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Plasma Synthesis of Integrated Graphene Nanoribbons and its Optoelectrical Applications

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We have developed a new, simple, scalable method based on novel plasma catalytic reaction [1-3] for directly fabricating narrow graphene nanoribbons (GNRs) devices on an insulating substrate [4]. Since the establishment of our novel GNRs fabrication method, direct conversion of a Ni nanobar to a suspended GNR is now possible. Indeed, GNRs can be grown at any desired position on an insulating substrate without any post-growth treatment, and the wafer-scale synthesis of suspended GNRs arrays with a very high yield (over 98%) is realized [5]. The growth dynamics of suspended GNRs is also investigated through the systematic experimental study combined with molecular dynamics simulation and theoretical calculations for phase diagram analysis. Unique optoelectrical property, known as persistent photoconductivity (PPC), is also observed in our suspended GNRs devices. By using the PPC, GNRs-based non-volatile memory operation is demonstrated [6]. High thermoelectric performance is also shown in our as-grown suspended GNRs [7]. We believe that our results can contribute to pushing the study of atomically thin layered materials from basic science into a new stage related to the optoelectrical applications [8-11] in industrial scale. [1] T. Kato and R. Hatakeyama, ACS Nano 4 (2010) 7395. [2] T. Kato and R. Hatakeyama, ACS Nano 6 (2012) 8508. [3] B. Xu, T. Kaneko, Y. Shibuta, T. Kato, Scientific Reports 7 (2017) 11149. [4] T. Kato and R. Hatakeyama, Nature Nanotechnology 7 (2012) 651. [5] H. Suzuki, T. Kaneko, Y. Shibuta, M. Ohno, Y. Maekawa, and T. Kato, Nature Communications 7 (2016) 11797. [6] H. Suzuki, N. Ogura, T. Kaneko, T. Kato, Scientific Reports 8 (2018) 11819. [7] Q.-Y. Li, T. Feng, W. Okita, Y. Komori, H. Suzuki, T. Kato, T. Kaneko, T. Ikuta, X. Ruan, K. Takahashi, ACS Nano 13 (2019) 9182. [8] T. Kato and T. Kaneko, ACS Nano 8 (2014) 12777. [9] T. Kato and T. Kaneko, ACS Nano 10 (2016) 9687. [10] T. Akama, W. Okita, R. Nagai, C. Li, T. Kaneko, T. Kato, Scientific Reports 7 (2017) 11967. [11] C. Li, T. Kameyama, T. Takahashi, T. Kaneko, T. Kato, Scientific Reports 9 (2019) 12958.