

Accepted Manuscript

Title: The Effect of Emitted Electrons during Femtosecond Laser-Metal Interactions: A Physical Explanation for Coulomb Explosion in Metals

Author: Sha Tao Benxin Wu



PII: S0169-4332(14)00164-0
DOI: <http://dx.doi.org/doi:10.1016/j.apsusc.2014.01.112>
Reference: APSUSC 27120

To appear in: *APSUSC*

Received date: 25-9-2013
Revised date: 23-12-2013
Accepted date: 19-1-2014

Please cite this article as: S. Tao, B. Wu, The Effect of Emitted Electrons during Femtosecond Laser-Metal Interactions: a Physical Explanation for Coulomb Explosion in Metals, *Applied Surface Science* (2014), <http://dx.doi.org/10.1016/j.apsusc.2014.01.112>

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The Effect of Emitted Electrons during Femtosecond Laser-Metal Interactions: a Physical Explanation for Coulomb Explosion in Metals

*Sha Tao and **Benxin Wu¹

* Advanced Optowave Corporation, 105 Comac St., Ronkonkoma NY 11779, USA,
taosha1979@gmail.com

**Department of Mechanical, Materials and Aerospace Engineering
Illinois Institute of Technology, Chicago IL 60616, USA, bwu11@iit.edu

Abstract: Recent experiments in the literature have observed Coulomb explosion (CE) in metals under femtosecond (fs) laser irradiation. This is different from the previous common belief that CE will be strongly inhibited in metals due to the existence of a large number of free electrons with good mobility and the associated screening effect. It is still not well understood why CE can occur in metals. CE requires a sufficiently high outwards pointing electric field in the metal near-surface region. Using a physics-based model, this study shows that during the early stage of fs laser-metal interactions, the emitted electrons due to fs laser irradiation are still very close to the metal target surface, whose effects also need to be considered. The emitted electrons will generate an additional outwards pointing electric field in the target near-surface region, and will also exert a repulsive force on the electrons flowing from the deeper region of the target towards its surface. These effects are helpful to the development of a large outwards pointing electric field in the target near-surface region. The model calculation considering the effects of emitted electrons shows that the electric field at around the target surface can exceed the CE threshold under the studied conditions. The study has provided a physical explanation for why CE can occur in metals under fs laser irradiation.

1. Introduction

Femtosecond (fs) lasers have unique capabilities of depositing a certain amount of energy into a target within an extremely short period [1-3]. They have numerous competitive applications, such as in micromachining, electronics, data storage, laser propulsion [4-5], and many other areas. Lots of research work has been

¹ Corresponding author: Department of Mechanical, Materials and Aerospace Engineering, Illinois Institute of Technology, 10 W. 32nd Street, Engineering 1 Building, Room 207A, Chicago, IL 60616. Phone: 312.567.3451, Fax: 312.567.7230, E-mail: bwu11@iit.edu

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