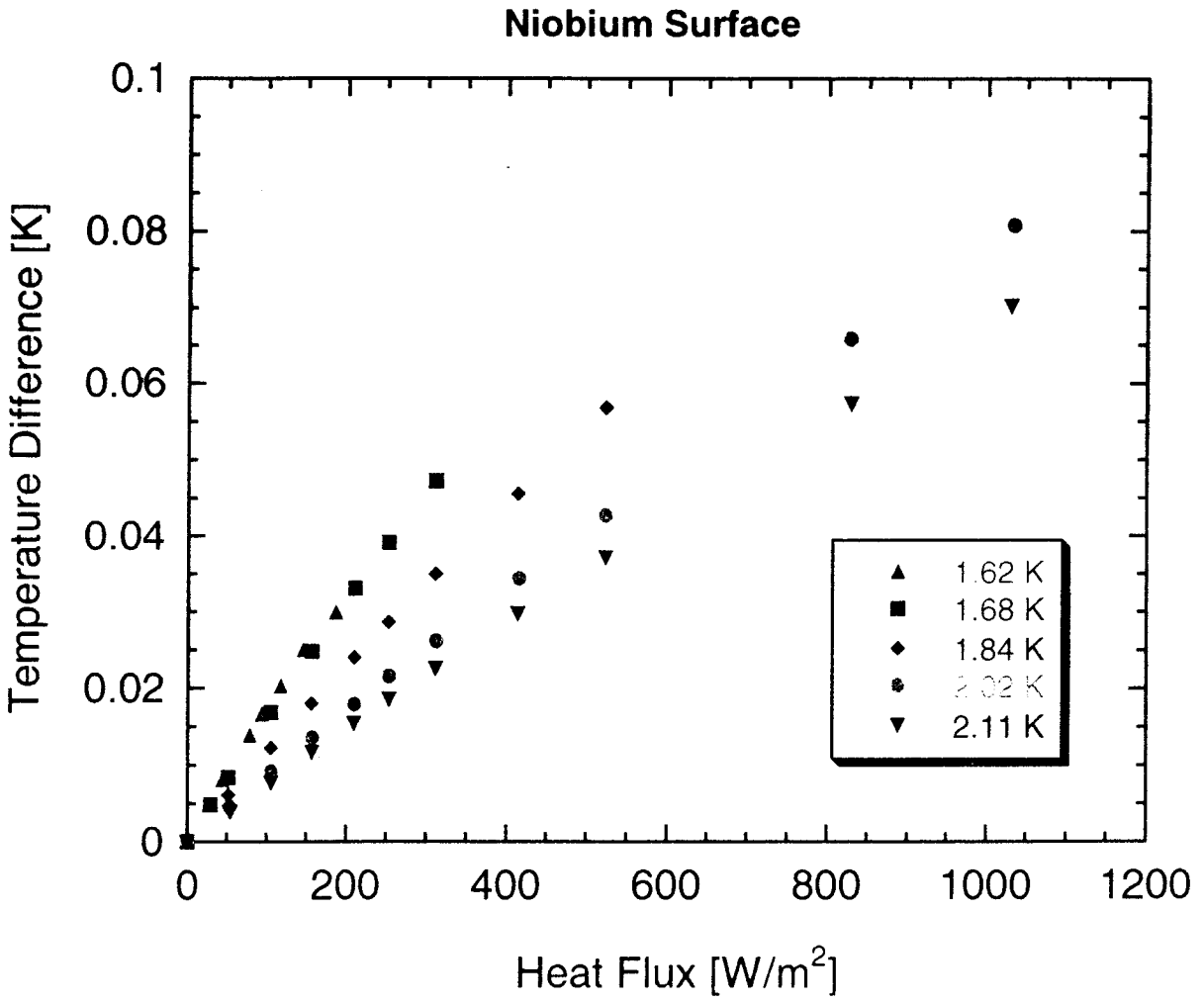
Work supported in part by DESY, the NHMFL, and the US Department of Energy, Division of High Energy Physics, under grant DE-FG02-96ER-40952

