Method For Superconducting Tunnel Junction Fabrication

Tech ID: 24082 / UC Case 2013-242-0

BACKGROUND

In recent years, superconducting tunnel junctions have become a viable technology for a range of cryogenic applications. Superconducting tunnel junction — also known as a superconductor–insulator–superconductor tunnel junction (SIS) — is an electronic device consisting of two superconductors separated by a thin layer of insulating material. Current passes through the junction via the process of quantum tunneling. These devices have a wide range of applications, including high-sensitivity detectors of electromagnetic radiation, magnetometers, high speed digital circuit elements, and quantum computing circuits. Normal-insulating-superconducting (NIS) junctions have been used as on-chip quantum refrigerators and more recently as bulk cryogenic coolers.

Both SIS and NIS technologies require pristine dielectric barriers limited to a thickness of a few nanometers. These barriers are typically fabricated using thermal oxidation of Al or Al alloys using a controlled combination of temperature, partial pressure of oxygen, and time. Unfortunately, the diffusive nature of thermal oxidation can lead to point defects in the tunnel barrier that affect junction quality and limit device performance.

TECHNOLOGY DESCRIPTION

Researchers from UC San Diego have developed a new process for fabricating high quality tunnel barriers in NIS and SIS tunnel junctions. Specifically, the inventors have demonstrated a large area superconducting tunnel junction using atomic layer deposition (ALD) to form a high quality insulating tunnel barrier.

APPLICATIONS

• Epitaxial deposition using ALD eliminates defects that previously prevented commercial viability of this technology.

• Application of ALD to create tunnel junction barriers allows the barrier thickness to be precisely tuned down to 0.02nm, allowing for further improvements in device properties.

• High quality tunnel barriers can be deposited on materials that do not natively oxidize.

• Tunnel junction cryogenic refrigerators, cryogenic thermometers, superconducting quantum computer bits (qubits).

STATE OF DEVELOPMENT

Working prototype demonstrates viability of technology: electronic transport measurements confirm that single-particle electron tunneling is the dominant transport mechanism, and the measured current-voltage curves demonstrate the viability of using these devices as self-calibrated, low temperature thermometers with a wide range of tunable parameters.

RELATED MATERIALS

▶ Stephanie M. Moyerman, Guangyuan Feng, Lisa Krayer, Nathan Stebor, Brian G. Keating. 17-Mar-2014. Atomic Layer Deposition of Tunnel Barriers for Superconducting Tunnel Junctions. Journal of Low Temperature Physics http://dx.doi.org/10.1007/s10909-014-1114-8 - 03/17/2014

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	9,425,377	08/23/2016	2013-242

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OTHER INFORMATION

KEYWORDS

Superconducting tunnel junctions; Atomic layer deposition; Tunnel barriers

CATEGORIZED AS

- **Engineering**
  - Engineering
- **Materials & Chemicals**
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- **Nanotechnology**
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  - Design and Fabrication

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