THERMAL SMOOTHING BY LASER-PRODUCED PLASMA OF POROUS MATTER

M. KALAL* and J. LIMPOUCH *Faculty of Nuclear Sciences and Physical Engineering*
Czech Technical University in Prague, Brehova 7, 115 19 Prague 1, Czech Republic

E. KROUSKY, K. MASEK, K. ROHLENA, P. STRAKA, and J. ULLSCHMIED
PALS Joint Research Laboratory of the Institute of Physics and the Institute of Plasma Physics, ASCR
Za Slovankou 3, 182 21 Prague 8, Czech Republic

A. KASPERCZUK and T. PISARCZYK *Institute of Plasma Physics and Laser Microfusion*
23 Hery St, P.O. Box 49, 00-908 Warsaw, Poland

S. Yu. GUS'KOV, A. I. GROMOV, and V. B. ROZANOV *P. N. Lebedev Physical Institute of RAS*
53 Leninski Ave., 119991 Moscow, Russia

V. N. KONDRASHOV *Troitsk Institute for Innovation and Fusion Research, 142190 Troitsk*
Moscow Region, Russia

Received August 13, 2002
Accepted for Publication September 19, 2002

Efficient energy transfer and smoothing effect in laser-irradiated polystyrene foam targets have been observed in preliminary experiments on the PALS iodine laser facility. A theory of laser light absorption region formation and ablation pressure generation in laser-produced plasma of porous matter has been developed and applied for discussion of the results obtained. In particular, two stages of homogenization of the porous matter, important for comprehension of the anomalously high absorption of laser radiation in supercritical foam matter, have been identified: the first, a considerably fast stage of partial homogenization, followed by a much slower second stage, leading to a uniform medium.

KEYWORDS: *laser-produced plasma, thermal smoothing, porous target materials*

INTRODUCTION

Smoothing of nonuniformities of laser energy deposition in laser-driven targets belongs to the most important problems in the field of inertial confinement fusion (ICF). A very smooth ablation pressure profile (typically up to a few percent) is required in the direct-drive experiments to suppress the onset and a subsequent growth of Rayleigh-Taylor instability, which might disrupt the target compression. As it is generally very difficult to meet the required uniformity level in the ablation pressure by an improvement of the illumination scheme as such, other smoothing mechanisms have been proposed, which are based on a modification of the laser-target interaction process. Among possible approaches are preliminary irradiations of the target by a comparatively low intensity X ray or laser pulse (prepulse).[1,2] Such prepulse forms a preplasma, which plays the role of a background to accommodate an energy transfer smoothing process after the main laser pulse reaches the target. Another approach employs a low-density porous matter as a voluminous absorber of laser radiation in ICF targets.[3,4] In this case, smoothing of laser energy deposition occurs mainly due to scattering properties of the low-density porous matter and fast energy transfer in the preformed plasma layer.

The main goal of this work was to demonstrate the sufficient energy transfer and smoothing effect of the low-density foam absorber. In this paper, results obtained during the past year are summarized.

1. PALS Experiments on Laser Beam Interactions with Targets Containing Porous Matter

Preliminary experiments were conducted on the PALS iodine laser facility to study the physics of laser-light

---

*E-mail: kalal@troja.fjfi.cvut.cz

absorption in the porous matter, the absorbed laser energy transfer inside the porous matter, the formation of ablation pressure in a laser-produced plasma of foam, and the ability of that pressure to accelerate a thin solid foil modeling the shell of an ICF target. In the experiments, the laser provided a 400-ps full-width at half-maximum pulse with the energy up to 600 J at the basic harmonic ($\lambda_1 = 1.32\ \mu$m) and up to 300 J at the third harmonic ($\lambda_3 = 0.44\ \mu$m) of laser light. Target irradiances at both wavelengths were varied from $I \approx 10^{14}$ W/cm^2 up to $I \approx 10^{16}$ W/cm^2 for different sets of experiments. Such intensity variations were obtained not only by laser energy variations but also by defocusing the laser beam with respect to the target surface. The radius of irradiation area on the target was changed for different sets of experiments from $R_L \approx 40\ \mu$m up to $R_L \approx 150\ \mu$m. The laser intensity distribution in the irradiated area was not quite uniform and had several concentric diffraction rings. Two types of planar targets were employed in these experiments: (a) single-layer foam targets and (b) double-layer targets (a foam layer was attached to a thin Al foil). The foam layers with thickness from 300 to 1000 μm were made of polystyrene with two different average densities, $\rho_1 = 10^{-2}$ g/cm^3 and $\rho_2 = 2 \cdot 10^{-2}$ g/cm^3. The thickness of the Al foil was $\Delta_{Al} = 5\ \mu$m and $\Delta_{Al} = 2\ \mu$m. The dimensions of the targets were 2000 × 2000 μm.