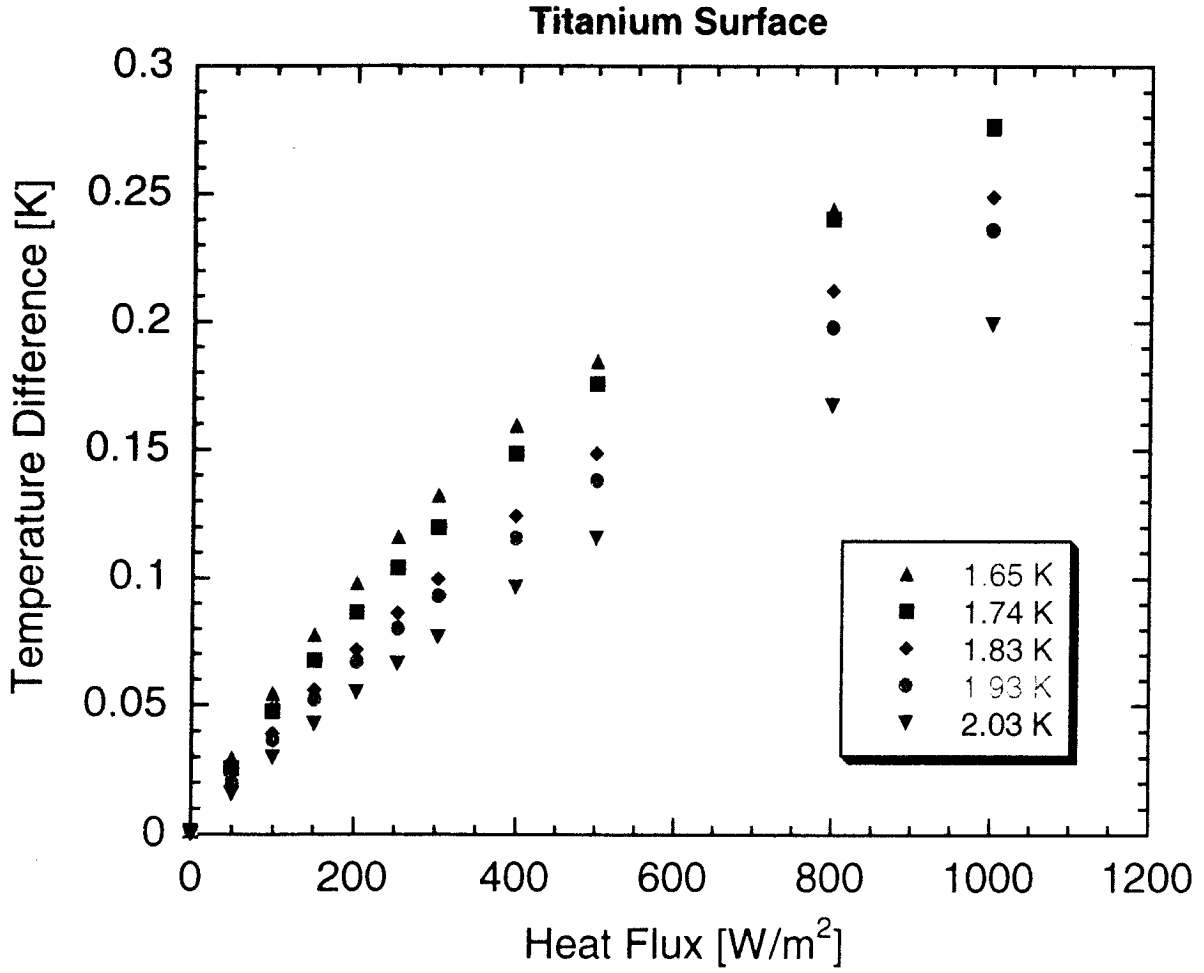
DESY Thermal Resistance Study

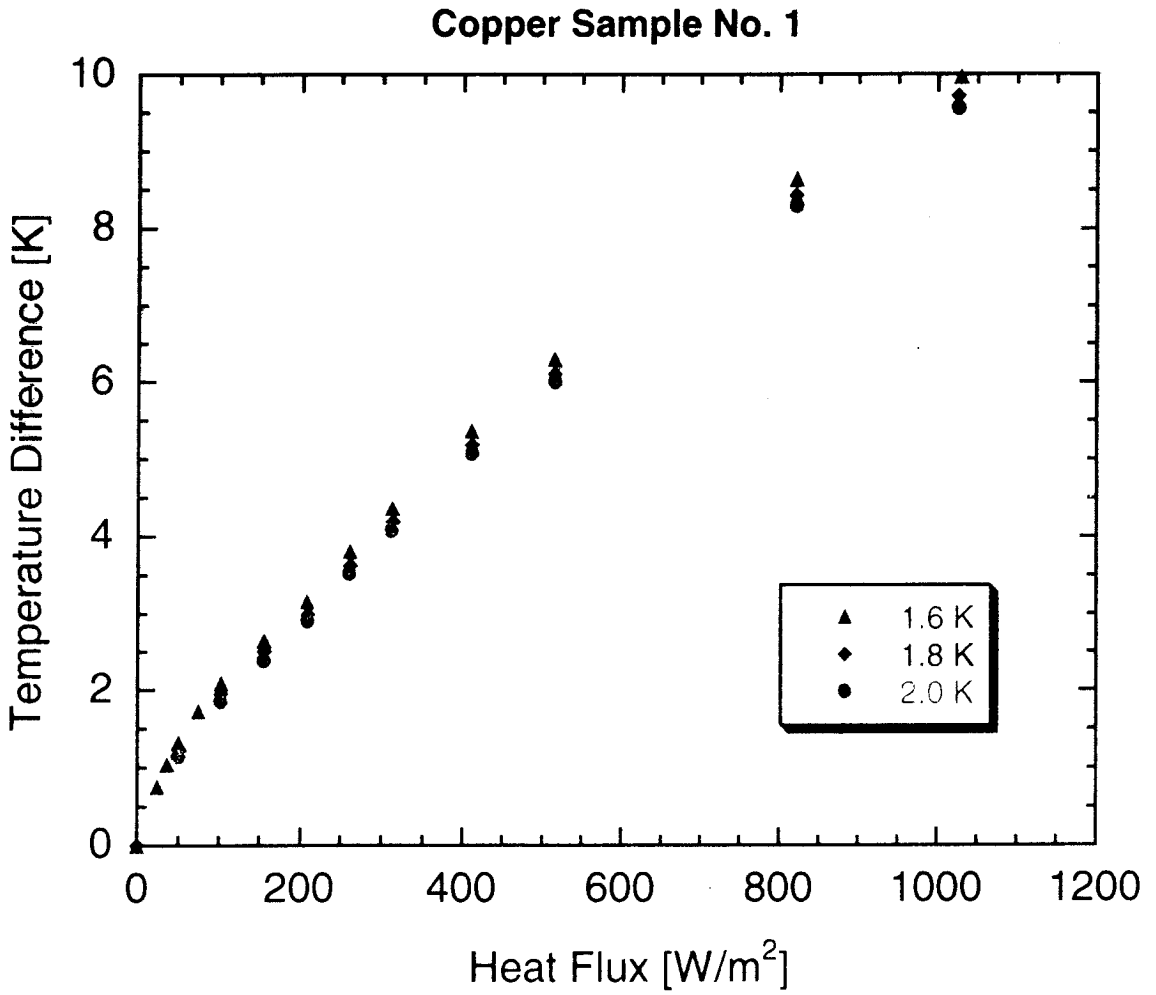


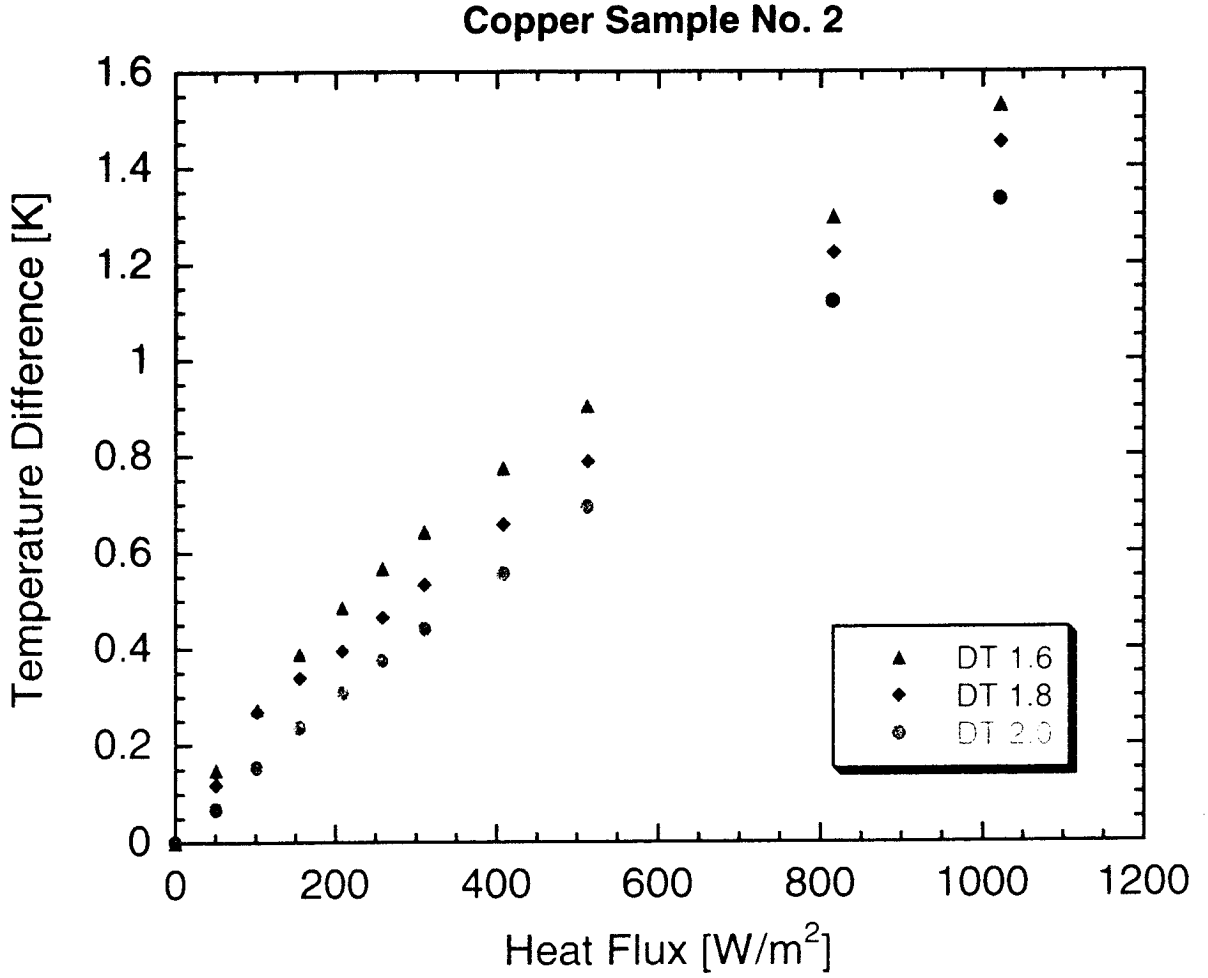


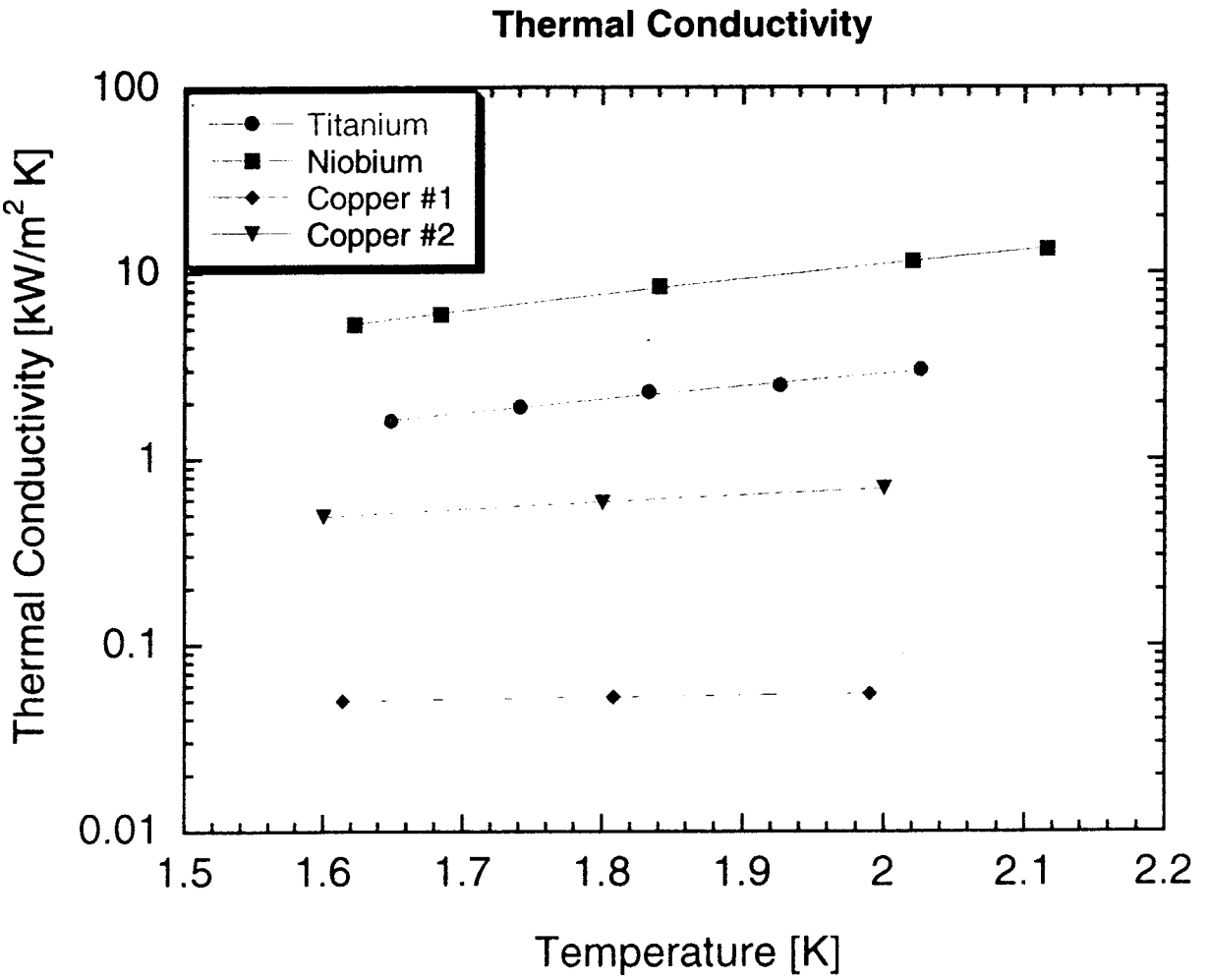
- SAMPLE DIMENSIONS:
  - ϕ85 mm X 3 mm THICK
  - COPPER COATED SAMPLES WERE MUCH THICKER
- ϕ 60 mm RESISTIVE HEATER MOUNTED TO THE VACUUM SIDE, COVERS NEARLY THE ENTIRE SURFACE
- CERNOX TEMPERATURE SENSORS, ± 1 mK


Niobium Surface
Temperature Difference [K]
0.1
0.08
0.06
0.04
0.02
0
0
200
400
600
800
1000
1200
Heat Flux [W/m^2]
1.62 K
1.68 K
1.84 K
2.02 K
2.11 K


Titanium Surface
Temperature Difference [K]
0.3
0.25
0.2
0.15
0.1
0.05
0
0
200
400
600
800
1000
1200
Heat Flux [W/m^2]
1.65 K
1.74 K
1.83 K
1.93 K
2.03 K


Copper Sample No. 1
Temperature Difference [K]
Heat Flux [W/m^2]
0
2
4
6
8
10
0
200
400
600
800
1000
1200
1.6 K
1.8 K
2.0 K


Copper Sample No. 2
Temperature Difference [K]
Heat Flux [W/m^2]
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
0
200
400
600
800
1000
1200
DT 1.6
DT 1.8
DT 2.0

