Carrier transport analysis of graphene with crystalline defects generated by helium ion beam irradiation

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Electron transport property in graphene can be modified by introducing crystalline defects, and ion beam irradiation is an excellent method to generate defects in graphene. For this purpose, helium ion microscope (HIM) is an excellent tool to apply ion beam to graphene, because it allows an extremely high spatial resolution of nanometer scale and with a controlled ion dose for precise control of the density of defects in graphene. It has been reported that, with a moderate ion dose, a transport gap is generated in graphene around the Dirac point, and it contribute to current on/off operation as a graphene transistor [ref]. However, the precise mechanism of carrier transport control by defects is not fully understood. In order to investigate the carrier transport property in such defective graphene, we have developed a technique of real-time measurement of electric conduction during helium ion beam irradiation to graphene. A sample stage for HIM is equipped with probes connected to shielded cables for detecting low-level current, and these probes were attached to metal pads of graphene devices. This measurement system allows monitoring of the carrier conduction change during helium ion irradiation, as well as the damage by low-dose ion irradiation of scanning to obtain HIM images. Applying this method, we have carried out a measurement of irradiated region length dependence of carrier conduction, finding a low-resistance regime in which resistance increases drastically as the irradiated region length increases, and a high-resistance regime in which resistance increases exponentially as the irradiated region length increases. We discuss the obtained results in terms of the electron localization due to interference of electron waves scattered by the generated defects. In the presentation, we also show the recent results in the analysis of carrier transport property.

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