Final Report

Project acronym: *ULTRAGRAF*

Project number*: 4340*

M-ERA.NET Call 20*17*

Period covered: 01/March/2020 to 31/August/2021

2. Publishable project summary

Ultrafast lasers have many important applications in physics, materials processing, chemistry, biology and medicine. Their pulses are among the shortest events ever produced, with durations reaching the few femtosecond regime (1 fs = 10^{-15} s). Nevertheless, the lack of adequate temporal measurement and control tools has hampered their migration out of the laboratory and into mainstream applications.
This project directly addressed these challenges by developing and demonstrating ultrafast pulse measurement and control devices, where the dispersion-scan technique is combined with the exceptionally broad bandwidth and high conversion efficiency of nonlinear third-harmonic generation (THG) in graphene coatings. A key problem we have identified was the laser-induced damage of graphene: samples degrade after a relatively short time under intense laser irradiation. This often ignored/unreported problem can easily occur at the intensities required for producing nonlinear optical effects. Its mitigation involved acting upon the graphene coatings, namely via functionalisation, and on protective overlayers, to improve the resistance to damage. These approaches have enabled extending the lifetime of the samples and demonstrating a graphene-coating-based system capable of measuring broadband pulses in the few-cycle, few-femtosecond regime. This technology has potential to enable new scientific, industrial and medical applications of ultrafast lasers and contribute to the growth of the ultrafast market. The performed work and the scientific results attained with this project also contributed to the advanced training of a number of young scientists.