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Plug-and-play stimulated Raman microscopy system for broadband coherent vibrational imaging

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Stimulated Raman scattering (SRS) microscopy is an emerging tool for biomedical imaging, with applications ranging from cell-drug interaction [1], cell sorting [2] to tissue analysis [3] and histopathology [4]. **Current commercial systems** [5] require users to deal with integration between laser, microscope and the detection system, resulting in **trade-offs** and, most importantly, **lack of user-friendliness**, thus hindering widespread application by non-specialists. This approach has pushed the laser market towards the development of high power (>100mW, >1nJ/pulse) narrowband (<1nm) tunable sources (Optical Parametric Oscillators (**OPOs**) and **Fiber-OPOs**) which can be coupled to off-the-shelf photodiodes and lock-in amplifiers, at the cost of detecting **one or** maximum **two frequencies at a time** [5].

Here we present a laser system designed to exploit **the full potential of SRS microscopy** in all its applications without compromises. It consists of an **all-fiber dual wavelength self-synchronized laser**, Fig.1a, developed starting from the architecture described in [6,7] and a detection unit based **on a compact multichannel lock-in amplifier**. The laser delivers a two-color synchronized output for **shot-noise limited broadband SRS** in **CH stretching region** (2800-3100 cm^{-1}). The detection unit minimizes the electronic noise between 1 and 10 MHz, reaching the **shot-noise limit** at a power per channel as low as **25µW**. This ensures state-of-the-art SRS performances over the entire CH spectrum, parallelizing the **detection of up to 38 channels in 400 ns**. SRS images on **human head and neck tumor** tissue, obtained at the protein peak at 2945 cm^{-1} are shown in Fig.1(b,c), along with **healthy** (d) and **senescent cells** (e) at protein and lipid (2850 cm^{-1}) peaks.

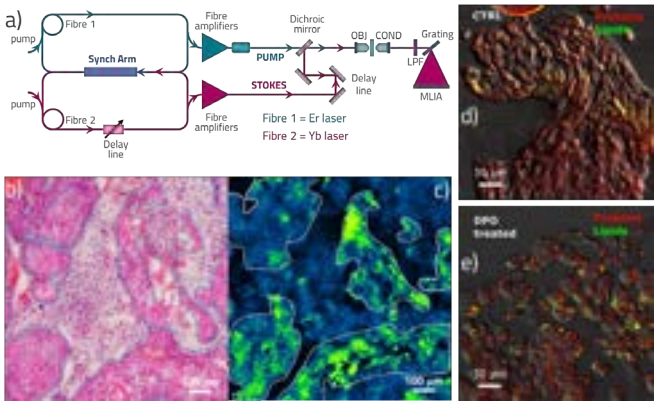

Fig. 1 (a) System architecture. PPLN: periodically poled lithium niobate crystal; OBJ: objective; COND: condenser; LPF: low-pass filter; MLIA: multi-channel lock-in amplifier; (b) Image of human head and neck tumor tissue obtained with standard H&E staining and SRS microscopy at 2945 cm^{-1} proteins peak (c) of adjacent tissue slices. HepG2 cells imaged with SRS microscopy (d, e) (grey brightfield, red proteins, green lipids) treated (e) and not treated (d) with DFO drug.

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