MAY 27, 2020
CONFERENCE ONLINE

Graphene Industrial Forum &2DM 2020

TEMPORAL MEASUREMENT OF FEW-CYCLE LASER PULSES BY THIRD-HARMONIC DISPERSION-SCAN WITH OPTICALLY IMPROVED GRAPHENE COATINGS

Tiago GOMES[1], Miguel CANHOTA[1], Alexandre CARVALHO[2], Bohdan KULYK[2], Miguel MIRANDA[3], Bruno JARRAIS[4], António José FERNANDES[2], Cristina FREIRE[4], Florinda COSTA[2], Helder CRESPO[1]

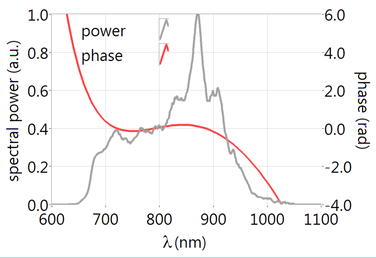
[1]IFIMUP and Departamento de Física e Astronomia, Faculdade de Ciências, Universidade do Porto, Rua do Campo Alegre s/n, 4169-007 Porto, Portugal
[2]I3N-Aveiro, Dept. of Physics, University of Aveiro, Aveiro, Portugal
[3]Sphere Ultrafast Photonics, S.A., Rua do Campo Alegre, 1021, Edifício FC6, 4169-007 Porto, Portugal
[4]REQUIMTE/LAQV, Dept. of Chemistry and Biochemistry, Faculy of Sciences, University of Porto, Porto, Portugal

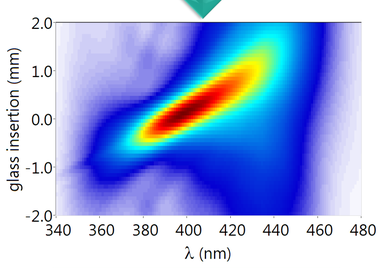
• Graphene in ultrafast photonics

Graphene consists of a single layer of carbon atoms arranged in an hexagonal lattice and is a very promising material in photonics, mainly due to its extremely high and broadband nonlinear optical susceptibility[1,2] and the possibility of occurrence of interband transitions at all optical frequencies. It allows broadband ultrafast third-harmonic generation (THG), enabling not only to characterize the used ultrashort pulses[3] but also to study the dynamics of the charge carriers in graphene. The possibility of obtaining an enhanced nonlinear signal and increased damage threshold in multi-layer[2] and functionalized graphene coatings are two key points in this work.

• Dispersion-scan[4]

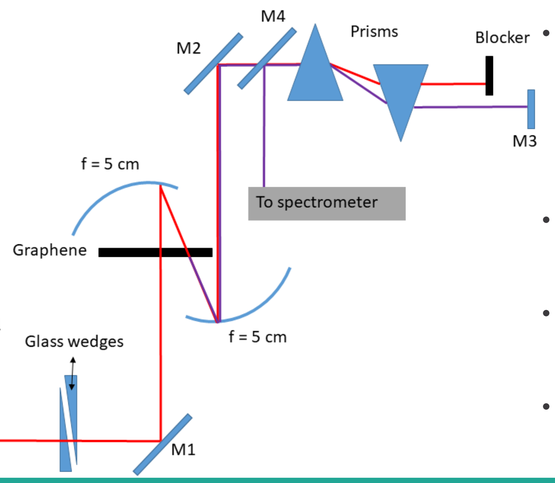
Ultrashort pulse with unknown temporal structure → Variable dispersion compensation → Nonlinear process (THG) → D-scan trace → Retrieval algorithm → spectral power and phase





Retrieved pulse (spectrum and spectral phase) → temporal pulse (duration, pre-pulses)

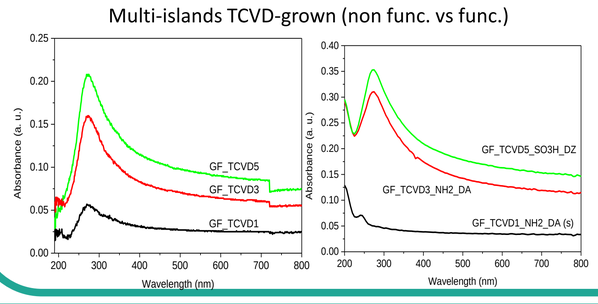
• Experimental setup



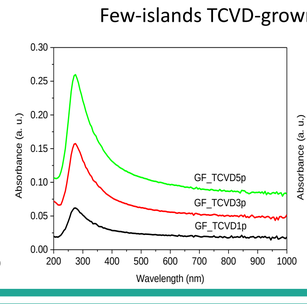
- **DCM's (Double Chirped Mirrors) and glass wedges:** dispersion compensation
- **M1,M2,M3,M4:** Mirrors
- **Energy per pulse:** ~1,25 nJ
- **Pulse duration:** sub-10 fs

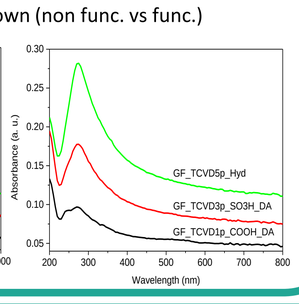
• Functionalization

Multi-islands TCVD-grown (non func. vs func.)

