21PB-097

Modeling of initial interaction between laser and Sn target for the EUV source
レーザー光とEUV光源用Snターゲットの初期の相互作用のモデリング

Akira Sasaki[1], Katsunobu Nishihara[2] and Atsushi Sunahara[3]
佐々木明[1], 西原功修[2], 砂原淳[3]

[1]*Kansai Photon Science Institute, Japan Atomic Energy Agency*
8-1-7 Umemidai, Kizugawa-shi, Kyoto 619-0215, Japan
原子力機構 関西光科学研究所 〒619-0215 京都府木津川市梅美台8-1-7
[2]*Institute for Laser Engineering, Osaka University*, 大阪大学レーザーエネルギー学研究センター
[3]*Institute for Laser Technology*, レーザー技術総合研究所

A simulation model for the initial interaction between relatively weak laser pulse and tin droplet for the EUV source is discussed. A new method to calculate including bubble or cluster formation during evaporation and condensation processes of laser heated material is proposed.

1.Introduction

The laser pumped plasma (LPP) extreme ultra-violet (EUV) light source has been investigated. It is shown that the small tin droplet target is broken up into cloud of particles by irradiation of weak prepulse laser. From which uniform low-density plasma, which is desired to obtain high efficiency, is produced by irradiation of the main laser pulse [1]. We study a hydrodynamics model of such an initial laser and matter interaction, which can be used for the optimization of the EUV source.

2. Model

In the study of laser fusion, the laser matter interaction has long been investigated using the simulation [2]. We develop a model of liquid-gas phase transition and combine this with 2D Lagrangian hydrodynamics simulation. The model uses triangular mesh, and formation of cluster or bubble is modeled by splitting a cell to liquid and gas cells. The volume of the region, which corresponds to each phase, is determined according to the Maxell's rule at a given temperature and density, that is, assuming thermodynamic equilibrium.

This technique is accomplished by the use of dynamic mesh adaption. When the distortion of the cell exceeds the limit, a cell is split into several cells or a cell is united with nearby cells, to the mesh self-organizes to present distribution of liquid and gas region properly.

3. Result

In the present model of tin, the condition of phase transition is determined using the Van-der-Warrs equation of state in ref. 3. When the temperature and density of the cell fall into the two-phase region, the cell is split into liquid and gas cells. Furthermore, a meta-cell is defined from the cells, which share a mesh point, the number of liquid and gas cells are changed to maintain the correct liquid-gas ratio for the meta cell, by redistributing the mass and internal energy.

Figure 1 shows an example of the expansion of a tin droplet into vacuum, given the solid density and temperature of 8000K as the initial condition. As the droplet expands, at the time the temperature becomes below T_c=7300K, condensation occurs to whole target material once turns into liquid. Subsequently, evaporation occurs from the surface in accordance with expansion cooling leaving liquid "core" near the center of the droplet.

References

[1] A. Endo, proceedings of the 2012 EUV source workshop (http://www.euvlitho.com)
[2] J. P. Christiansen, et al.: Comput. Phys. Commun. **7** (1974) 271.
[3] D. A. Young, Phys. Rev. A, **3** (1971) 364

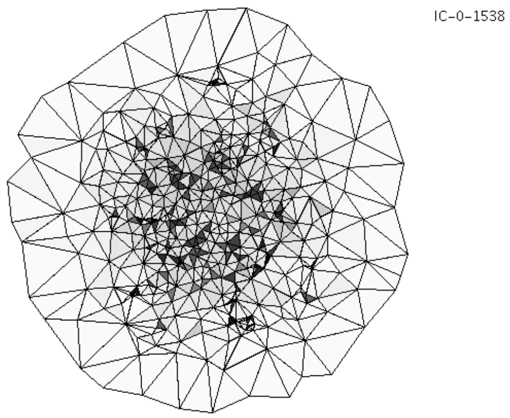

Fig.1. Density profile of an expanding hot tin droplet.