NASA TECH BRIEF

Preparation of Superconducting Thin Films of Transition-Metal Interstitial Compounds

The problem:

Preparation of thin films of NbN, or of similar compounds, having transition temperatures similar to that of the bulk material. Hitherto no superconducting compounds having transition temperatures extending into the liquid-hydrogen range ($\gtrsim 13.6°K$) have been successfully made into thin films for use in tunneling devices.

The solution:

By a new technique such transition-metal interstitial compounds can be formed into thin films having transition temperatures similar to those of the bulk materials. Since the films' magnetic-field and current-carrying properties exceed those of the bulk materials, they may have applications other than in tunneling devices.

How it's done:

An all-glass-and-metal sputtering system was constructed, capable of evacuation down to the low 10^{-10} Torr range. The disposition chamber proper consists of two glass portions sealed together over copper gaskets. Multiple electrodes entering the chamber, through glass presses, permit the use of a quartz-crystal microbalance, temperature-monitoring thermocouples, bias sputtering, or substrate-heating —in addition to the sputtering. The system is evacuated with an oil-diffusion pump trapped with liquid nitrogen. After a 16-hour bake-out at about 400°C or its equivalent, the system normally reaches a pressure of less than about 5×10^{-10} Torr.

Simple cold-cathode dc sputtering is used, but a unique cathode configuration can be employed. Instead of the usual flat configuration the cathodes are shaped like a square box open at one end, the substrate-holder being positioned inside the box. As well as removing the substrate from the line of sight of the residual gas impurities in the system, this system provides a gettering action from the material sputtered from the back and sides of the cathode.

After evacuation and the baking-out, and with the pumps still operating, nitrogen is leaked into the system until the pressure reaches 6×10^{-5} Torr. Argon is then introduced until the desired current-voltage conditions are established: 80 mA and 1700 V. At this current the cathode is bombarded at about 1 mA/cm^2; the pressure of argon required for this power is about 50×10^{-3} Torr. The rate of sputtering under these conditions is about 5 Å/sec at a substrate-target distance of 0.375 inch. No external heating of the substrate need be employed since, under the conditions described, the substrates reach a temperature of about 500°C within about 30 seconds and remain there throughout.

The conditions described are for NbN; related compounds can be sputtered as easily by variation of the compositions of the cathode target and the reactant gas—of either or both. Thin films of NbN can be grown having transition temperatures between 15° and 16°K; they have upper critical fields at least 50-kgauss higher than do bulk samples, and at 4.2°K they are still superconducting at 180 kgauss.

Note:

No further documentation is available. Inquiries may be directed to:

Technology Utilization Officer
Headquarters
National Aeronautics
and Space Administration
Washington, D.C. 20546
Reference: B69-10470

(continued overleaf)

Patent status:

Title to this invention has been waived, under the provisions of the National Aeronautics and Space Act [42 U.S.C. 2457 (f)], to the Westinghouse Electric Corporation, Pittsburgh, Pennsylvania 15235.

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