Implementing Plasma XUV-lasing for table-top nano-analytics

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Abstracts: *A comprehensive computational study of the main parameters involved in the generation of lasing across a plasma medium is presented. The latter served to optimize the design of a compact experimental demonstrator (Beagle^{Plus}), which is the platform for enabling proof-of-principle research on advanced analytical technologies for materials science and nano-technology.*

Laser action in the extreme ultraviolet and soft X-ray has been demonstrated using laser-produced and discharge-produced hot/dense plasmas as single-pass high-gain media. In the time of large *accelerator-based* X-ray lasers, fundamental and applied research on compact *plasma-driven* X-ray laser carries the promise of bridging the gap between the user and the tools. This demands contributions in (i) better quantitative understanding of the parameter effect on plasma-lasing, and generalization of the empirical models, (ii) assembling compact "table-top" demonstrators with the required robustness to address research and industry challenges, (iii) performing proof-of-principle experiments on “real world” advanced materials.

A comprehensive computational study was performed to understand the effect of pump pulse structure and characteristics on the plasma-lasing process. Laser-produced plasma optimum characteristics could be predicted by self-developed scaling laws, which help the design of an experimental setup of advanced capabilities.

Experiments were run using the newly installed *Beagle*^{Plus} system at the Empa Laboratories. A 0.2ps Nd:glass oscillator feeds a chirped-pulse amplification stage to deliver Terawatt pulses on a target for TGRIP X-ray plasma lasing. The “*back-end system*”, i.e. compact and close to the application needs, uses also a self-developed pseudospark XUV source for imaging or spectroscopy. A parametric study is also presented.

Nano-analytics were indeed performed on certified reference materials as well as catalysts. Imaging was performed using a self-developed Schwarzschild microscope, with a back-end resolution well-below the resolution of commodity confocal microscopes and without the sample prep for super-resolution techniques. Proof-of-principle spectroscopy experiments using a home-built FT-Time-of-Flight Spectrometer as well as X-ray absorption and fluorescence measurements in the so-called HEROS (High-Energy Resolution Off-resonance Spectroscopy) configuration are discussed. The latter tests were validated at the Elettra beamline in Trieste, to be replicated on the *Beagle*^{Plus}.