Effect of suspended electrodes on the dynamics of Graphene nano-resonators

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Nanoscale mechanical resonators are candidates for ultra-sensitive sensing applications[1] of vital physical quantities, such as, mass, force, charge, etc. It is further advantageous to fabricate nanoscale resonators from ultra-thin materials to achieve high-resolution sensing, due to their small effective mass. Graphene, a stable, atomically-thin 2D carbon material (along with its exceptional mechanical properties) is therefore an excellent choice for fabricating nanoscale resonator[2,3]. Typically, a suspended graphene nano-ribbon is vibrated in its fundamental frequency (f) by a periodic mechanical excitation (Fig. 1(A)); shift in this frequency (δf) under the influence of an external perturbation, like addition of mass by gas adsorption, is then used to measure the extent of that perturbation, facilitating the sensing process[4].

A common way to suspend graphene nano-ribbon (GNR; produced by mechanical exfoliation or reactive etching of CVD graphene film on SiO_2/Si substrates) is by (bHF) etching of the oxide layer underneath the GNR[5,6]. This process often undercuts the metal-electrodes[5,6] on the GNR-resonator, partially suspending them along with the GNR-resonator (Fig. 1(A)); however, the influence of the suspended electrodes on the eigenmodes and the dynamics of the GNR-resonators is unknown. Using finite element simulation (Comsol Multiphysics), we analyze the eigenmodes of GNR-resonators with suspended metal (Au) electrodes. We show the role of the suspended metal electrodes in determining the mode-shapes and the eigen-frequencies of such GNR-resonators (Fig. 1(B)).

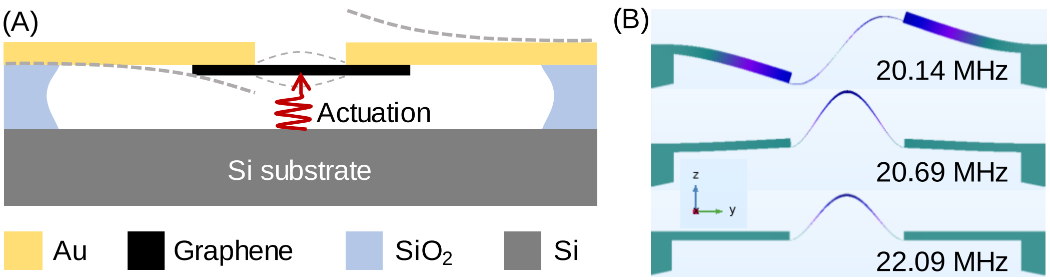

Fig. 1. (A) Schematic diagram of GNR-resonator structure (suspended by etching of SiO_2) with overhanging metal film on top, (B) closely spaced eigen-frequencies and mode-shapes calculated by finite element analysis.

Acknowledgement: This research is supported by TAIYO YUDEN Co. Ltd and Grant-in-Aid for Scientific Research Nos: 18K04260, 18H03861, 19H05520 from Japan Society for the Promotion of Science (JSPS).

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