Probing graphene nanomesh fidelity by electrical transport measurement

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An intrinsic energy gap can be opened in monolayer graphene due to quantum confinement by preparing narrow graphene nanoribbons (GNRs). However, the current carrying capacity of each individual GNR is low, and the formation of graphene with a dense array of pores was suggested as an alternative [1]. The so called graphene nanomesh (GNM) is commonly prepared by masked reactive ion etching with neck widths down to 6 nm, however, the dimensions have a large variation and no structural control is possible. The structural control is required for several applications, such as wave guides [2] and phononic crystals (PnCs) [3]. Recently, we succeeded to form GNMs in suspended graphene by helium ion beam milling with pitch down to 9 nm [4]. For slightly larger devices with 200-300 nm length, the pitch of 18 nm is obtained.
An effective energy gap of ~450 meV is observed for a perfect device with 18 nm pitch. This gap vanishes in other devices where pores are omitted on purpose or other reasons. We attribute this to the formation of a leakage path between source and drain along the less-constricted graphene areas. We report a similar dependence on the effective energy gap for large area GNM, as well. Here, we will discuss how the variation of GNM dimensions (such as neck width) directly affect the confinement, and we discuss how the quality of graphene nanomesh can be probed by electrical measurement before integrating the GNM into more challenging measurement schemes.

Acknowledgments: The authors acknowledge T. Iijima and Y. Morita for the usage of the helium ion microscope at the AIST SCR station for the helium ion irradiations**.** This research was supported through the Center Of Innovation (COI) program of the Japan Science Technology Agency.

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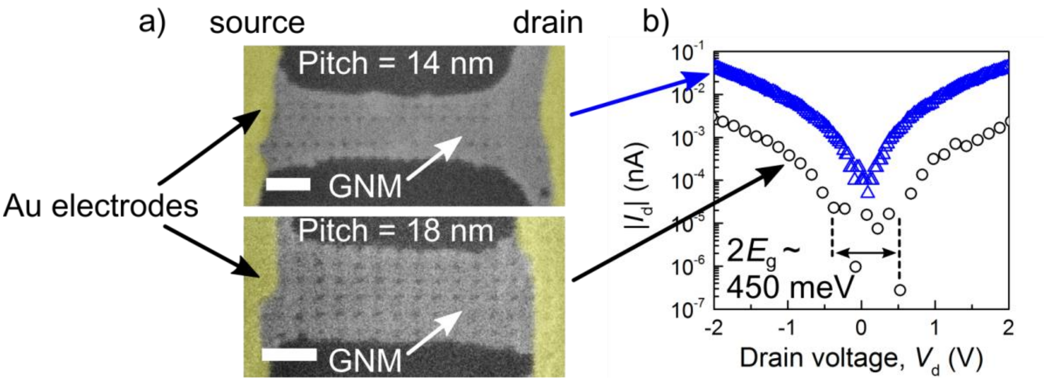

Figure 1: (a) GNM devices with pitch of 14 and 18 nm. In the upper GNM, a row of pores is missing, while the bottom GNM is of high quality. (b) Source-drain measurement results for the two GNM in (a). The GNM with missing pores shows metallic behavior, while the high quality GNM has an effective energy gap of ~450 meV.