Measurements employing interferometry and shadowgraphy were carried out by means of a three-frame polari-interferometric system with automated image-processing technique (described in Ref. 5). Each of three recording channels was equipped with a charge-coupled device camera of the Pulnix TM-565 type, with a matrix of 768 × 512 pixels. The diagnostic system used a probing beam at the third harmonic derived from an auxiliary laser beam. A delay time between the first and the second channels, as well as between the second and the third channels, was set to 3 ns. The probing time of the first channel varied for individual shots. Interferogram processing included parasitic noise filtering, comparison of object and reference interferograms, and a subsequent reconstruction of radial electron density distributions.

The target holder (opaque for the visible light) as well as the probing beam refraction in denser plasma regions limited the field of view, so that only underdense plasma in the corona and at the target's rear side were accessible for the investigation. Interferograms recorded in three consecutive moments of time in experiments with the basic harmonic beam irradiating a single-layer foam target are presented in Fig. 1 and demonstrate a good symmetry, smooth fringes, and absence of any local plasma perturbations at the target's rear. In this case (shot 26), the laser beam energy was 100 J, and the diverging heating beam (the laser focus in front of the foam target) radius on the target was 150 μm. Thickness of the $2 \cdot 10^{-2}$ g/cm^3 dense foam layer was 420 μm. Keeping the same size of laser spot on the target, the experiment with a converging heating beam (the laser focus inside the foam target) showed slightly worse uniformity of rear plasma expansion than in the shot with the aforementioned diverging beam. Thus, though a smoothing effect was definitely observed even in this case, smoothing properties of the foam seemed to be far from its optimum.

The analysis of time evolution of the density profiles reconstructed from the interferograms obtained in

