**Optically transparent microwave devices based on engineered graphene**

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## Abstract

Up to now, graphene properties in the microwave range have been studied by means of theoretical models and in experimental contexts including coplanar waveguides, metallic rectangular waveguides and THz etalon measurements [1].
However, state-of-the-art experimental values of graphene sheet resistance invalidate the possibility to use this two-dimensional material as a conducting layer for microwave applications such as electromagnetic shielding, telecommunications and antennas [2].
Is it then possible to imagine the realization of optically transparent devices with a single technology based on graphene avoiding more complex technological approaches? A viable answer to this question is indicated by *quasi-metallic* graphene that shows a very low sheet resistance, provides full microwave reflection and behaves as an optically transparent metal [3].
In this contribution, we report on the realization of a new class of optically transparent microwave devices based on engineered Chemical Vapour Deposition (CVD) graphene (Figure 1(a)). In particular, we demonstrate the tuning of the graphene response to the microwave radiation by engineering its sheet resistance from the *lossy-dielectric* to the *quasi-metallic* region (Figure 1(b)) [3]. This approach enables the fabrication of novel microwave devices, i.e. polarizers (Figures 1(c)-(d)), shields and absorbers, with peculiar functionalities such as optical transparency, tunability and flexibility.

### References

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[2] M. Dragoman, et al, "A tunable microwave slot antenna based on graphene". *Applied Physics Letters* **106**, 153101 (2015).
[3] M. Grande, G. V. Bianco, M. A. Vincenti, D. de Ceglia, P. Capezzuto, M. Scalora, A. D'Orazio, G. Bruno, "Optically transparent microwave polarizer based on quasi-metallic graphene", *Scientific Reports*, **5** - 17083 (2015).

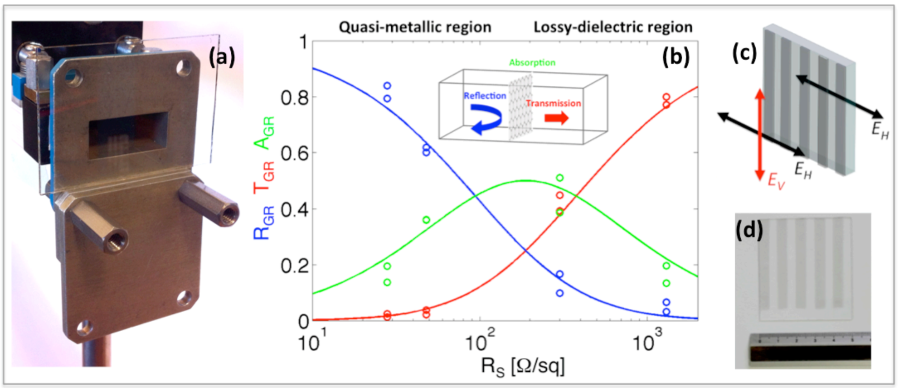


**Figure 1:** (a) Detail of the experimental setup consisting of a WR90 rectangular waveguide capped with an optically transparent engineered graphene supported by a glass substrate. (b) Analytical model (solid line) and experimental findings (circles) for the reflectance $R_{GR}$ (blue), transmittance $T_{GR}$ (red) and absorbance $A_{GR}$ (green) when $R_s$ is varied in the range 10 Ω/sq – 2 kΩ/sq. Please note that the *x*-axis is in logarithm scale. The maximum absorbance (obtained considering Rs = $\eta_0/2$ where $\eta_0$ is the vacuum impedance) separates the *quasi-metallic* region (Rs < $\eta_0/2$) from the *lossy-dielectric* region (Rs > $\eta_0/2$). The reflectance and transmittance were measured at 9 GHz. (c) Sketch of the graphene-based wire-grid polarizer and its working principle. (d) Picture of the fabricated graphene-based wire-grid polarizer.