Niobium and Titanium

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Abstract

This paper summarizes some of the many differnt properties of Noibium and Titanium. Lattice dimmantions, elastic constants, some optical properties are mentioned. More interesting are the low temperature properties of these two materials. In specific, these two materials are being used to create multi-layered Joesphson Junctions arrays.

I. INTRODUCTION

The two materials Niobium and Titanium have many different properties. A compairson of lattice dimentions, elastic constants and some different reflective properties are given. The low temperature physics is discuessed and an applications of these two materials

II. LATTICE STRUCTURES

Niobium has a body centered cubic lattice while Titanium has a hexognal close packed structure. The lattice dimension for Niobium is $a = 0.33004\ nm$ and for Titanium $a = 0.29506\ nm$ and $c = 0.46835\ nm$ [2]. The density of Niobium is $8.578\ g/cm^3$ and Titanium has a density of $4.5063\ g/cm^3$. The Debye temperature determines the specific heat of a material and is 273 for Niobium and 415 for Titanium [1].

III. ELASTIC CONSTANTS

The elastic constants for Niobium and Titanium were taken at 27 *degrees celsius* and were measured using sound propagation methods [3], [4] in units of $10^11\ d/cm^2$. For Niobium, $C_{11} = 24.65$, $C_{44} = 2.873$, $C_{12} = 13.45$. For Titanium, $C_{11} = 16.240$, $C_{12} = 9.200$, $C_{13} = 6.900$, $C_{33} = 18.070$ and $C_{55} = 4.670$.

IV. OPTICAL PROPERTIES

The optical properties of Niobium and Titanium are given here for two different wavelengths of the incident light (4132.67 and 1239.8 angstroms). The index of refraction is n, the extinction coeficient is k and the angle of normal incident reflection in radians is R are given for both wavelength values. For $\lambda = 4132.67\ A^0$, $n = 2.51$, $k = 2.68$ and $R = 0.485$ for Nb and $n = 1.59$, $k = 2.17$ and $R = .444$ for Ti. When $\lambda = 1239.8\ A^0$ $n = 1.18$, $k = 1.05$ and $R = .194$ while for Ti $n = .89$, $k = .88$ and $R = .180$. The dielectric function $\epsilon = \epsilon_1 + i\epsilon_2$ where $\epsilon_1 = 2nk$ and $\epsilon_2 = n^2 + k^2$. The complex index of refraction is $N = n + ik$ can also be found[1].

V. LOW TEMPERATURE PROPERTIES

Niobium and Titanium have very different properties at low temperatures. Titanium is a type I superconductor and is rather uninteresting by itself because it doesnot go superconducting until temperatures below $.4\ K$. While Niobium on the other hand go superconducting at $9.25\ K$ and is a type II superconductor. See Figure 1[1] for the superconducting transitions. These two materials are useful together in a multi-layered structure such as a 3-D Joesphson Junction array. Niobium and Titanium are good candiates for this because of the temperature range in which one can make observations, i.e. $.4 < T < 9.2\ K$. This is being studied here at U. C. by Luis Gometz.

The critical field that each material can with stand is also very different. For Niobium, a type II superconductor, there are two critcal fields. Below the first critical field, Niobium acts like a perfect diamagnet. Above which Niobium enters the mixed state. In this state, a material allows regions of normal conducting material to coexist with superconducting material. Flux tubes form in the normal regions and allow the applied magnetic field to penatrate which inturn forces supercurrents to circulate around the flux tubes. The number of flux tubes continue grow in integer numbers until the applied field reaches the second critical limit. This limit is 2060 Oersted for Niobium. Above this field, the material reverts to it's normal state. Since Titanium doesnot have these properties, it is a good inbetween layer. The difference in entropy near the T=0 range between the superconducting and normal states is related directly to the electronic specific heat, γ. $(S_s - S_n)$ as $T- > 0$ $= -\gamma T$. For Niobium $\gamma = 7.80\ mJ/molK$ and for Titanium $\gamma = 3.3\ mJ/molK$ [1].

VI. SECONDARY ELECTRON EMISSION

When a material bombarded with electrons, electron-electron interactions will allow electrons to be freed. The ratio of freed elecrtons to emitted electrons is called δ. This secondary yield is a function of the incident electron energy. δ_{max} is the maximum yield corresponding to the primary electron energy E_{max}. The energies corrisponding to δ of unity are E_i and $E_i i$. Figure 2 is a generic graph of δ vs primary electron energy[1]. Niobium has a δ_{max} of 1.3 corrisponding to a maximum energy of 375 eV. Titanium has a deltamax of 0.9 corrisponding to a maximum energy of 280 eV. Titanium doesnot have any seconday emmissions that corrispond to a delta to unity. Niobium does have two primary electron energies that corrispond to δ of unity. They are 150 and 1050 eV respectively.

VII. CONCLUSION

In conclusion, Niobium has many interesting properties at low temperatures. The different properties of Niobium and Titanium at low temperatures allows for multi-layered superconductors to be built. This is an exciting field, and when achived will make a great contrabution to physics.

REFERENCES

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FIGURES

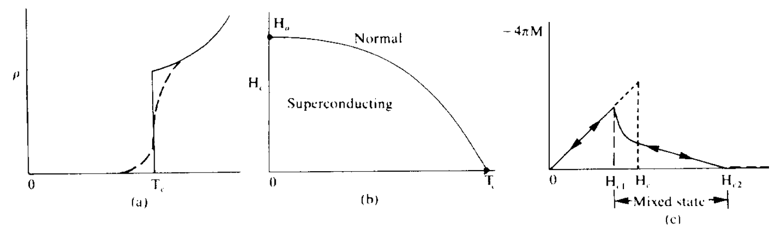

Figure 1. PHYSICAL PROPERTIES OF SUPERCONDUCTORS

(a) Resistivity versus temperature for a pure and perfect lattice (solid line). Impure and/or imperfect lattice (broken line).
(b) Magnetic-field temperature dependence for Type-I or "soft" superconductors.
(c) Schematic magnetization curve for "hard" or Type-II superconductors.

FIG. 1. Graphs describing the superconducting state.

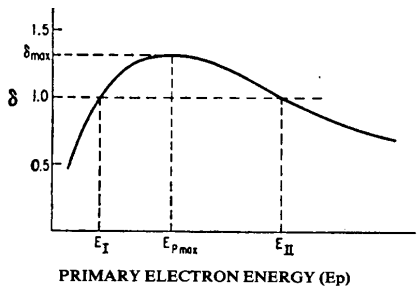

FIG. 2. Graph showing the δ vs. incident electron energy.