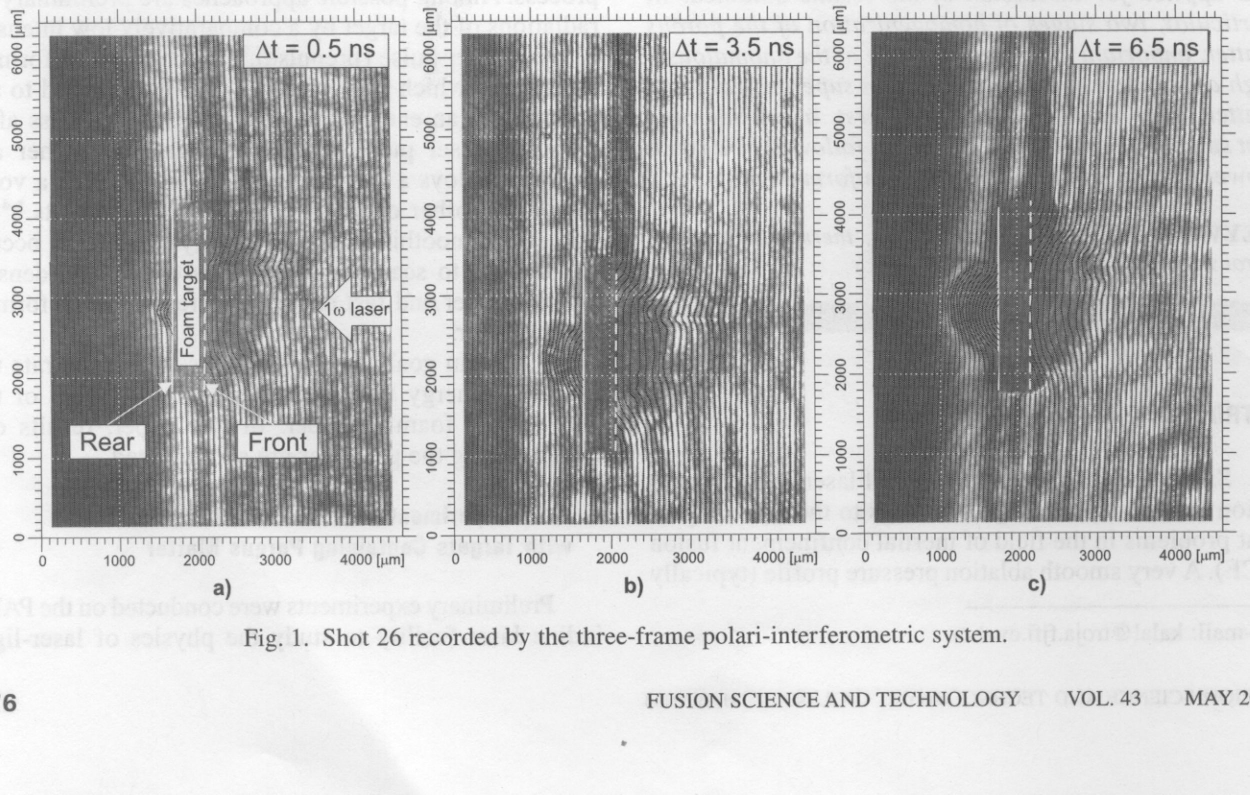
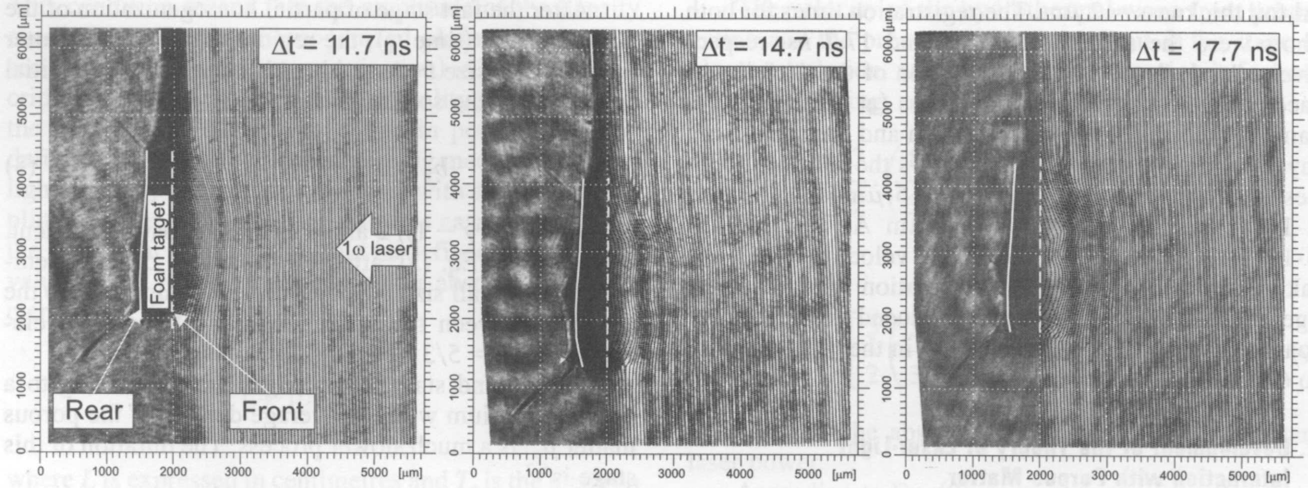


Fig. 1. Shot 26 recorded by the three-frame polari-interferometric system.

