Scaling of emission efficiency and optical depth in dense 1µm-laser-driven Sn plasmas

Ruben Schupp[1], Francesco Torretti[1,2], Randy Meijer[1,2], Muharrem Bayraktar[3], Alex Bayerle[1], Ronnie Hoekstra[1,4], Wim Ubachs[1,2], Oscar Versolato[1]

[1]ARCNL, Amsterdam, The Netherlands
[2]Vrije Universiteit, Amsterdam, The Netherlands
[3]University of Twente, The Netherlands
[4]University of Groningen, The Netherlands

Laser-produced plasmas from tin micro-droplets are efficient sources of extreme ultraviolet light finding application in state-of-the-art nanolithography. Tin is an ideal fuel for these sources because of its serendipitous electronic structure where a broad range of charge states from Sn^{8+} to Sn^{15+} have multiple configurations which radiatively decay within an industrially relevant 2% bandwidth around 13.5nm. The dense nature of these laser-produced tin plasmas, in particular when driven with 1µm laser light, gives rise to opacity related broadening of the spectral emission outside of the utilizable 2% bandwidth. We experimentally investigate the influence of changes in laser intensity, laser pulse duration and size of the liquid tin droplet on the spectral emission of the plasma and its efficiency in emitting EUV light using a 1µm drive laser. To capture the efficiency in radiating EUV light a geometrical model is employed featuring a characteristic plasma scale length. Observed spectral broadening with increasing laser pulse duration or droplet size is connected to the relative optical depth of the plasma using an analytical model for radiation transport in a homogeneous, thermal plasma.