# Measurement on electron transport via nanomechanical electron shuttle

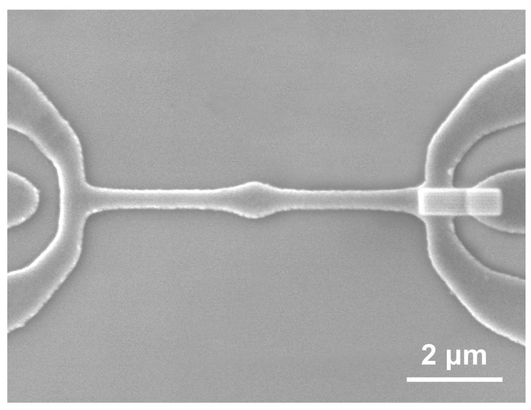
Donggeun Lee[1,2], Byungho Lee[1,3], Hokyun Lim[1,4], Chulki Kim[1]
[1]Sensor System Research Center, Korea Institute of Science and Technology, Republic of Korea
[2]Department of Electrical and Electronic Engineering, Yonsei University, Republic of Korea
[3]Department of Mechanical Engineering, Pohang University of Science and Technology, Republic of Korea
[4]Department of Physics, Kookmin University, Republic of Korea

## Abstract

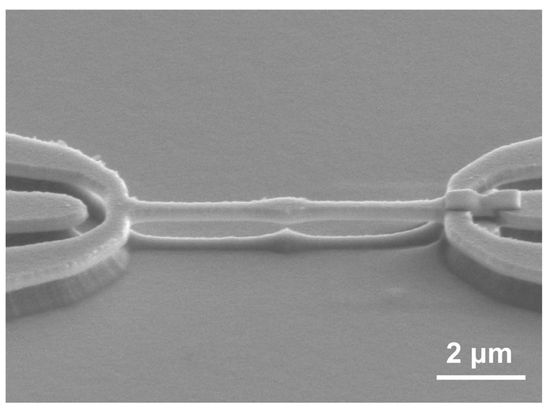
We realized a nanomechanical electron shuttle which consists of a metallic island on a cantilever. This nano mechanical pendulum was fabricated on a $SiO_2$/Si substrate using conventional semiconductor fabrication processes. The metallic island is externally driven to oscillate between source and drain electrodes due to the cantilever motion in an in-plane flexural mode . The upper part of the cantilever was excited by applying an AC voltage between two electrodes on the left and right hand sides of the cantilever. The shuttling current was observed with the application of a bias voltage between the source and drain electrodes.

## Device Fabrication

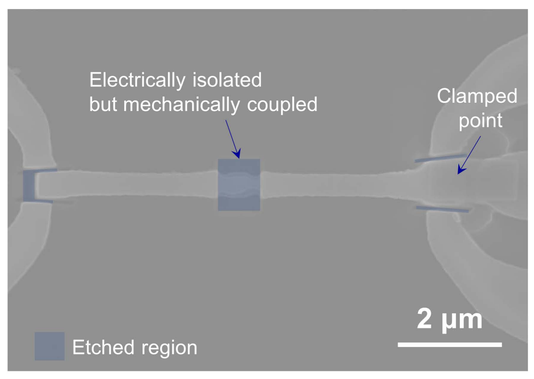
### 1. Photolithography & Electrode Deposition



