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METHOD FOR SPUTTERING NIOBIUM OR TANTALUM THIN FILMS

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Fig. 1.

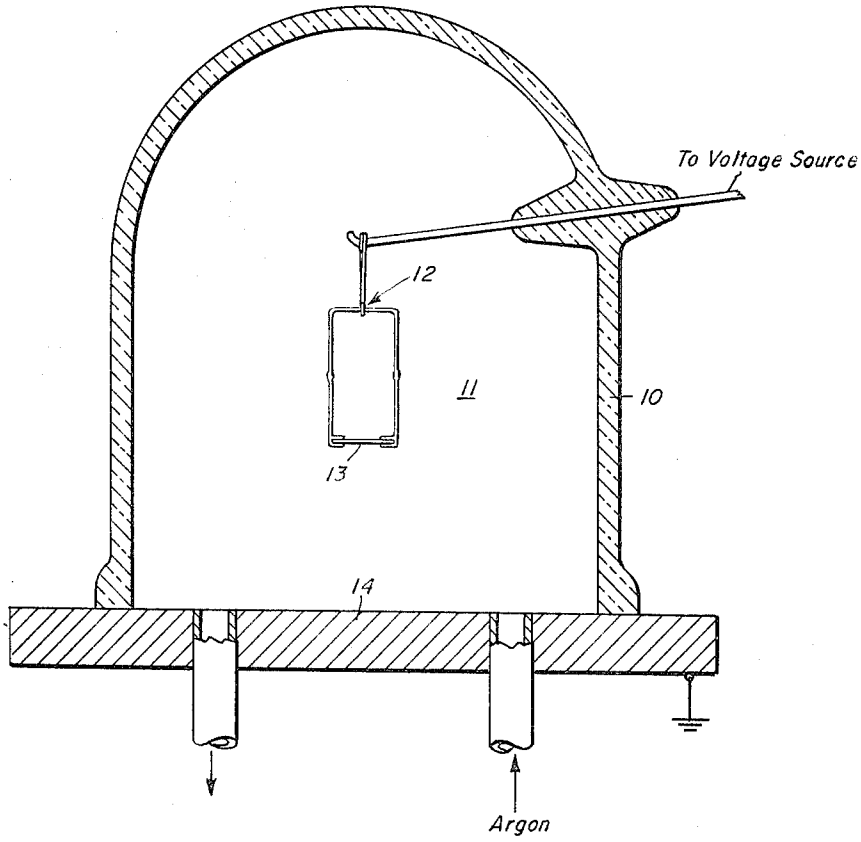
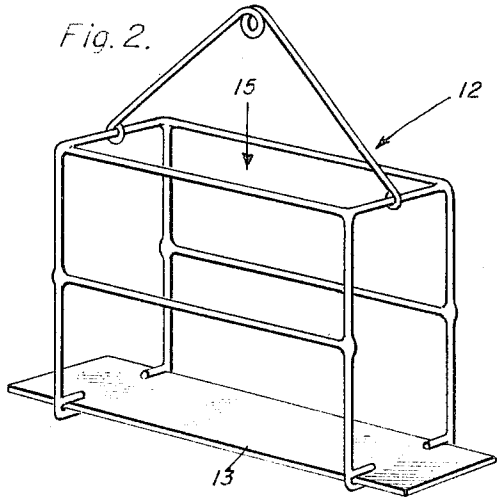


Fig. 2.



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METHOD FOR SPUTTERING NIOBIUM OR TANTALUM THIN FILMS

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1 Claim. (Cl. 204—192)

This invention relates to sputtered metal films and more particularly to an improved sputtering process for producing superconductive films of niobium or tantalum.

In recent years, intensive investigation has been undertaken in the area of superconductivity and especially in that concerning superconductive thin films. The metals tantalum and niobium have evoked considerable interest but, unfortunately, these metals are often difficult to obtain in thin films which retain the superconductive properties of the bulk material. Among the various methods attempted to produce thin superconductive films of tantalum or niobium is cathodic sputtering. However, the process must usually utilize an asymmetric alternating current so that what is termed "back sputtering" from the anode is accomplished, it being felt that this back sputtering eliminates impurities from the film as it is being formed that would otherwise preclude obtainment of superconductive properties.