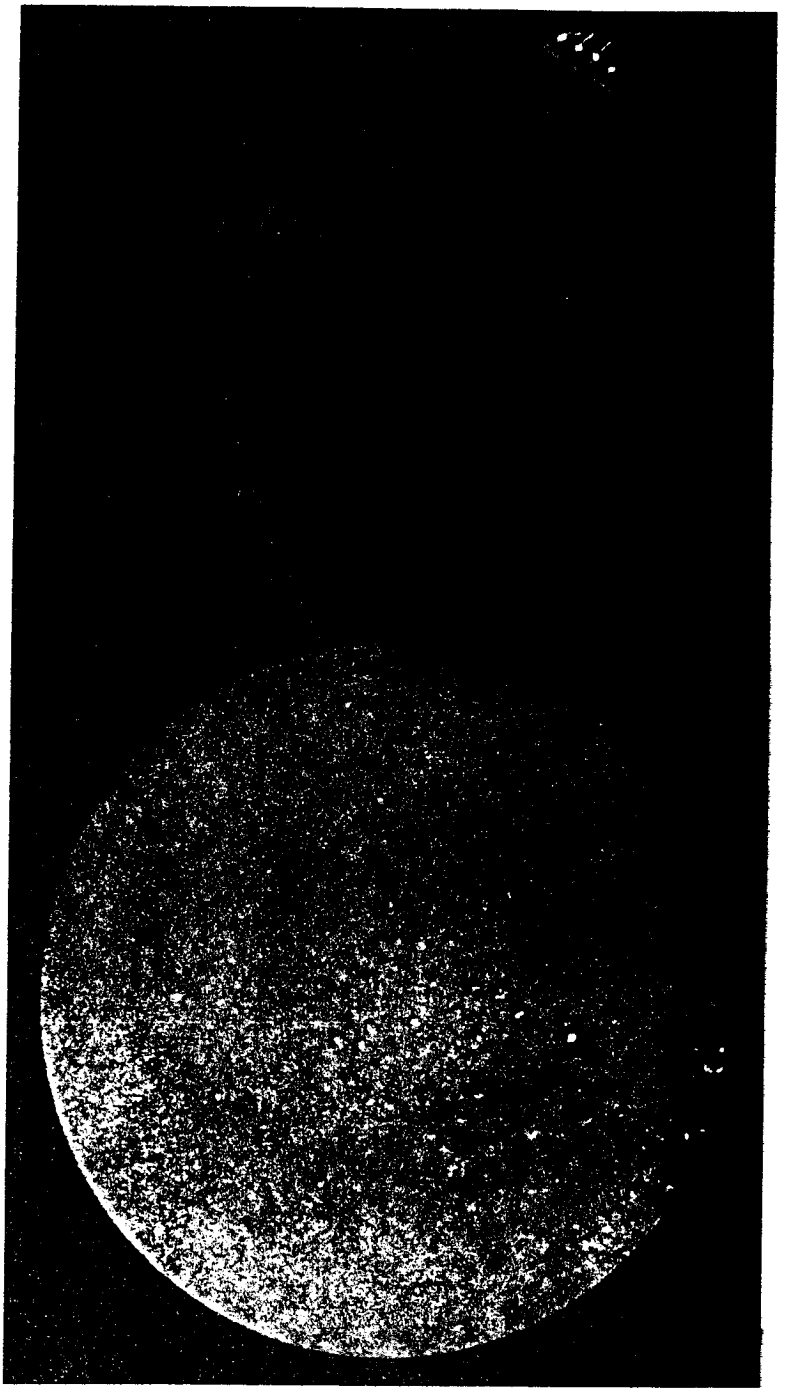

Thermal Conductivity
Titanium
Niobium
Copper #1
Copper #2
Thermal Conductivity [kW/m^2 K]
100
10
1
0.1
0.01
1.5
1.6
1.7
1.8
1.9
2
2.1
2.2
Temperature [K]