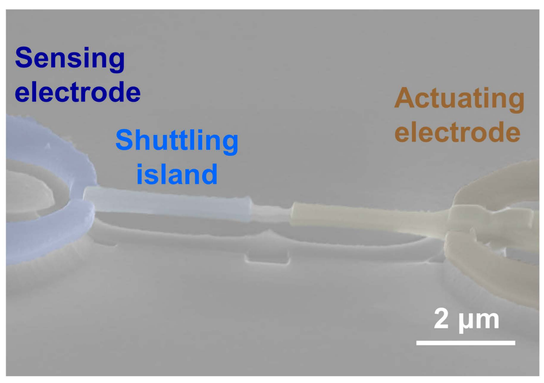

### 2. Reactive Ion etching




### 3. Selective Etching with Focused Ion Beam

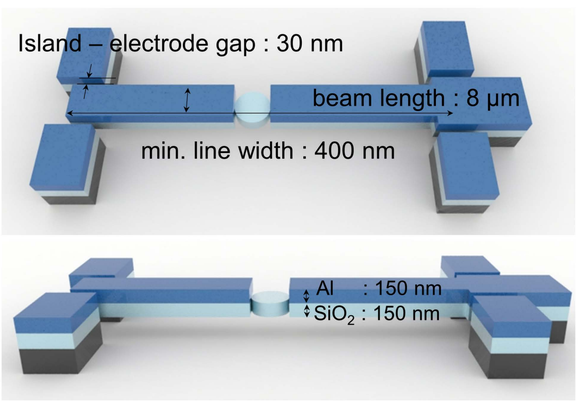



### 4. Fabrication Result of NEM electron shuttle

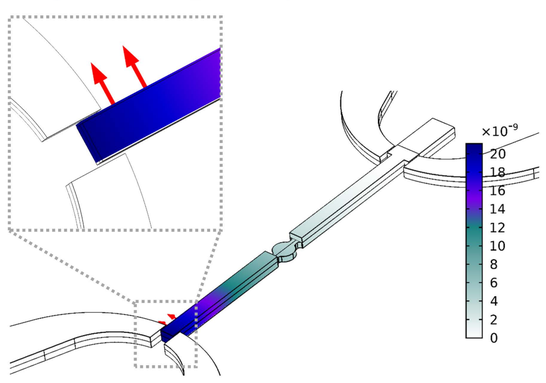



## Finite Element Model Analysis

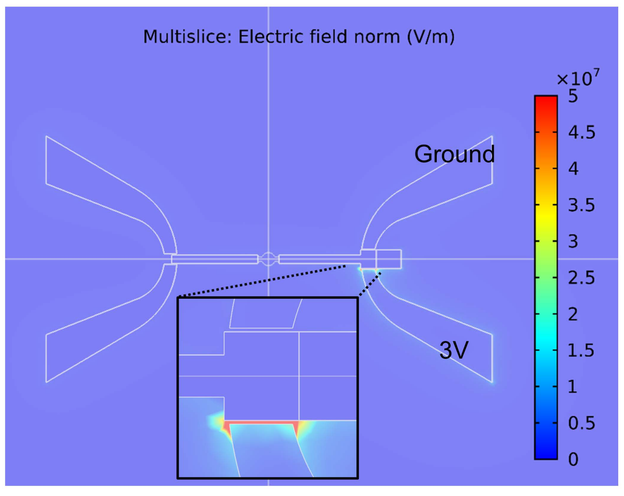
### Device Structure



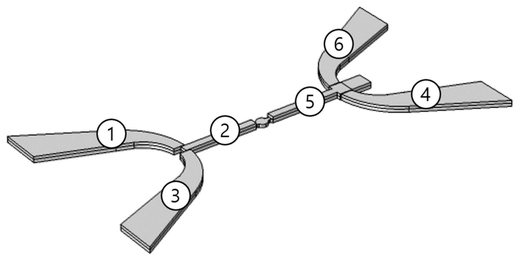