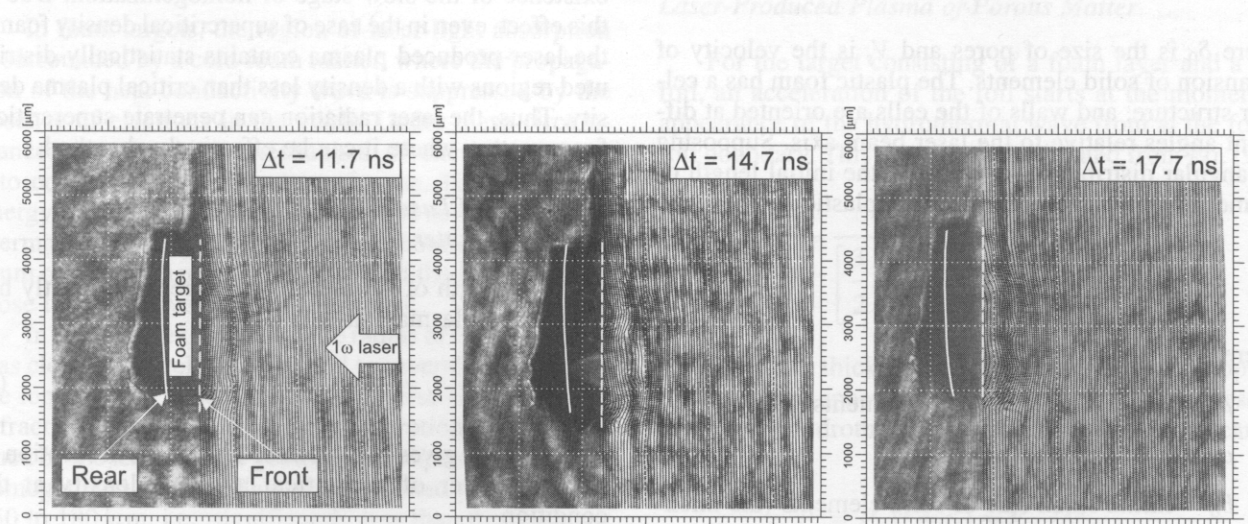


a) b) c)

Fig. 2. Shot 53 recorded by the three-frame polari-interferometric system.

the interaction experiments with single-layer foam targets shows a high velocity of longitudinal and transverse transfer of absorbed laser energy inside the porous matter. In the case of basic harmonic light irradiation, the plasma expansion velocity is close to 1 to $2 \cdot 10^7$ cm/s at the laser beam intensity of $\sim 10^{14}$ W/cm^2. This result is in good agreement with the data published in Ref. 6, obtained in experiments with the Nd laser basic harmonic irradiation of foam targets. As a new result, by irradiating the target by shorter wavelength of the laser light, namely, by the third harmonic of the iodine laser, we obtained an increase by a factor of 1.5 to 2 in the longitudinal transfer velocity of absorbed energy.

In Figs. 2 and 3, the data from the double-layer target experiments (shots 53 and 56, respectively) are presented. These data contain the shadow images of the rear side (external side of the Al foil) and interferograms of the plasma at the front side of the target (foam layer). For the shot 53, the laser parameters were as follows: basic harmonic, energy ≈ 101 J; beam radius ≈ 120 μm. The double-layer target parameters were foam layer thickness ≈ 300 μm, foam density $\approx 2 \cdot 10^{-2}$ g/cm^3, Al foil thickness, ≈ 5 μm. For the shot 56, the laser parameters were: basic harmonic, energy ≈ 94 J; beam radius $\approx$ 120 μm. Double-layer target parameters were foam layer thickness ≈ 300 μm, foam density $\approx 2 \cdot 10^{-2}$ g/cm^3,



a) b) c)

Fig. 3. Shot 56 recorded by the three-frame polari-interferometric system.

Al foil thickness ≈ 2 μm. The registration times for both shots were the same: 11.7, 14.7 and 17.7 ns, respectively. Analysis of the time evolution of the Al foil surface positions for different thickness (at practically the same conditions of target irradiation and the same foam layers of double-layer targets) shows the following values of Al foil velocities: velocity of 5-μm Al foil is 1 to $2 \cdot 10^6$ cm/s and velocity of 2-μm Al foil is 5 to $6 \cdot 10^6$ cm/s. On the basis of these velocity values and taking into account the foil acceleration time, the average ablation pressure of laser-produced plasma of the foam matter can be estimated to be in the region from 4 to 6 Mbar.

2. Development of the Theory of Laser-Light Interaction with Porous Matter

The dynamics of formation of laser-produced plasma in the foam, including the processes of laser-light absorption and energy transfer, is determined, to a large extent, by phenomena connected to collisions of plasma flows of laser-exploded solid elements of the foam.

