Electro-thermal and electromagnetic response of industrial-grade graphene materials based on quantum effects

Antonio Maffucci
Dept. of Electrical and Information Engineering, Univ. of Cassino and Southern Lazio, Cassino, Italy
maffucci@unicas.it

1. Response of industrial-grade graphene nanoplatelets films.

This work summarizes some of the results obtained in the frame of the Horizon 2020 project TERASSE (Terahertz Antennas with Self-amplified Spontaneous Emission) [1]. Specifically, the work focuses on the study of novel graphene-based materials and on their electrical and thermal properties.

Materials based on graphene are extensively researched because to exceptional mechanical, thermal, and electrical properties. However, due to its high cost, the substance that is formally denoted as graphene is not very interesting for practical uses. As a result, in recent times, interest has been drawn to what is known as "industrial graphene," which refers to substitute, less expensive materials that are simple to manufacture on an industrial scale. The materials based on so-called graphene nanoplatelets (GNPs) among these offer a good trade-off between improved physical qualities, large-scale production, and affordable costs [2].

This work examines the electro-thermal and electromagnetic response of commercial graphene films based on graphitic nanoparticles (GNPs), which are produced using an inexpensive graphitic precursor (intercalated expandable graphite) using an industrial procedure.

(a) (b)

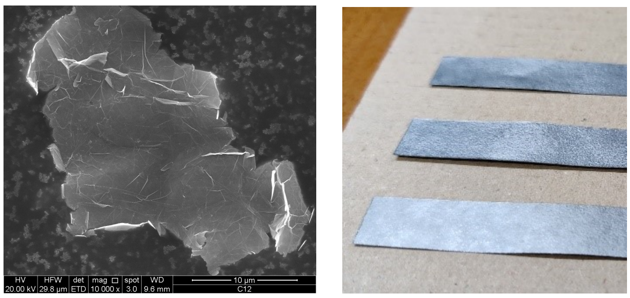

Figure 1. The material under investigation: (a) a single GNP flake (the scale is 10 µm).; (b) macroscopic GNP thin films.

A picture of a single GNP and of the final strip analyzed in this paper is provided in Fig.1. The GNP flakes have an average lateral dimension of about 30µm, and thickness of about 14 nm, Fig.1a. In this paper, two types of films have been investigated, differing from the percentage of GNPs and of the binders, in the following denoted as G-Preg 95/5 and G-Preg 70/30, see Fig.1b.

The equivalent electrical resistivity and thermal conductivity are studied by means of models and experimental characterization. The temperature dependence of the electrical resistance shows an unusually negative temperature coefficient of the resistance, which is a favorable feature for heat management in electronic systems. A theoretical explanation of this behavior is based on quantum effects related to the electrical transport in these materials [3].

As for the thermal conductivity, a novel procedure has been assessed as an alternative to the laser-flash characterization usually adopted for thin films. The procedure proposed here is based on the analysis of the time evolution of the thermal transients after the strip is heated to the target temperature. The measured values of these parameters for the commercial graphene strips under investigation ranged from 200 to 400 W/mK [4].

Finally, this material has been characterized in terms of its electromagnetic shielding effectiveness, with the idea of using it as an innovative coating for electronics cases. A shielding effectiveness of about 40–50 dBs has been demonstrated in a wide frequency range.

2. Acknowledgement.

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3. References

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