### Eigen Frequency (3.774 MHz)




### Electric Field Distribution




### Capacitance



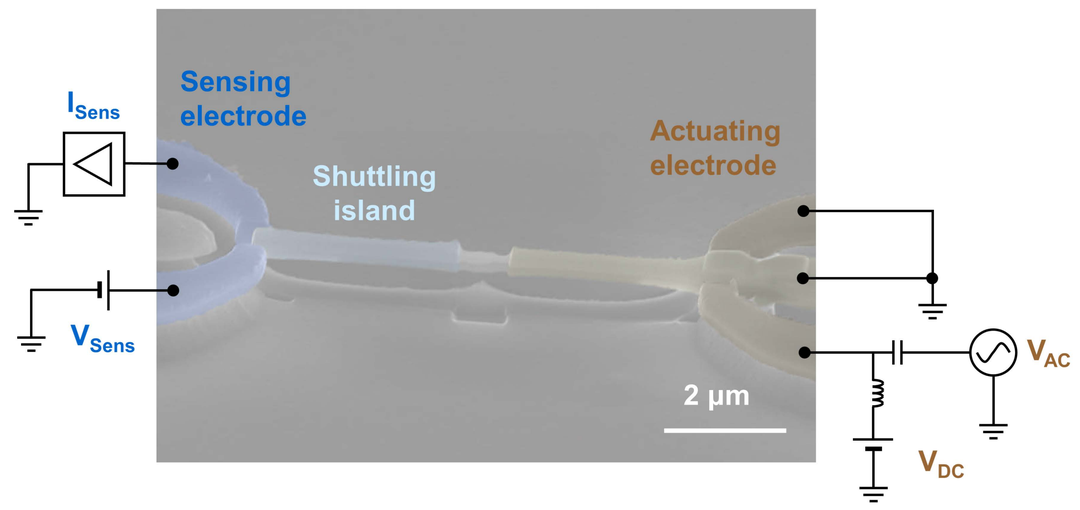

$C_2 \approx 150$ [aF]

$E_C = e^2/(2C) \approx 0.5$ [meV]

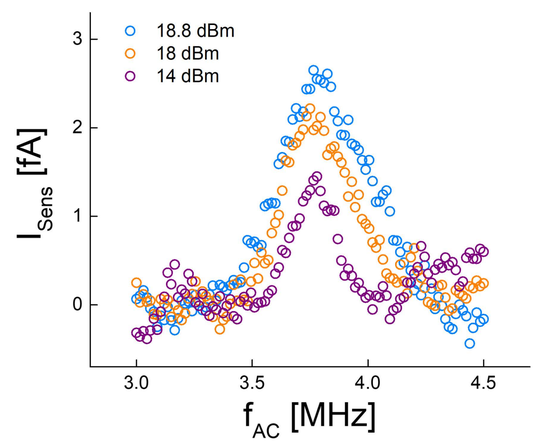
$T \approx 6$ [K]

## Measurement Setup & Results

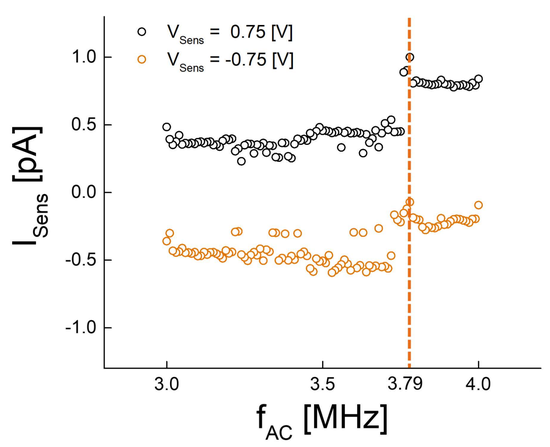
### AC/DC Measurement in Vacuum Chamber (~$10^{-6}$ Torr)



