課題番号	:F-18-KT-0001
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及び熱発電素子の開発
Program Title(English)	:Developing thermotunneling refrigerator and energy harvester
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キーワード／Keyword	:リソグラフィ・露光・描画装置、micro-fabrication, thermotunneling, nanogap

1. 概要(Summary)

We are developing a novel method to fabricate nanogap electrods (~ 100 nm) with uniform gap distance across large overlapping area (~ 10 μm^2). We propose a micro-electromechanical system (MEMS) to fabricate large-area uniform nanogap electrodes by controllably cleaving a <111>-oriented micro-beam of silicon through an integrated thermal actuator, and using the smooth fracture surfaces as emission electrodes while maintaining their required orientation using springs [1].

2. 実験(Experimental)

【利用した主な装置】

1. Laser pattern generator (A3)
2. Double-sided mask aligner (A54)
3. Thermal evaporator (B4)
4. Reactive ion deep silicone etcher (DRIE) (B8-2)
5. Vapor HF release etching (B12)

【実験方法】

The Microelectromechanical device was fabricated by adopting silicon microfabrication technique [1]. Silicon-On-Insulator (SOI) wafer is utilized. First, the metal patterns (electrodes) are formed by lift off process using double sided mask aligner and for photolithography and thermal thin film deposition machine for metal film deposition (Cr-Au-Cr). The bottom Cr layer (20 nm) is for improving adhesion of the Au film (200 nm) with the silicon surface, and the top Cr film will act as a mask layer for subsequent DRIE process. After this process, the device layer is patterned with photolithography, which produces photoresist mask of the device components for the DRIE process. DRIE process is subsequently conducted, which defines the device areas. After removing the DRIE mask materials and dicing the wafers into chips, HF vapor etching was conducted to release the device layer.

Chips were attached on the packages and electrical connections are made and the fracture fabricated nanogaps are produced. Then, it is placed inside SEM chamber for in situ current – voltage (I-V) studies in vacuum.

3. 結果と考察(Results and Discussion)

The emission current – voltage (I-V) result across the nanogap is shown in the plot in Fig. 1. The nonlinear regime is observed to follow the Fowler-Nordheim type emission, as a plot between $\ln(I/V_b^2)$ versus $1/V_b$ shows a linear behavior [1].

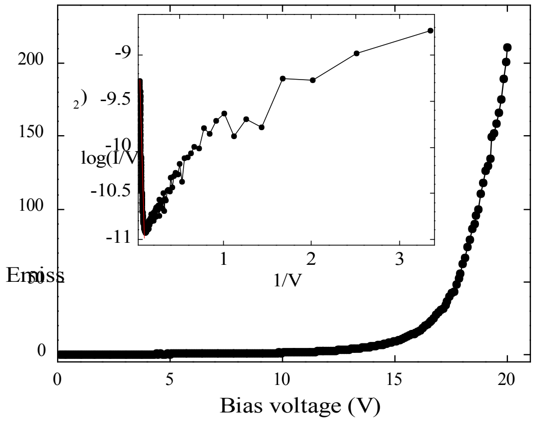

Fig. 1 Emission data from a 120 nm size nanogap. Inset shows a corresponding Fowler-Nordheim plot.

4. その他・特記事項(Others)

・参考文献 Reference

[1] A. Banerjee, Y. Hirai, T. Tsuchiya, and Osamu Tabata, Jpn. J. Appl. Phys 56, 06GF06 (2017).

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・Yazaki Foundation

関連論文

(1) A. Banerjee, Y. Hirai, T. Tsuchiya, O. Tabata, Jpn. J. Appl. Phys., 56 06GF06 (2017).

(2) A. Banerjee, Y. Hirai, T. Tsuchiya, O. Tabata, IEEE international meeting for IMFEDK., Kansai, 17082316 (2017).

(3) A. Banerjee, Y. Mori, Y. Hirai, T. Tsuchiya, O. Tabata, MRS Fall meeting, Boston, ES09.03.28 (2017).

5. 論文・学会発表(Publication/Presentation)

なし。

6. 関連特許(Patent)

なし。