It is a principal object of the invention to provide an improved process for sputtering superconductive films of niobium or tantalum onto a suitable substrate.

Other objects and advantages of this invention will be in part obvious and in part explained by reference to the accompanying specification and drawings.

In the drawings:

FIG. 1 is a side elevation of one type of apparatus which can be used to carry out the process of this invention, and

FIG. 2 is a somewhat schematic illustration showing the type of cathode grid used to carry out the present process.

Generally, the process of this invention comprises locating a suitable substrate within an enclosure chamber which is connected to a source of argon. Also located within the enclosed chamber is a perforate or screen-like cathode which is positioned in operative relationship with respect to the film substrate. By providing an argon atmosphere within the enclosed chamber and activating the cathode, the cathode being constructed of either tantalum or niobium, argon atoms are ionized and directed against the surface of the cathode body. Simultaneously, some of the argon ions which miss the cathode hit the substrate and thus clean the substrate surface of impurities. Metal ions are propelled from the cathode due to the ion bombardment and some strike the substrate so that a film of metal is gradually built up. It has been found that by following this process, superconductive films of the two metals mentioned can be formed.

Referring to the drawings, the numeral **10** indicates means defining an enclosed chamber **11**. The means **10** may constitute, as shown, a simple bell jar arrangement. Within chamber **11** is located a cathode **12** which is constructed of either tantalum or niobium, a growth substrate such as quartz plate **13** and an anode **14** which is the ground return for cathode **12**. It will be noted that the growth substrate **13** is located between the cathode and the anode so that ions which miss the cathode will flow toward anode **14** and strike the substrate **13**.

FIG. 2 of the drawings illustrates one specific cathode construction which enables the present process to be carried out. Specifically, the cathode **12** is perforate so that it has a number of passages **15** through which argon ions may pass. The cathode may take many configurations as long as openings exist through which the argon ions can pass without striking the cathode itself. For example, the cathode may be of a screen-like mesh configuration or may be a punched sheet.

Using an apparatus similar to that shown in FIG. 1, the enclosed chamber **11** was supplied with an argon gas of 0.1 micron pressure which was continuously pumped through the chamber, the cathode was at a potential of 1000 volts to effect the sputtering operation which was effected for about 20 minutes. At the end of this time, the quartz substrate **13** had a body centered cubic niobium film 4000 A. thick which film had a critical current of 4 amps at 4.2° K. in no applied magnetic field. When the argon system was changed so that a fresh supply was not present during the entire sputtering operation, that is a stagnant argon atmosphere of 0.1 micron, the film had a face-centered cubic structure but was superconducting.

To test the efficacy of the process with tantalum, a mesh cathode was constructed and placed in an apparatus like that of FIG. 1. Argon was pumped through the sputtering chamber at a pressure of 0.09 micron, the cathode current was 10 milliamperes and cathode voltage was 800–1000 volts. Sputtering was effected for 60 minutes using a quartz substrate on which the tantalum film was deposited. The resulting thin film was superconducting at 4.2° K. with a critical current of 3.4 milliamperes in zero applied magnetic field.

Although the present invention has been described in connection with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and the appended claim.

What I claim as new and desire to secure by Letters Patent of the United States is:

A method of sputtering superconductive films of niobium or tantalum on to a supporting substrate comprising, positioning a perforate cathode having at least one opening the axis of which is substantially perpendicular to the substrate and which is constructed of a metal selected from the group consisting of niobium and tantalum within an enclosed chamber, providing an anode operatively spaced from the cathode, locating a suitable substrate within the enclosed chamber between the cathode and the anode, introducing a supply of argon into the enclosed chamber, and energizing the perforate cathode with direct current whereby the substrate is hit simultaneously by ionized argon and cathode metal to form a superconductive film.

References Cited by the Applicant

"Superconductive Films Made by Protected Sputtering of Tantalum or Niobium," Rudolph Frericks, Journal of Applied Physics, 33, 5, 1898 (1962).

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