Homogenization of Laser-Produced Plasma of Porous Matter

At the initial stage of interaction, when the plasma flows propagate between the positions of adjacent solid elements, the laser beam penetrates the foam at the length of geometric transparency. The length of geometric transparency L_g decreases during this stage due to the swelling of expanding elements, which are heated and evaporated under the action of laser radiation. The duration of this stage is, in an order of magnitude,

$$t_1 \approx \frac{\delta_0}{V_s} \ , \tag{1}$$

where δ_0 is the size of pores and V_s is the velocity of expansion of solid elements. The plastic foam has a cellular structure, and walls of the cells are oriented at different angles relative to the laser beam axis. Supposing the angular distribution is uniform, the initial length of geometric transparency of the foam plastic is

$$L_{g0} \approx \frac{\pi}{2} \cdot \frac{\rho_s}{\rho_a} \cdot b_0 \ , \tag{2}$$

where

ρ_s = initial density of solid elements

ρ_a = average density of foam

b_0 = initial small size of solid elements (the thickness of the cell wall).

The large size of solid elements is approximately equal to the size of pores δ_0.

After the fast stage of partial homogenization of the porous matter (time t_1), the regions of the dense matter have a small size b_1, considerably larger than the initial small size of the solid elements[6,7]:

$$b_1 \approx \frac{\delta_0}{(\beta + 1)^{3/2\beta}} \ , \tag{3}$$

where $\beta = 3(\gamma - 1)/2$ and γ is the adiabatic exponent. According to Eq. (3), after the first stage of homogenization, the small size becomes almost comparable to the distance between the initial position of the solid elements: for $\gamma = 5/3$ $b_1 \approx \delta_0/2.8$.

The second stage of homogenization, leading to a uniform medium with the average density of the porous matter ρ_a, is a much slower process. The duration of this stage is[6,7]

$$t_2 \approx \frac{(\delta_0 - b_1)^2}{\lambda_i \cdot V_s} \approx 10^{-9} \cdot \frac{\delta_0^2 \cdot \rho_a}{T^{5/2}} \ , \tag{4}$$

where λ_i is the mean free path of ion-ion collisions, the right side corresponds to $\gamma = 5/3$, and the units are as follows: t_2 (s), δ_0 (μm), T (keV), $\rho_a = \rho_s$ (g/cm^3).

In the conditions of PALS experiments, with laser pulse power $W \approx 0.2$ to 0.3 TW applied to the samples with average density $\rho_a \approx 10$ to 20 mg/cm^3 and $\delta_0 \approx 40$ to 60 μm, at a temperature of $T \sim 1$ keV, the duration of the first stage of homogenization is $t_1 \approx 50$ to 100 ps, and the duration of the second stage of homogenization is $t_2 \approx 20$ to 30 ns. The laser pulse length $\tau_L \approx 400$ ps is thus longer than the duration of the first stage of homogenization and shorter than the duration of the second stage. Therefore, the laser light is absorbed in the partly homogenized plasma. For comprehension of the anomalously high absorption of laser radiation in the supercritical foam matter, it is very important to include the existence of the slow stage of homogenization. Due to this effect, even in the case of supercritical density foams, the laser-produced plasma contains statistically distributed regions with a density less than critical plasma density. Thus, the laser radiation can penetrate supercritical foam matter, where it can be effectively absorbed.

The Depth of Laser-Light Absorption in Porous Matter

The length of geometric transparency of partly homogenized plasma[7,8] is

$$L = 14.8 \cdot \left(\frac{\rho_s}{\rho_a} \right)^{1/2} \cdot b_0 \ . \tag{5}$$

Equation (5) gives the depth of laser light absorption in porous matter of subcritical average density at the condition

$$b_0 > 0.27 \cdot \left(\frac{\rho_{cr}}{\rho_s} \right)^{1/2} \cdot \delta_0 \ . \tag{6}$$

This condition means that the amplitude of the density oscillations of partly homogenized plasma (during the second, slow stage of homogenization) is larger than the critical density. At the opposite inequality sign in Eq. (6), the depth of laser-light absorption in porous matter is defined by the inverse bremsstrahlung mechanism of the light in partly homogenized plasma with subcritical amplitude of density oscillations. In this case, the depth of the laser-light absorption should be defined as an inverse value of the inverse bremsstrahlung absorption coefficient, i.e.,

$$L = 1.4 \cdot 10^{-4} \cdot \frac{T_e^{3/2}}{\rho_a^2} \ , \tag{7}$$

where L is expressed in centimetres and T_e is the electron temperature measured in kilo-electron-volts.

