The Optical Society (OSA)
2010 Massachusetts Ave., NW
Washington, DC 20036 US
www.osa.org

1559-128X/14/317202-06$15.00/0

http://dx.doi.org/10.1364/AO.53.007202

International Journal of Optical Society of America

APPLIED OPTICS / Vol. 53, No. 31 / 1 November 2014, 7202 - 7207

1559-128X/14/317202-06$15.00/0
© 2014 Optical Society of America
http://dx.doi.org/10.1364/AO.53.007202
Applied Optics Division Editor: aomss@osa.org

Photonic jet breakthrough for direct laser microetching using nanosecond near-infrared laser

Andri Abdurrochman,[1,2,*] Sylvain Lecler,[1] Frédéric Mermet,[3] Bernard Y. Tumbelaka,[2] Bruno Serio,[4] and Joël Fontaine[5]

[1]ICube-Instrumentations et Procédés Photoniques, Université de Strasbourg, Boulevard Sébastien Brant, CS 10413, 67412 Illkirch, Strasbourg, France

[2]Department of Physics, Universitas Padjadjaran, Jl. Raya Bandung-Sumedang KM. 21, Jatinangor Sumedang 45363, Indonesia

[3]Irépa Laser, Boulevard Sébastien Brant, 67412 Illkirch, Strasbourg, France

[4]Laboratoire Energétique Mécanique Electromagnétisme, Université Paris-Ouest Nanterre La Défense, 92410 Ville d'Avray, France

[5]ICube-Instrumentations et Procédés Photoniques, Institut National des Sciences Appliquées de Strasbourg, Boulevard de la Victoire, 67000 Strasbourg, France

*Corresponding author: andri.abdurrochman@etu.unistra.fr

Received 18 July 2014; accepted 11 September 2014;
posted 24 September 2014 (Doc. ID 216744); published 22 October 2014

Nanosecond near-IR lasers are commonly used for industrial laser processing. In this paper, we demonstrate that a 70 μm diameter beam generated from a 5 W, 28 ns, near-IR (1064 nm) Nd:YAG laser can etch a silicon wafer with a lateral feature size as small as 1.3 μm. Surprisingly with this laser, microetching can also be achieved on glass, despite the low absorption of this material at this wavelength. This breakthrough is carried out in ambient air by using glass microspheres with diameters between 4 and 40 μm that generate a concentrated beam at their vicinity, a phenomenon referred to as a photonic jet. The roles of parameters such as laser fluence, pulse number, microsphere diameter, and distance between the microsphere and the sample are discussed. A good correlation has been observed between the computed photonic jet intensity distribution and the etched marks' geometry. © 2014 Optical Society of America

OCIS codes: (220.4000) Microstructure fabrication; (290.4020) Mie theory; (290.5850) Scattering, particles; (050.6624) Subwavelength structures.

http://dx.doi.org/10.1364/AO.53.007202

1. Introduction

In the microfabrication field many techniques have been developed with different advantages. Photolithography, a common technique, uses chemical agents and typically shares about 30% of the manufacturing cost of an integrated circuit [1]. Some dry methods, namely, ion beam, electron beam, and near-field optics technologies [2–5], have attracted a great deal of interest because of many potential benefits such as the chemical-free manufacturing environment. These processes have a higher resolution; however, they have to be conducted in vacuum, require expensive equipment, and are not adapted to mass production. Direct laser-etching (or laser-dry-etching) is another alternative method considered in this paper. The method is very useful, for example, for selective removal of thin films [6]. However, due to the diffraction limit, the traditional laser optical

1559-128X/14/317202-06$15.00/0