Drive-laser-wavelength dependence of the power partitioning in a laser-produced tin plasma with relevance to EUV nanolithography

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New-generation nanolithography machines employ extreme ultraviolet (EUV) light to pattern nanometre-scale features on silicon wafers in the production of new-generation integrated circuits. EUV light is efficiently produced in a laser-produced plasma formed on tin microdroplet targets [1]. One of the principal parameters governing the plasma characteristics is the drive laser wavelength.

In current EUV lithography machines, CO_2 lasers (operating at a wavelength of 10.6 μm) drive the EUV-emitting plasma. Researchers are now investigating the feasibility of using solid-state lasers systems, such as those operating at 1.064 (Nd:YAG) [2] and 1.88 μm (Th) [3,4], to drive the plasma emission. Such laser systems exhibit many favourable features, such as an ease of scalability to higher output powers, higher wall-plug efficiencies as well as excellent pulse shaping capabilities.

In this theoretical study, we consider a tin plasma driven by laser wavelengths between (and including) 1.064 μm and 10.6 μm. We take the simplified case of a single-pulse illumination of a spherical droplet target to explore the influence of drive laser wavelength on the plasma expansion dynamics [5] and radiative properties. To investigate these plasma properties, we consider the subdivision of instantaneous power. We quantify the fraction of laser power that is absorbed and how this absorbed power is channelled into plasma expansion kinetics and radiative emission, including the desired in-band EUV radiation. Our aim is to supplement the search for an optimum drive laser wavelength and substantiate the necessity of target pre-shaping at long drive laser wavelengths.

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