Graphene synchronized all-fiber laser for coherent Raman spectroscopy

D. Popa[1]
D. Viola[2], G. Soavi[1], B. Fu[1], L. Lombardi[1], S. Hodge[1], D. Polli[2], T. Scopigno[3,4], G. Cerullo[2], A. C. Ferrari[1]

[1] *Cambridge Graphene Centre, University of Cambridge, 9 J.J. Thompson Avenue, Cambridge CB3 OFA, UK*
[2] *IFN-CNR, Dipartimento di Fisica, Politecnico di Milano, P.za L. Da Vinci 32, 20133 Milano, Italy*
[3] *Dipartimento di Fisica, Universita' "Sapienza", P.le A. Moro 2 00185 Roma, Italy*
[4] *Istituto Italiano di Tecnologia, Center for Life Nano Science, V.le Regina Elena 291, 00161 Roma, Italy*

dp387@cam.ac.uk

Coherent Raman scattering (CRS) [1] is a nonlinear microscopy technique which can enhance the Raman intensity by orders of magnitude, ultimately reaching video-rate imaging speeds [1]. However, it comes at the cost of an increased experimental complexity compared to conventional spontaneous Raman measurements. In particular, it requires synchronized ultra-fast lasers, where two ps pulses (pump and Stokes) are used to set up and detect a vibrational coherence within the sample [1,2]. So far, solid-state lasers pumped optical parametric oscillators have been the source of choice for CRS, as they allow access to the full Raman spectrum (0–4000 cm^{-1}) [2]. However, these rely on bulk optics, which are inconvenient to handle, sensitive to misalignment and prone to instability. This, together with the high cost and large footprint of the system, still prevents CRS instrumentation from being translated to clinical environments.

Graphene has been extensively used for mode-locking lasers, due to its ultrafast recovery time, broadband operation, ease of fabrication and integration [3,4]. Here we show that nonlinear laser synchronization of an Er and Yb laser can be achieved over a broad range using a graphene-based saturable absorber (GSA) [3,4]. We demonstrate an all-fiber source (Fig. 1) of synchronous ps pulses tunable over the 1535-1560 and 1040-1080 nm ranges in the Er and Yb arms respectively. We use the laser to perform Coherent Anti-Stokes Raman Scattering (CARS) [2] of a methanol test sample. Due to its compactness and all-optical synchronization, this is an ideal source for CRS in the high-wavenumber region.

References

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Figures

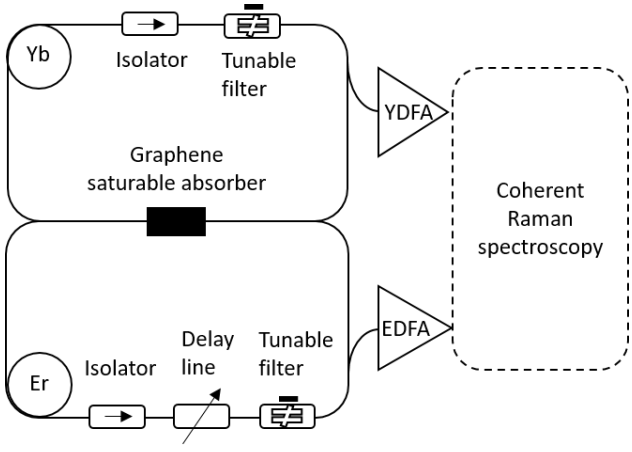

Figure 1: Synchronous Erbium/Ytterbium (Er/Yb) fiber laser setup. YDFA - ytterbium-doped fiber amplifier; EDFA - erbium-doped fiber amplifier.