Josephson Junction Device for Superconductive Electronics
Technology #12362

Applications

Josephson Junctions (JJ) are used in a variety of superconductive electronic technologies including telecommunications, superconducting quantum computers, sensitive magnetic sensors, and biological applications including neuron signaling.

Problem Addressed

Existing Josephson junction devices have a low operating temperature and a low frequency range. These JJs are based on niobium or niobium nitride which require cryogenic liquids to cool to operating temperatures. Niobium and niobium nitride are also costly materials which require long manufacturing times. Niobium is not naturally abundant and is also toxic. MgB$_2$ has been studied extensively since it can function at temperatures between 20-25K using cryocoolers. Trilayer Josephson tunnel junctions using Al$_x$O$_y$ or AlN, as a thin tunnel barrier layer have also been reported; however, the properties of the barrier layer and the MgB$_2$/barrier interface are not ideal because they are not well understood or difficult to control. The high cost of materials, cooling techniques, and lack of design control in existing JJs has made them difficult to commercialize.

Technology

This Josephson junction is a two terminal trilayer thin film structure consisting of two superconductors separated by an ultra-thin tunnel barrier insulator. MgB$_2$ is an optimal superconductor for this application since it can be fabricated by point contact into ramp type and various planar structures. This device functions at temperatures close to its superconducting ordering temperature. Since the operating temperature is above 20K, the device can work by simply cooling with closed cycle refrigeration that uses only electrical power. This gets rid of the need for cryogenic liquids. The trilayer structure is made on a buffered semiconductor wafer, grown in situ in one step at temperatures below 300 C. Molecular beam epitaxy is used to create the structure, and photolithography and electron-beam lithography are used to pattern the Josephson junction into micron and nano sized devices. MgB$_2$ based JJ devices make it ideal to develop superconductive electronics that will be essential in the future for device operation in the picosecond time scale with essentially no energy loss.

Advantages

- Al$_2$O$_3$, MgB$_2$, and MgO are naturally available materials with considerably lower costs than Niobium
- MgB$_2$ Josephson junctions can be mass manufactured at low cost on cheap Si wafers
- Higher operating temperature enables cheaper closed cycle refrigeration rather than expensive cryogenic liquid cooling
Categories For This Invention:

Electronics & Circuits
Electronic Components
Superconductors

Intellectual Property:

Josephson junction device for superconductive electronics with a magnesium diboride
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Publications:

Magnesium diboride superconductor thin film tunnel junctions for superconductive electronics
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External Links:

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Image Gallery: