

課題番号 : F-16-KT-0064  
利用形態 : 機器利用  
利用課題名(日本語) : 熱トンネル現象を用いた冷却素子  
Program Title(English) : Development of thermotunneling refrigerator  
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### 1. 概要(Summary)

We are developing a futuristic refrigerator, integrable in chip-scale devices, that operates by quantum-mechanically tunneling higher energy (greater than Fermi energy) electrons across a nano size gap[1]. To fabricate a nano gap, we take the following approach: fabricating a pair of electrodes by controlled fracture of an overhanging silicon microbeam along <111> direction through a MEMS device, which is likely to result in smooth and conformal electrodes. This will help increasing the emission area, and therefore the effect of electronic energy transfer will be more prominent. We fabricated devices to generate and measure the nano gap by cleaving at Nanotechnology Hub, Kyoto University.

### 2. 実験(Experimental)

#### 【利用した主な装置】

Laser pattern generator (A3) , Double-sided mask aligner (A54), Thermal evaporator (B4), Reactive ion deep silicone etcher (DRIE) (B8), Vapor HF release etcher (B12)

#### 【実験方法】

First, the metal patterns (electrodes) were formed by lift off process using A54 and thermal evaporator. After this process, the device layer was patterned with A54. DRIE process was subsequently conducted using B8.

### 3. 結果と考察(Results and Discussion)

The fabricated electromechanical device is

shown in Fig. 1. The nanogap is shown in the insert. The emission current across the nanogap has been measured successfully.

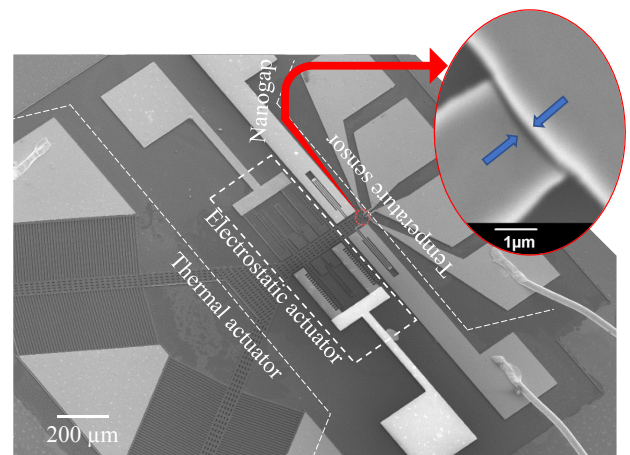


Fig. 1 MEMS device and its parts.

### 4. その他・特記事項(Others)

#### ・参考文献 Reference

[1] Y. Hishinuma, T. H. Geballe, B. Y. Mozyshes, and T. W. Kenny, Appl. Phys. Lett. 78, 2572 (2001).

#### ・関連論文

(1) A. Banerjee, Y. Hirai, T. Tsuchiya, and O. Tabata, Jpn. J. Appl. Phys. (in press).

(2) A. Banerjee, Y. Hirai, T. Tsuchiya, and O. Tabata, 11th IEEE Int. Conf. Nano/Micro Engineered and Molecular Systems (IEEE-NEMS 2016), 2016, B3P-B-61.

(3) A. Banerjee, Y. Hirai, T. Tsuchiya, and O. Tabata, 29th Int. Microprocesses and Nanotechnology Conf. (MNC 2016), 2016, 11C-10-5

### 5. 論文・学会発表(Publication/Presentation)

なし。

### 6. 関連特許(Patent) なし。