Advanced Analytical Technologies Boosted by Soft X-ray Plasma-Lasing

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Short-wavelength light sources (VUV, DUV, EUV, and X-rays) have dramatically impacted on material science, enabling the possibility of retrieving structures, the chemistry, and the kinetics of reactive pathways. Besides such remarkable impact in analysis science, the material fabrication industry has benefited too. The semiconductor industry for instance is striving for extending the growth leveraged on deep UV lasers, and move on towards Extreme UV at λ=13.5nm for advanced nano-patterning. The latter resides on hopes for technology readiness of powerful 150-300W EUV sources for high volume manufacturing of nano-chips. Besides patterning sources, also technology readiness of compact EUV lasers for mask defect metrology, is not fulfilled. Mask defectivity degrades the production yield and has thus huge economic relevance.

Advanced X-ray sources, e.g. synchrotron, have the advantage of high brightness and spectral tunability. Unfortunately, the construction and running costs of third and fourth generation synchrotrons are prohibitive for a single research group or industrial enterprise, i.e. 0.5-1.5 billion Euros. Furthermore, it is hard obtaining frequent measurement shifts at any of the few worldwide installations. Fortunately, the perspective to engineer table-top EUV laser setups is at hand.

Indeed, micro-plasmas are bright sources of radiation. In brief, a powerful pump pulse (approx. 1 TW) directed on a target material generates a rapidly expanding brilliant micro-plasma. The plasma emissivity is largely in the X-ray domain, and shaping the plasma as a 50-by-100_m by 15mm "column" leads to laser action. In fact, if the focal spot is a line, the elongated geometry of the plasma medium is favorable to support amplified spontaneous emission across its length, up to output brightness as high as 6 orders of magnitudes larger than the synchrotron's! Plasma-based laser action is thus attractive as a platform for advanced analytical technologies, such as X-ray nano-scale imaging and spectroscopy on a table-top.

Tremendous progress has been made, such that nowadays wavelengths as low as 6 nm (ca. 200eV photon) are possible on a table-top setup. The technology readiness of plasma XUV lasers is, however, still at research level. We are however carrying out advanced analytical applications with the plasma X-ray laser, such as microscopy, lensless imaging, materials processing, and chemical spectroscopy. The lecture will summarize all these aspects and put them in perspective.