**Decreasing contact resistance in graphene devices by optimizing edge contact under metal**

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**Abstract**
Graphene is two dimensional material which has combination of unique mechanical, electrical and optical properties. Due to the unique properties of graphene, it has potential for several applications such as RF devices[1] and ultrafast photodetectors[2]. Reducing contact resistance of metal-graphene is important for further improvement of graphene devices and for realization of graphene based electronics[3]. Graphene contact resistance can be reduced in many ways such as reducing surface roughness of metal[4]; removing photoresist residues[5] and increasing edge contact length [6]. The contact resistance of graphene was significantly improved by contact area patterning where the edge contact length was increased [3], [7]. Patterned area also increases transfer length which in turn improves contact resistance by reducing current crowding effect [7]. This method is reproducible and has further room to improve the contact resistance.
In this research, graphene under the metal contacts was patterned with series of holes of 100nm to 300nm radius. The holes were patterned by E-beam lithography (Fig.1a), and metallization was carried out by electron beam evaporation (Pd(20nm)/Au(30nm)) followed by lift-off process(Fig.1b). The effects of the geometrical parameters of the holes and different graphene length under the metal are investigated experimentally and numerically. Also, the effects of removal of PMMA residue by oxygen plasma etching on top of the structures are studied.

**References**
[1]L. Yu, Y.-H. Lee, X. Ling, E. J. G. Santos, Y. C. Shin, Y. Lin, M. Dubey, E. Kaxiras, J. Kong, H. Wang, and T. Palacios, *Nano Lett.*, no. Cvd, May 2014.
[2]F. Xia, T. Mueller, Y.-M. Lin, A. Valdes-Garcia, and P. Avouris, *Nat. Nanotechnol.*, vol. 4, no. 12, pp. 839–43, Dec. 2009.
[3]J. T. Smith, A. D. Franklin, D. B. Farmer, and C. D. Dimitrakopoulos, *ACS Nano*, vol. 7, no. 4, pp. 3661–3667, 2013.
[4]E. Watanabe, A. Conwill, D. Tsuya, and Y. Koide, *Diam. Relat. Mater.*, vol. 24, pp. 171–174, 2012.
[5]J. a. Robinson, M. Labella, M. Zhu, M. Hollander, R. Kasarda, Z. Hughes, K. Trumbull, R. Cavalero, and D. Snyder, *Appl. Phys. Lett.*, vol. 98, no. 5, pp. 2011–2014, 2011.
[6]K. Nagashio and A. Toriumi, *Jpn. J. Appl. Phys.*, vol. 50, no. 7, p. 070108, Jul. 2011.[7]S. Min Song, T. Yong Kim, O. Jae Sul, W. Cheol Shin, and B. Jin Cho, *Appl. Phys. Lett.*, vol. 104, no. 18, p. 183506, 2014.

**Figures**

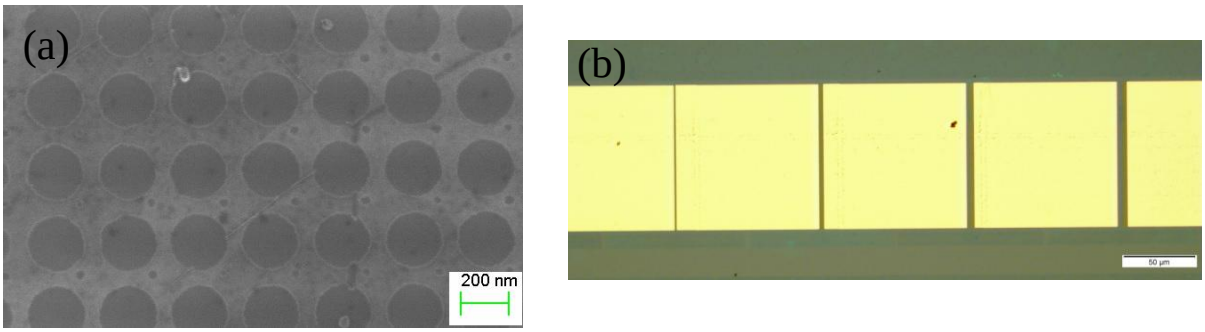


Figure1: a) Holes with 100nm radius on graphene patterned by E-beam lithography. B) Metal contacts with various 1-7 micron graphene channel for TLM measurements