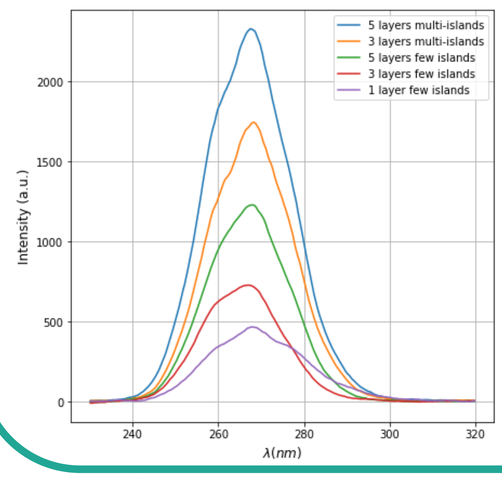


Few-islands TCVD-grown (non func. vs func.)



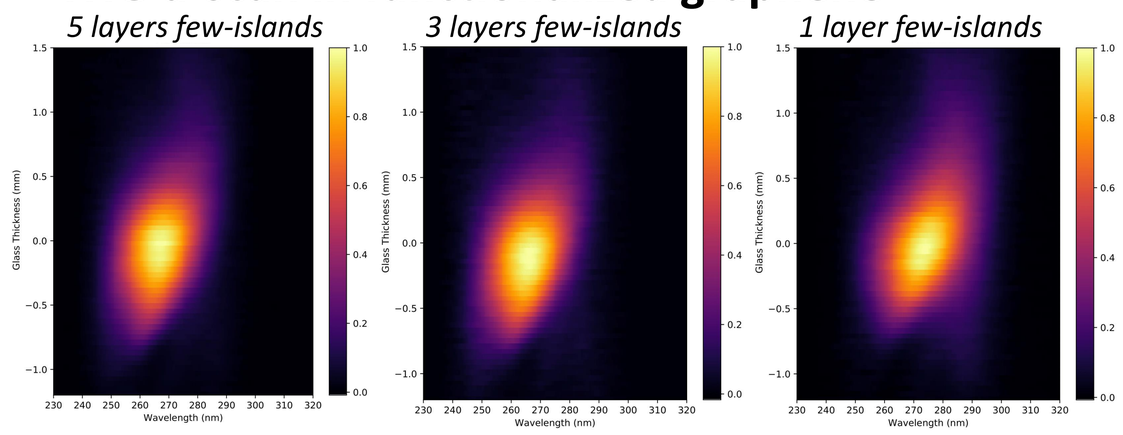


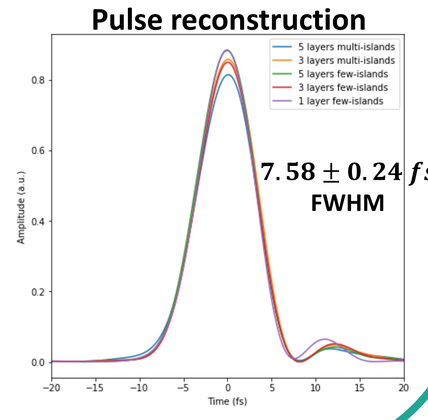
• THG in functionalized graphene



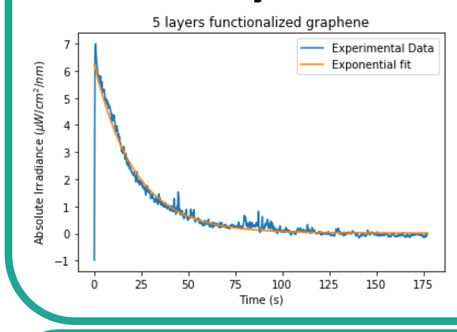
- In average, "multi-islands" have a higher coverage of domains with varying number of layers, and therefore are less uniform compared to "few-islands" graphene.
- Signal increases with number of layers
- Similar THG spectrum for all samples, except for 1-layer few-islands (signal comparable to substrate – 1mm thick fused silica)
- Extremely broadband THG, from 240-300 nm (~25 nm FWHM)

• THG d-scan in functionalized graphene

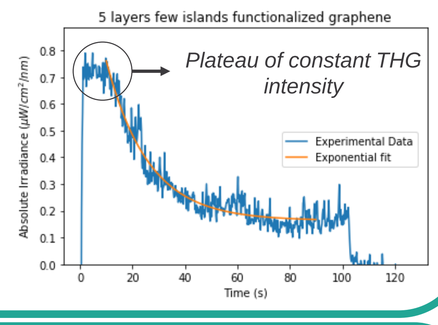




• Durability of functionalized graphene



5 layer few-islands graphene is more resilient to ablation/damage (dark blue zone), proving the point of its functionalization



• Conclusions

- We obtained broadband third-harmonic generation in single and multi-layer functionalized graphene.
- We were able to fully retrieve the temporal profile of our laser pulses from a Ti:Sapphire 80 MHz Rep. Rate oscillator, with very similar temporal structures for all samples (FWHM = $7.58 \pm 0.24 fs$).
- The hydration functionalization for the 5-layer few-islands graphene was successful, as a plateau of constant THG intensity over exposure time can be obtained.

CONTACT PERSON

Tiago Gomes
up201504587@fc.up.pt

IFIMUP—IN Material Physics Institute of the University of Porto
U.PORTO FACULDADE DE CIÊNCIAS UNIVERSIDADE DO PORTO

REFERENCES

[1] E. Hendry et al., Phys. Rev. Lett., 105, 97401 (2009)
[2] S. A. Mikhailov, Physica E 44, 924-927 (2012)
[3] F. Silva et al., in Conference on Lasers and Electro Optics (CLEO) (OSA, 2013), paper CW1H.5
[4] M. Miranda et al., Opt. Express 20, 688-697 (2012)

ACKNOWLEDGEMENTS

The authors acknowledge funding from the Foundation for Science and Technology (FCT) trough grants UID/04968/2020, M-ERA-NET2/0002/2016,

Graphene Industrial Forum &2DM 2020