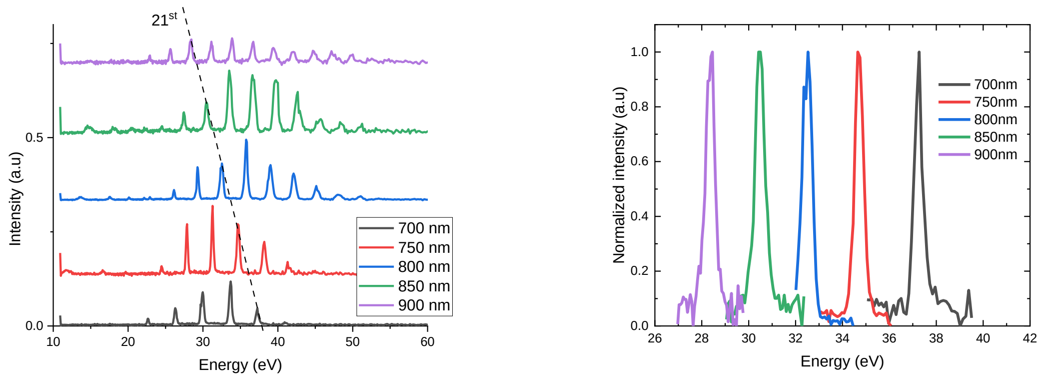
High Harmonic Generation from a Microplasma Source

Maria Carla Lupu, Filchito Renee Bagsican, Tatsunosuke Hanano, Michael K. L. Man, Julien Madéo and Keshav M. Dani

Femtosecond Spectroscopy Unit, Okinawa Institute of Science and Technology, 1919-1 Tancha, Onna son, Okinawa, Japan, 904-0495
E-mail: kmdani@oist.jp

The nonlinear process of High Harmonic Generation (HHG) has enabled table-top ultrafast sources of coherent radiation, mainly in the extreme ultraviolet (XUV) spectral region, with extensive use in a large variety of domains, such as industry [1], biology [2], and photoemission science [3]. In particular, the latter would greatly benefit from tunable high repetition rate XUV sources, to map the electronic band structure of materials over a large range of the Brillouin Zone with fast data acquisition. Generally, in HHG experiments, the required peak intensity is reached with the use of femtosecond lasers with a pulse energy in the range of 10 µJ – 1 mJ, typically focused down to a spot diameter of 10 µm – 100 µm, respectively. Focusing the beam tighter than a few microns, thus generating a microplasma, would enable the use of sub-µJ sources. However, a microplasma HHG source is expected to lead to a very poor XUV photon flux. This assumption originates from the phase matching condition in an ultra-tight focusing geometry, where the significant contribution of Gouy phase factor cannot be balanced out. Prior HHG work based on micron-scale spot diameter [4] has shown an XUV photon flux multiple orders of magnitude lower than the requirement for photoemission experiments [3]. Here, we demonstrate experimentally the high efficiency of a microplasma XUV source [5], with a photon flux that exceeds 10^{11} photons/s/harmonic, driven by a pulse energy lower than 1 µJ. As a driving source, we use a noncolinear optical parametric amplifier system operated at 4 MHz repetition rate, from which we tune the driving wavelength between 700 nm - 900 nm. In Fig. 1, we show the measured XUV spectra, with two regimes of tunability: a) a discrete harmonic tunability ranging from 20 to 50 eV and b) a continuous tunability of about 9 eV. The generation of efficient XUV radiation with sub-µJ class sources could open a new era for spectroscopy and material science.



a) b)

Fig. 1. a) Measured XUV spectra for driving wavelength varied from 700 nm to 900 nm. b) Continuous tunability of the 21st harmonic.

Acknowledgments
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