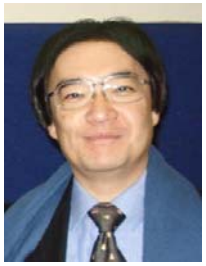
【Grant-in-Aid for Scientific Research(S)】
Science and Engineering (Engineering)



Title of Project : Development of graphene NEMS hybrid functional devices for autonomous and ultrasensitive integrated sensors

Hiroshi Mizuta
(Japan Advanced Institute of Science and Technology (JAIST),
School of Materials Science, Professor)

Research Area : Engineering, Electric and electronic engineering
Keyword : Electronic devices / integrated circuits, NEMS, graphene, mass detection sensors

【Purpose and Background of the Research】

Highly-functional hybrid electronic devices based on nano-electro-mechanical-systems (NEMS) are getting increasing interests. RF NEMS switches and ultrasensitive NEMS sensors are intensively studied for extreme mass and charge detection, thanks to their large surface-to-volume ratios.
In this project, we aim at developing resonant graphene NEMS sensors which enable simultaneous detection of an extremely-small mass change with mass responsivity ranging from sub-zeptogram/Hz down to Dalton/Hz and single-electron-level charge transfer. We also study nonvolatile graphene NEMS switches by controlling short-range forces such as van der Waals force between graphene and substrate. In addition, we build multi-scale simulation and process integration technologies for autonomous and ultrasensitive graphene NEMS sensor systems.

【Research Methods】

The present project is divided into the following five work packages, [WP1] – [WP5]. In [WP1], we investigate a highly-accurate sensing principle by combining detection of the resonant frequency shift caused by gas molecules adsorbed on the graphene nanoribbon (GNR) and electrical detection of charge transfer between adsorbed molecules and GNR in terms of the shift of the charge neutrality point. WP2 intends to develop a novel sensing method to identify adsorbed molecule species via their molecular vibration spectra by using inelastic tunneling spectroscopy. In WP3, we develop nonvolatile gprahene NEMS power management devices which enable quasi-energy-reversible switching. WP4 focuses on building multiscale simulation covering *ab initio* modeling of GNRs to equivalent circuit modeling for NEMS integrated circuits as well as atom-scale analysis of adsorbed molecules on GNRs using state-of-the-art scanning transmission electron microscope (STEM). In WP5, we develop fabrication processes to co-integrate our graphene NEMS sensors and power management devices monolithically.

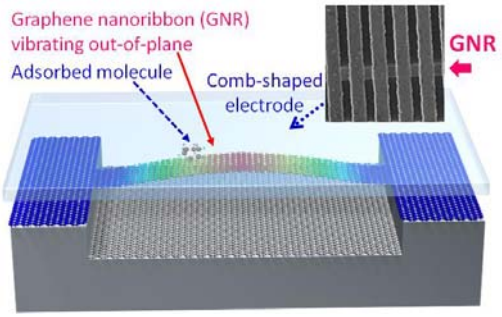


Figure 1 Resonant GNR mass detection sensor

【Expected Research Achievements and Scientific Significance】

This is highly original research aiming at co-integrating functional NEMS sensors and nanoscale power management devices on a new monolayer material platform, graphene. The unique ultrasensitive environmental sensing technology will enable to detect a wide range of harmful gas molecules such as volatile organic compound (VOC) molecules. In addition, the developed power management nanotechnology can be used widely to make integrated systems autonomous. The project impacts will therefore be paramount both on basic science and ICT industry.

【Publications Relevant to the Project】

- F. A. Hassani, H. Mizuta *et al.*, 'Numerical analysis of zg/Hz-level mass responsivity for in-plane resonant nano-electro-mechanical sensors', Microelectronic Engineering **88**(9), 2879-2884 (2011)
- H. Mizuta and Y. Tsuchiya, 'NEMS and nanodeices', *New technologies and applications of nano silicon* (in Japanese), *N. Koshida ed.*, 108 – 121, CMC publishing (2010)

【Term of Project】 FY2013-2017

【Budget Allocation】 124, 800 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.jaist.ac.jp/ms/labo/mizuta.html
mizuta@jaist.ac.jp