Electrically continuous graphene from single crystal copper verified by terahertz conductance spectroscopy and micro four-point probe.

The electrical performance of graphene synthesized by chemical vapor deposition and transferred to insulating surfaces may be compromised by extended defects, including for instance grain boundaries, cracks, wrinkles, and tears. In this study, we experimentally investigate and compare the nano- and microscale electrical continuity of single layer graphene grown on centimeter-sized single crystal copper with that of previously studied graphene films, grown on commercially available copper foil, after transfer to SiO₂ surfaces. The electrical continuity of the graphene films is analyzed using two noninvasive conductance characterization methods: ultrabroadband terahertz time-domain spectroscopy and micro four-point probe, which probe the electrical properties of the graphene film on different length scales, 100 nm and 10 μm, respectively. Ultrabroadband terahertz time-domain spectroscopy allows for measurement of the complex conductance response in the frequency range 1-15 terahertz, covering the entire intraband conductance spectrum, and reveals that the conductance response for the graphene grown on single crystalline copper intimately follows the Drude model for a barrier-free conductor. In contrast, the graphene grown on commercial copper foil shows a distinctly non-Drude conductance spectrum that is better described by the Drude-Smith model, which incorporates the effect of preferential carrier backscattering associated with extended, electronic barriers with a typical separation on the order of 100 nm. Micro four-point probe resistance values measured on graphene grown on single crystalline copper in two different voltage-current configurations show close agreement with the expected distributions for a continuous 2D conductor, in contrast with previous observations on graphene grown on commercial copper foil. The terahertz and micro four-point probe conductance values of the graphene grown on single crystalline copper shows a close to unity correlation, in contrast with those of the graphene grown on commercial copper foil, which we explain by the absence of extended defects on the microscale in CVD graphene grown on single crystalline copper. The presented results demonstrate that the graphene grown on single crystal copper is electrically continuous on the nanoscopic, microscopic, as well as intermediate length scales.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanointegration, Experimental Surface and Nanomaterials Physics, Silicon Microtechnolgy, Department of Photonics Engineering, Teraherts Technologies and Biophotonics, Center for Nanostructured Graphene, Capres A/S, McGill University
Number of pages: 8
Pages: 6348-6355
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: Nano Letters
Volume: 14
Issue number: 11
ISSN (Print): 1530-6984
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 13.07
Web of Science (2017): Impact factor 12.08
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 13.4
Web of Science (2016): Impact factor 12.712
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 14.76
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 14.04
Web of Science (2014): Impact factor 13.592