In porous matter of supercritical density, Eq. (5) determines the laser-light absorption depth, provided that

$$b_0 > 6.7 \cdot 10^{-2} \cdot \left(\frac{\rho_a}{\rho_s} \right)^{1/2} \cdot \delta_0 \ . \tag{8}$$

For the opposite inequality sign in expression (8), the absorption of laser light in porous matter is the same as in a continuous medium of supercritical density; i.e., the laser radiation is absorbed in the external plasma of subcritical density, which is produced as a result of the ablation process.

For the PALS experiments, the depth of laser-light absorption is determined by the depth of geometric transparency, and is close to 150 to 180 μm.

Energy Transfer in Laser-Produced Plasma of Porous Matter

In foam targets, the region of laser-light absorption is surrounded by a cold foam matter, where the propagation of the heat conductivity wave is suppressed by the absence of electrons in the voids. Under these circumstances, the dominant mechanism of energy transport into cold foam is a hydrodynamic one. The process of energy transfer can be described by the so-called hydrothermal wave propagation[6,7] in the homogeneous medium of the average foam density with the front velocity close to a sound velocity of the matter.

In the PALS experiments, the radius of the laser beam was close to the cell size or equal to several cell sizes, so the longitudinal as well as the transverse (in the case of refraction) size of the laser-light absorption region is defined by the length of the geometric transparency of partly homogenized plasma. That size, as noted previously, is 150 to 180 μm, i.e., significantly less than the propagation distance of the energy transfer wave. This makes possible the use of the approximation of the point energy source in the model of the spherical hydrothermal wave.

The velocity of the hydrothermal wave front propagation and the pressure behind the front at the stage of plasma evolution, when the absorption region is formed, are the following:

$$V_{ht} \cong 0.4 \cdot \left[\frac{3}{2} \cdot \left(\frac{5}{3} \right)^2 \cdot \frac{(\gamma - 1) \cdot E_{ab}}{\pi \cdot \rho_a} \right]^{1/5} \cdot t^{-3/5}$$

and

$$P_{ht} \cong 0.16 \cdot \left[\frac{3}{2} \left(\frac{5}{3} \right)^3 \cdot \frac{\rho_a^{3/2} \cdot E_{ab}}{\pi \cdot (\gamma - 1)^{3/2}} \right]^{2/5} \cdot t^{-6/5} \ , \tag{9}$$

where E_{ab} is the absorbed laser energy at the constant laser power.

According to Eq. (9), in conditions of the PALS experiments, presuming that all of the laser energy $E_L \approx$ 100 J is absorbed in the foam layer, for the matters with average densities $\rho_a \approx$ (10–20) mg/cm^3, velocity of the energy transfer could be estimated as 3 to $5 \cdot 10^7$ cm/s.

It is quite certain that the structure of the foam would have some influence on the energy transfer in such a medium.[7–9] In particular, in Ref. 9, the influence of the plasma density distribution forming as a result of the thermal explosion of the structural element has been theoretically studied. The corrections for the hydrothermal wave velocity in Ref. 7 have been obtained in a different approximation from evaluation of the electron conductivity in the plasma filling the foam cell. The magnitude of such a correction does not exceed 50%. These two examples clearly show that the problem of the influence of the foam structure on the energy transfer process needs further careful investigation.

Acceleration of the Thin Foil by the Pressure of Laser-Produced Plasma of Porous Matter

For the target consisting of a foam layer and a thin foil, an acceleration of the foil starts at the moment of appearance of the hydrothermal wave front at the foam-foil boundary. This time can be estimated from Eq. (9) as

$$t_f \approx \frac{\Delta^{5/2}}{\left[\frac{3}{2} \cdot \left(\frac{5}{3} \right)^2 \cdot \frac{(\gamma - 1) \cdot E_{ab}}{\pi \cdot \rho_a} \right]^{1/2}} \ ,$$

where Δ is the thickness of the foam layer. In the approximation of the spherical hydrothermal wave, the pressure behind the hydrothermal wave at the moment t_f can be expressed as

$$P_a = P_{th}(t = t_f) \approx E_{ab}/\Delta^3 \ . \tag{10}$$

The time of the shock-wave propagation through the foil is

$$\Delta t_f \approx \frac{\Delta_f^{5/2}}{\left[\dfrac{(\gamma+1)\cdot E_{ab}}{2\cdot\rho_a}\right]^{1/2}} ,$$

where Δ_f is the thickness of the foil.

