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Temperature dependence of electric resistivity in nanocrystalline graphene deposited by metal-free plasma enhanced chemical vapor deposition method

北陸先端大 [1], サザンプトン大 [2],
°シュミット・マレク [1], ムルガナタン・マノハラン [1], チョン・ハロルド [2]、水田博 [1,2]

JAIST [1], Univ. of Southampton [2], °Marek E. Schmidt [1], Manoharan Muruganathan [1], Harold M.H. Chong [2], Hiroshi Mizuta [1,2]

E-mail: schmidtm@jaist.ac.jp

Introduction

Nanocrystalline graphene (NCG) deposited by metal-free plasma enhanced chemical vapor deposition (PECVD) directly onto insulating substrates is an interesting material due to its mechanical robustness and ease of deposition [1]. The individual grains consist of graphene and have a size of 2-3 nm as obtained from Raman spectroscopy [2]. Here, we report about recent temperature-dependent resistance measurements of 60 μm wide NCG lines.

Method

The films were deposited using an Oxford Instruments Nanofab 1000 Agile tool directly onto thermally oxidized 10x10 mm^2 samples. The process chamber is first conditioned with hydrogen at 1000 mT and a flow rate of 100 sccm. This is followed by a heat-up procedure from loading temperature of 700°C to the processing temperature of 900°C. During deposition (15 min), methane and hydrogen (flow rate 72 and 90 sccm, respectively) are introduced at a pressure of 1500 mT and RF power of 100 W is applied. Optical lithography and reactive ion etching is then used to pattern 60 μm wide NCG lines, followed by electrical contacting using a Ti/Au lift-off process. Such a structure is shown in the lower right inset in Figure 1. Electrical measurements are done using an Agilent B1500A Semiconductor Device Parameter Analyzer at temperature between 200°C and -194°C in vacuum conditions.

Results and Discussion

The measured room temperature resistivity of NCG strips with different lengths (80 to 680 μm) is shown in Figure 1. The resistance values are obtained through linear fitting of the metallic I_D/V_D data. This data is used to extract the contact resistance of 1.38 kΩ, which is low in comparison to the overall device resistances. The I_D/V_D curves for different temperatures are shown in the upper left inset of Figure 1.

The device resistance for two additional 80 μm long structures for temperatures between 200°C and -194°C is shown in Figure 2. The increasing resistance for low temperature had been reported before [3] for similar films grown by a remote PECVD setup. The films measured here, however, show an additional increase of resistance between 100°C and 200°C.

References

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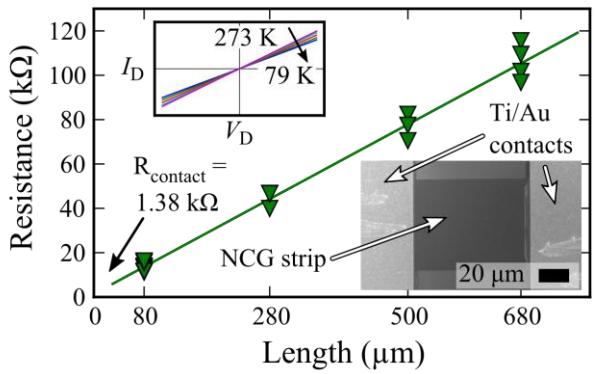

Fig. 1. Room temperature resistance of 60 μm wide NCG strips with various lengths. A 80 μm long device is shown lower right inset. The I_D/V_D results used for linear fitting are shown in upper left inset.

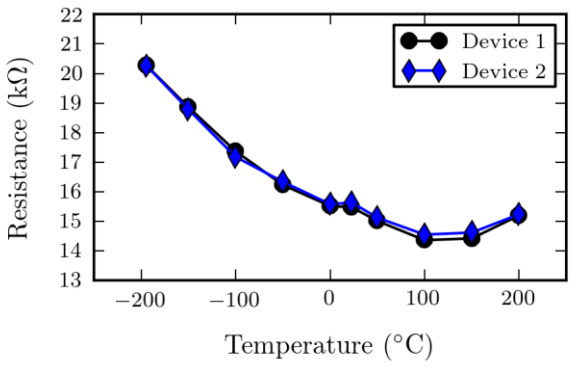

Fig. 2. Resistance of 60 μm wide and 80 μm long NCG devices for different temperatures.