Erratum: “Plasma formation and structural modification below the visible ablation threshold in fused silica upon femtosecond laser irradiation” [Appl. Phys. Lett. 91, 082902 (2007)]

D. Puerto, W. Gawelda, J. Siegel, J. Solis, and J. Bonse

Citation: Appl. Phys. Lett. 92, 219901 (2008); doi: 10.1063/1.2929370
View online: http://dx.doi.org/10.1063/1.2929370
View Table of Contents: http://apl.aip.org/resource/1/APPLAB/v92/i21
Published by the American Institute of Physics.

Related Articles
Homogeneous bubble nucleation in water at negative pressure: A Voronoi polyhedra analysis  

Open-shell pair interaction energy decomposition analysis (PIEDA): Formulation and application to the hydrogen abstraction in tripeptides  

Additional information on Appl. Phys. Lett.
Journal Homepage: http://apl.aip.org/
Journal Information: http://apl.aip.org/about/about_the_journal
Top downloads: http://apl.aip.org/features/most_downloaded
Information for Authors: http://apl.aip.org/authors

ADVERTISEMENT

Does your research require low temperatures? Contact Janis today.  
Our engineers will assist you in choosing the best system for your application.

10 mK to 800 K  
LHe/LN2 Cryostats  
Cryocoolers  
Magnet Systems  
Dilution Refrigerator Systems  
Micro-manipulated Probe Stations

sales@janis.com  www.janis.com

Click to view our product web page.
Erratum: “Plasma formation and structural modification below the visible ablation threshold in fused silica upon femtosecond laser irradiation” [Appl. Phys. Lett. 91, 082902 (2007)]

D. Puerto,1,a) W. Gawelda,1 J. Siegel,1, b) J. Solis,1 and J. Bonse2
1Laser Processing Group, Instituto de Optica, CSIC, Serrano 121, 28006-Madrid, Spain
2Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie, Max-Born-Strasse 2A, D-12489 Berlin, Germany

(Received 21 April 2008; accepted 25 April 2008; published online 28 May 2008)

[DOI: 10.1063/1.2929370]

We have discovered an error in laser fluence determination in the above-mentioned letter,1 which is likely to affect also a considerable number of publications in this field. The peak laser fluence is calculated as twice the pulse energy divided by the spot size $A$ (area over which the beam intensity is $\approx 1/e^2$ of the peak intensity). While we had used correct values for the pulse energies, the spot size had been determined erroneously on fused silica, using a representation of the diameter of an optically induced pattern (in our case the maximum extension of the transient free electron plasma) as a function of the natural logarithm of the pulse energy, as proposed by Liu et al.2 However, beam intensity profiling with this method requires the use of a low band-gap material, which shows linear absorption at the laser photon energy used ($h\nu=1.55$ eV), a condition that is not fulfilled by fused silica ($E_g=7.2$ eV). While for moderate band gap materials such as borosilicate glass ($E_g=4$ eV) spot size determination using the method of Liu et al. appears to provide correct values,3,4 we observe a substantial deviation from the linear behavior in the above-mentioned representation for fused silica and significant data scattering.

In order to obtain a correct value of the spot size, we propose chalcogenides for phase change applications as suitable beam profiling materials because of their typically low band gap and the large optical contrast upon phase change. We have used polycrystalline 45 nm thick Ge$_2$Sb$_2$Te$_5$ films ($E_g=0.5$ eV) grown on Si wafers and performed a series of single laser pulse irradiations at increasing pulse energies, causing localized film amorphization.5 The diameter of the so-produced amorphous spots was chosen as the optically induced pattern for the above explained representation, yielding a linear dependence with very little scatter. The so-obtained experimental elliptical spot size $A_{GST}$ ($75.9$ $\mu$m $\times 50.8$ $\mu$m) was by a factor of 16% larger than the one obtained using fused silica as profiling material ($71.4$ $\mu$m $\times 46.4$ $\mu$m) under identical focusing conditions. As a consequence, the fluence values reported in Ref. 1 have to be corrected by applying the spatial intensity distribution corresponding to the spot size $A_{GST}$, which was done for the fluences quoted in Ref 1, and which are listed in Table I.

Another aspect has to be considered when comparing the laser fluence values reported in Ref. 1 (obtained for an angle of incidence $\alpha=54^\circ$) with literature data (predominantly reported for normal incident radiation). An elevated angle of incidence for an s-polarized beam leads to an increase of the observed threshold values by an angle-dependent factor due to a higher Fresnel reflectivity. This factor can be estimated6 for fused silica irradiated at 800 nm as $C_{angle}=\left[1-R_s(54^\circ)/\left[1-R_s(0^\circ)\right]\right] \approx 0.91$. Thus, fluence values taken from Ref. 1 can be compared directly with fluence values reported in literature for normal incident radiation, after correcting them using the true spot size $A_{GST}$ (Table I, column 2) and multiplying them by $C_{angle}$ yielding the values listed in column 3 of Table I. Figure 1 has been updated using fluence values corrected by $C_{spotsize}$ for $\alpha=54^\circ$.

This correction has no effect on the conclusions drawn in the above-mentioned letter.

![Figure 1](Color online) Temporal evolution of the characteristic features of the image sequence shown in Fig. 2 of Ref. 1. Surface reflectivity at different positions (inset) and, thus, different local fluences (labels), corrected according to the method described above and valid for the angle of incidence $\alpha$ used ($54^\circ$). The inset corresponds to a reflectivity image taken at 7 ps delay.

TABLE I. Relation of original fluence values published (left column) in Ref. 1 to corrected fluence values at angles of incidence $\alpha=54^\circ$ (middle column) and $\alpha=0^\circ$ (right column). For details, see text.

<table>
<thead>
<tr>
<th>Fluence values (J/cm$^2$) reported in Ref. 1 $\alpha=54^\circ$</th>
<th>Fluence values (J/cm$^2$) corrected by spot size $A_{GST}$ $\alpha=54^\circ$</th>
<th>Fluence values (J/cm$^2$) corrected by $A_{GST}$ and constant factor $C_{angle}$ $\alpha=0^\circ$</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.8</td>
<td>11.9</td>
<td>10.8</td>
</tr>
<tr>
<td>10.5</td>
<td>10.0</td>
<td>9.1</td>
</tr>
<tr>
<td>8.5</td>
<td>8.2</td>
<td>7.5</td>
</tr>
<tr>
<td>6.4</td>
<td>6.4</td>
<td>5.9</td>
</tr>
<tr>
<td>4.7</td>
<td>4.9</td>
<td>4.4</td>
</tr>
</tbody>
</table>

a)Electronic mail: puerto@io.c firearm.csic.es.
b)Electronic mail: j.siegel@io.c firearm.csic.es.