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Xiaocong Zhang, Xuan He, Qiming Liu, Bertrand Poumellec, Matthieu Lancry, Francois Brisset

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Abnormal elemental redistribution in silicate glasses irradiated by ultrafast laser

Xiaocong Zhang,[a] Xuan He,[a] Qiming Liu,[a*] Bertrand Poumellec,[b*] Matthieu Lancry[b] and Francois Brisset[b]

[a]School of Physics and Technology, Key Laboratory of Ariticial Micro- and Nano-structures of Ministry of Education, Wuhan University, Wuhan 430072, China

[b]Institut de Chimie Moléculaire et des Matériaux d'Orsay, UMR CNRS-UPS 8182, Bâtiment 410, Université de Paris Sud 11, 91405 Orsay Cedex, France

*Corresponding author: qmliu@whu.edu.cn, bertrand.poumellec@u-psud.fr

We report on an abnormal element distribution in silicate glass, induced by 300 kHz, 1030 nm femtosecond laser irradiation. Chemical analysis has taken on the cross section of the laser tracks and also along the writing direction. Energy-dispersive X-ray, wavelength-dispersive spectroscopy and nuclear microprobe demonstrates that no elemental migration occurred after femtosecond laser irradiation, which is quite different from the previous results. The possible mechanism is also briefly discussed.

1. Introduction

In recent years, high repetition rate femtosecond (fs) laser induced element redistribution in glasses has become an advanced research hotspot since this technique can control glass composition three-dimensionally[1-3]. The composition of glass is an important parameter that affects many glass properties such as luminescence, absorption, refractive index, crystallization temperature and other physical and chemical properties. Some interesting results of this phenomenon as well as potential applications have been reported by various research groups[3,4]. Temperature gradients caused by thermo-diffusion and diffusion coefficient of various elements are considered as two key factors for the formation mechanism of element redistribution[5]. According to previous observation, the elemental migration in silicate glasses can be summarized as follows: the relative concentrations of the glass network former ions, e.g. Si^{4+}, are higher in the central area of the laser focal point, while the glass network modifier ions, e.g. Ca^{2+}, migrate to the outside to form ring-shaped regions. While in tellurite glass, the relative glass composition distribution remain almost unchanged compared with the un-irradiated area[6]. The extraordinary glass network structure, consist of small structure units, rather than large multi-membered structure, is responsible for this counterexample. Except for common circular patterns which are due to the circular temperature distribution, shape-controlled of element distribution can also be formed flexibly by simultaneous