From the equation of motion, the foil velocity V_f at the moment of the shock-wave appearance at the rear side of the foil is equal to

$$V_f \approx \left[\frac{2}{(\gamma+1)}\cdot\frac{P_a}{\rho_a}\right]^{1/2} \approx \left[\frac{2}{(\gamma+1)}\cdot\frac{E_{ab}}{\rho_a}\right]^{1/2}\cdot\Delta_f^{-3/2} . \quad (11)$$

Note that the measurement of the moment of the shock-wave appearance at the rear side of the foil, $t_{rs} = t_f + \Delta t_f$, or the foil velocity at the moment close to this event makes it possible to obtain the value of the pressure in porous matter plasma.

For PALS experiments, supposing that all of the laser energy is absorbed in the foam layer, the pressure, according to Eqs. (9) and (10), could be estimated as 5 to 8 Mbar; the velocity of Al foils, according to Eq. (11), could be estimated as $2\cdot10^6$ cm/s for 5-μm foil and as $8\cdot10^6$ cm/s for 2-μm foil.

CONCLUSION

Experimental and theoretical results obtained for the velocity of the energy transfer wave are in reasonably good agreement and justify the possibility of drawing the conclusion that the efficiency of the laser-light absorption in the considered porous matter of supercritical density should be within 50 to 100%.

Other important results are the demonstration of a very fast energy smoothing process in laser-produced plasma of porous matter, with a velocity of 2 to $5\cdot10^7$ cm/s, megabar-pressure production in such a plasma, and effective acceleration of thin solid foils by the pressure of foam absorbers of laser radiation.

ACKNOWLEDGMENTS

The Czech and Russian authors were partially supported by INTAS under the contract INTAS-01-572. The work of the Polish authors was partially supported by the European Committee program Transnational Access to Research Infrastructure under contract HPRI-CT-1999-0053. The Czech authors were further supported by their Ministry of Education, Youth and Sports under the Laser Plasma Research Centre contract (LN00A100). Additional support for this research was also provided by the International Atomic Energy Agency under the IFE-CRP, CZR-11655. All these financial supports are gratefully acknowledged.

REFERENCES

1. T. BOEHLY et al., *Phys. Rev. A*, **42**, 6962 (1990).

2. J. NILSEN et al., *Phys. Rev. A*, **48**, 4682 (1993).

3. S. YU. GUS'KOV, N. V. ZMITRENKO, and V. B. ROZANOV, *JETP*, **81**, 296 (1995).

4. M. DUNNE et al., *Phys. Rev. Lett.*, **75**, 3858 (1995).

5. T. PISARCZYK, R. ARENDZIKOWSKI, P. PARYS, and Z. PATRON, "Polari-Interferometer with Automatic Images Processing for Laser Plasma Diagnostic," *Laser Part. Beams*, **12**, 549 (1994).

6. S. YU. GUS'KOV, A. CARUSO, V. B. ROZANOV, and C. STRANGIO, "Interaction of High-Power Laser Pulse with Supercritical-Density Porous Materials," *Quantum Electron.*, **30**, 191 (2000).

7. A. E. BUGROV et al., "Interaction of High-Power Laser Beam with Low-Density Porous Media," *JETP*, **84**, 497 (1997).

8. S. YU. GUS'KOV and V. B. ROZANOV, "Interaction of Laser Radiation with a Porous Medium and Formation of a Non-Equilibrium Plasma," *Quantum Electron.*, **27**, 696 (1997).

9. S. V. BONDARENKO et al., "Energy Transfer in a Volume Structured Media," *Quantum Electron.*, **30**, 39 (2001).

M. Kalal (MSc, physical electronics, 1976; PhD, physical engineering, 1984; and Doc, applied physics, 1999, Czech Technical University (CTU) in Prague, Czech Republic) is a Vice Dean in the Faculty of Nuclear Sciences and Physical Engineering (FNSPE), CTU. He is currently teaching and doing research at the FNSPE. His current research interests are complex interferometry and laser imprint treatment.

J. Limpouch (MSc, 1978, and PhD, 1984, CTU Prague) is presently associate professor of applied physics at CTU Prague, and he is also with the Institute of Physics of AS CR. He specializes in theoretical and computational physics of intense laser-matter interactions and inertial confinement fusion (ICF).