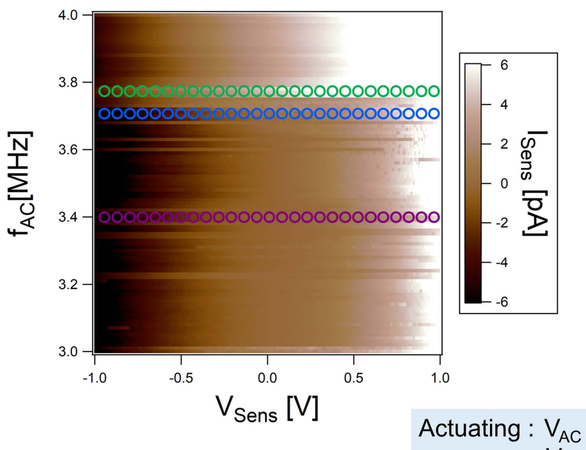

### Shuttling current spectrum at 300K

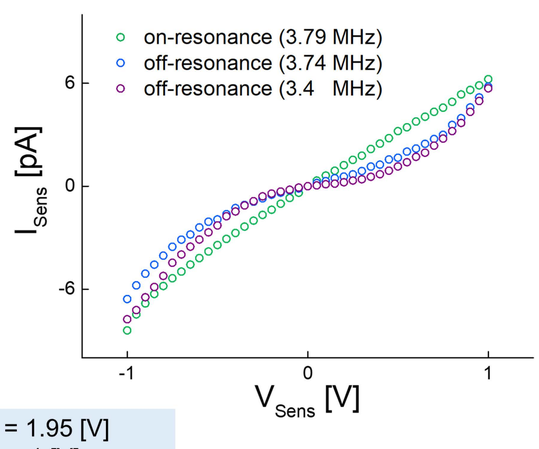



Actuating : $V_{AC}$ = 2 ~ 0.8 [V]
$V_{DC}$ = 0.1 V
Sensing : $V_{Sens}$ = 0.1 V




Actuating : $V_{AC}$ = 1.95 [V]
$V_{DC}$ = 1 [V]
Sensing : $V_{Sens}$ = -0.75, 0.75 [V]

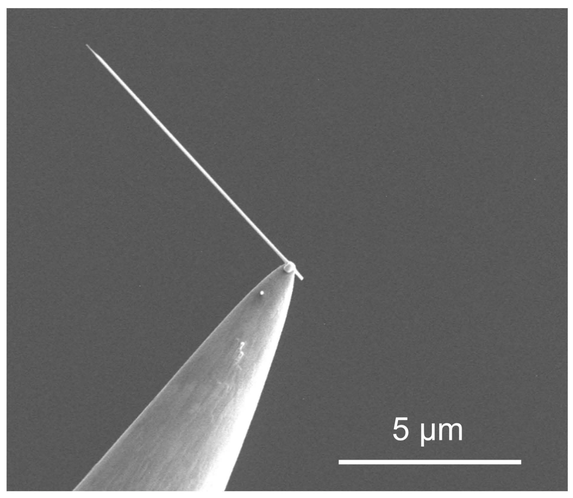


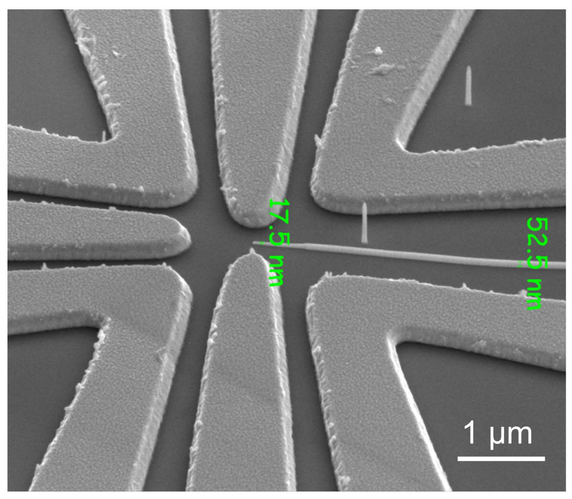




Actuating : $V_{AC}$ = 1.95 [V]
$V_{DC}$ = 1 [V]
Sensing : $V_{Sens}$ = -1 ~ 1 [V]

## Future work

- Perform electron transport measurement at low temperature
- Measure the supercurrent below its critical temperature
- Observe nanowire's mechanical motion due to self-excitation and measure the shuttling current

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