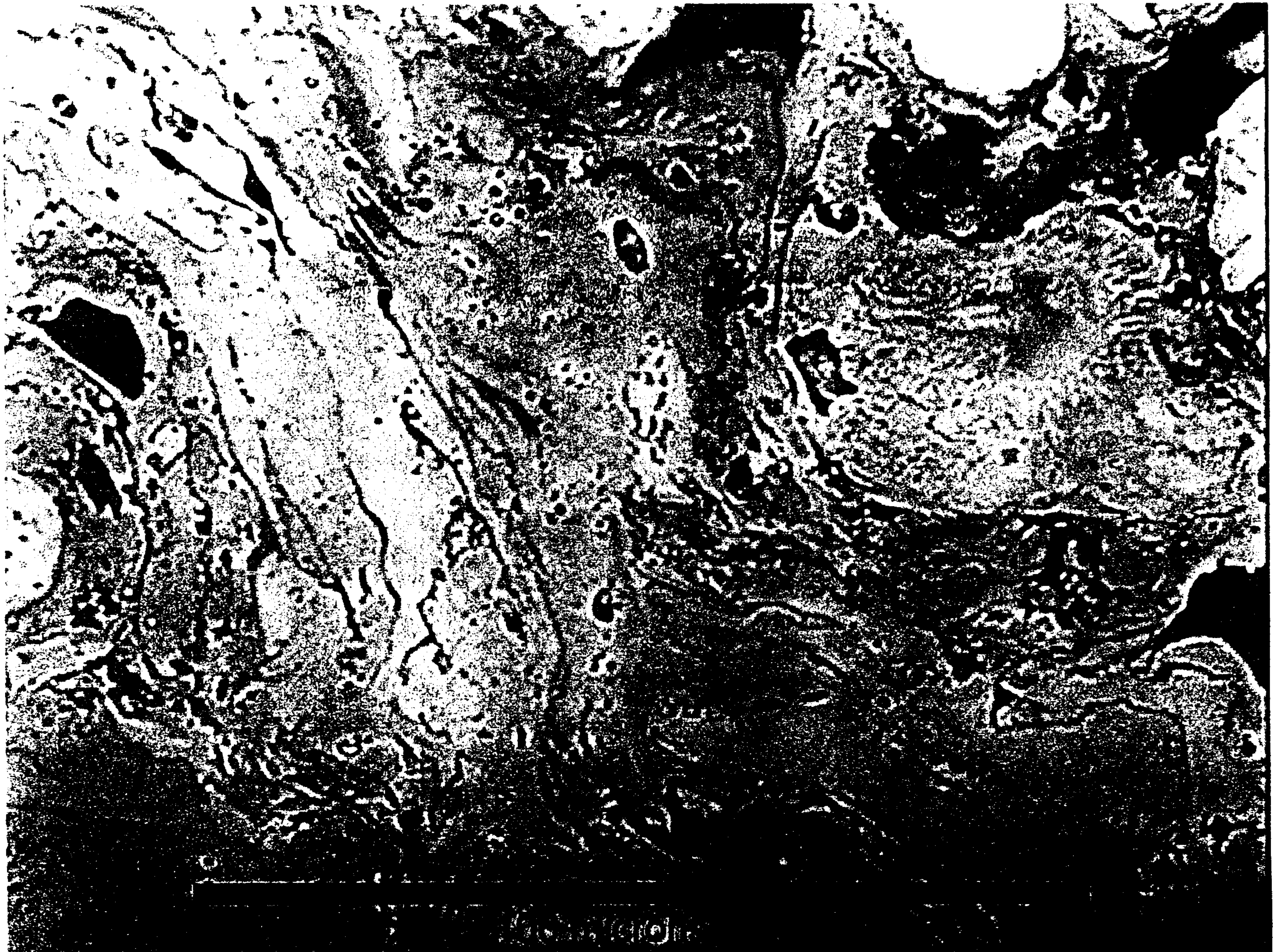
FITS OF THE FORM:

$$K_{eff} = \alpha \cdot T^{\beta}$$

WHERE

	α	β
Niobium	0.955	3.543
Titanium	0.363	2.993
Copper #1	0.0404	0.447
Copper #2	0.2299	1.594





CONCLUSIONS:

- PURE NIOBIUM HAS THE BEST OVERALL THERMAL CONDUCTANCE
- TITANIUM COATING LOWERS THE THERMAL CONDUCTANCE
  - CONTACT RESISTANCE AT Nb/Ti INTERFACE
  - POSSIBLE FORMATION OF Nb/Ti ALLOY AT THE INTERFACE
- COPPER COATING DRASTICALLY LOWERS THERMAL CONDUCTANCE
  - HIGH FRACTION OF COPPER OXIDE DUE TO UNCONTROLLED ENVIRONMENT DURING APPLICATION
  - MULTIPLE UNCONNECTED VOIDS MAY HAVE AN INSULATING EFFECT
  - HIGHLY VARIABLE RESULT FROM SAMPLE TO SAMPLE