E. Krousky (diploma, mathematics and physics, Charles University, Czech Republic, 1968, and PhD, Institute of Physics of Academy of Sciences, Czech Republic, 1979) is engaged in diagnostics of high-temperature plasma, determination of its radiative characteristics, and in applications of nonconventional spectroscopic methods.

K. Masek (PhD, Charles University, 1968; DSc, Academy of Sciences, Czech Republic, 1991) is a member of the laboratory at Prague Asterix Laser System (PALS). His main field of research is laser-produced plasma.

K. Rohlena (MSc, physics, Charles University, 1963; PhD; plasma physics, Czechoslovakia Academy of Science, 1972) is a division head at the Institute of Physics of Academy of Sciences and is the director of the Joint Research Center PALS. His interests are in the physics of laser plasma and interaction of high-power laser radiation with matter.

P. Straka (MSc, quantum and nonlinear optics, 1992, and PhD, quantum optics and optoelectronics, 1997, Charles University) works in the Department of Nonlinear Optics at the Institute of Physics, Czech Academy of Sciences and the Research Center PALS, Czech Academy of Sciences. His interests are in the areas of ultra-high-power laser pulses, hybrid laser nonlinear optics, ultrafast optics, and lasers.

J. Ullschmied (MSc, physical electronics, CTU, 1965; PhD, experimental plasma physics, Institute of Plasma Physics, CSAS, 1971) is a deputy director at the PALS Research Center. His interests are in pulsed power, high-power lasers, laser plasma production, and hot plasma diagnostics.

A. Kasperczuk (diploma, physics, Institute of Plasma Physics and Laser Microfusion, 1974; MSci, nuclear physics, 1974, and PhD, plasma physics, 1984, Military University of Technology) is a senior researcher in the Institute of Plasma Physics and Laser Microfusion. His interests are investigating laser-produced plasma and plasma generated in a great plasma focus device (PF-1000) by using polari-interferometric methods.

T. Pisarczyk (diploma, physics, Institute of Plasma Physics and Laser Microfusion, Poland, 1976; MSci, nuclear physics, 1974; PhD, plasma physics, 1987, Military University of Technology, Poland; DSc, plasma physics, Sołtan Institute of Nuclear Studies, Warsaw, Poland, 1999) is an associate professor and head of the Laser Plasma in Magnetic Field Section in the Institute of Plasma Physics and Laser Microfusion in Warsaw. His interests are investigations of laser-produced plasma and plasma generated in a great plasma focus device (PF-1000) by using polari-interferometric methods.

S. Yu. Gus'kov (MSc, solid state physics, Moscow Engineering-Physical Institute, Russia, 1973; PhD, 1977, and DSc, 1977, quantum radiophysics, and professor, 1999, P. N. Lebedev Physical Institute, Russia) is a head research fellow at the P. N. Lebedev Physical Institute. His current research interests are high-temperature plasma, inertial confinement fusion, and laser interaction with matter.

A. I. Gromov (MSc, vacuum tools, Moscow Institute of Electronic Machinery, Russia, 1974; PhD, 1997, and DSc, 1997, quantum radiophysics, P. N. Lebedev Physical Institute) is a senior scientific worker. His current research interests are multishell targets for thermonuclear tools: design, production, and monitoring.

V. B. Rozanov (MSc, nuclear physics, Lomonosov Moscow State University, Russia, 1955; PhD, plasma physics, Russian Nuclear Federal Center–Russian Research Institute of Technical Physics, Russia, 1965; DSc, plasma physics and quantum radiophysics, P. N. Lebedev Physical Institute, Russia, 1974; professor, theoretical and experimental physics, Moscow Engineering–Physical Institute, Russia, 1983) is currently a head research fellow and head of the Laser Plasma Theory Department at the P. N. Lebedev Physical Institute. His research interests are plasma physics, hydrodynamics, inertial confinement fusion, laser interaction with matter, and radiation physics.

V. N. Kondrashov [diploma, experimental nuclear physics, Moscow Engineering Physics Institute (MEPhI), 1975; PhD, plasma physics, Kurchatov Atomic Energy Institute, 1987] is a leading research scientist in the Optical and Magnetic Research Department at the Troitsk Institute for Innovation and Fusion Research, Russia. His current research interests are in laser-plasma interaction, plasma hydrodynamics, plasma diagnostics, and laser-aided applications.