On-Chip Microfluidic Dilution Refrigerator for Quantum Devices

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OTHER INFORMATION

KEYWORDS

On-Chip Microfluidic Dilution Refrigerator, Quantum Devices, Quantum Processors, Quantum Sensors, Cryogenic Cooling, Helium 3, Helium 4, Mixing Chamber

CATEGORIZED AS

- **Optics and Photonics**
  - All Optics and Photonics
- **Biotechnology**
  - Other
- **Energy**
  - Other
- **Engineering**
  - Engineering
- **Imaging**
  - Other
- **Materials & Chemicals**
  - Other
- **Nanotechnology**
  - Other
- **Research Tools**
  - Other

BACKGROUND

When quantum systems, like quantum processors and sensors, operate at room temperature, they do so at optical wavelengths to avoid the thermal population of their qubit states. Avoiding thermal population at longer wavelengths requires cryogenic temperatures. Despite current challenges in reaching these low temperatures, low-temperature quantum computers are better poised for commercial implementation due to the relative ease of manipulating electrons in low-temperature systems as compared to photons at room temperature. Conventional cooling systems such as dilution refrigerators are large, costly, and unlikely to be adopted outside a laboratory environment. A solution that achieves the required cryogenic conditions and is efficient both in cost and form factor would help usher in the benefits of quantum information science at a commercial scale.

DESCRIPTION

Researchers at the University of California, Santa Barbara, have developed a concept for an on-chip microfluidic dilution refrigerator (MDR) that can efficiently cool quantum components — a critical advancement toward fully integrated quantum processors and sensors. The invention features a microfluidic system comprising a mixing chamber wherein helium 3 dissolves in helium 4 to form a mixture that absorbs heat, thereby cooling a device in thermal contact with the mixing chamber. A pumping system circulates the helium 3 that is evaporated from the mixture to a heat exchanger via a microfluidic channel, then diverts the helium 3 back to the mixing chamber. Fully integrated quantum systems, with their far lower size and cooling power requirements, are the most viable path toward commercial applications of quantum technology. The success of these processors will rely on their cooling systems, and this technology could provide a compact, low-power, and affordable cryogenic cooler.

ADVANTAGES

- Integrates cryogenic cooling on-chip for quantum processors
- Drastically reduced size (80×20×3 mm) and cost compared to conventional dilution refrigerators

APPLICATIONS

- Quantum Computing
  - Quantum sensing
  - Space-based applications

PATENT STATUS

Patent Pending

RELATED CASES

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