Development of laser target sight-on system based on multiple transmission through a tapered glass capillary for ion microbeam irradiation

Mikiko Koushima*, Tokihiro Ikeda[†,*] [1], Mitsuyoshi Matsubara*, Takafumi Masuyama*, Tatsuya Minowa*, and Wei-Guo Jin*

[*] Department of Physics, Toho University, 2-2-1 Miyama, Funabashi, Chiba 274-8510 Japan
[†] RIKEN Nishina Center for Accelerator-Based Science, 2-1 Hirosawa, Wako, Saitama 351-0198 Japan

Synopsis An estimation method of micro-meter sized laser profile created by the laser beam transmission through a tapered glass capillary is developed for the target sight-on system of ion microbeam irradiation to living cells. In our system, both the laser and the ions are designed to be transmitted through the same capillary so that the laser spot is surely on the ion track. By selecting the excitation light of a fluorescent protein in cell nucleus, the fluorescent volume can be confirmed as the targeted area.

A method to irradiate single cells with a microbeam of a few MeV ions extracted from a tapered glass capillary with thin end-window has been developed [1]. One of the advantages of this method is that the projectile ion can stop inside the cell employing the short range, which is a few to 100 μm in water for MeV-H or He ions. Therefore, micron-scale pin-point damage can be realized with the maximized stopping power called as Bragg peak.

Depending on the irradiation angle defined as the angle between the capillary axis and the objective lens axis, an assist to align the target on the beam axis is necessary. We propose a laser target sight-on system, where the capillary will be used for both the ion and the laser transmissions. The laser micro-spot created by the capillary coincides with the area to be irradiated. When the wavelength (λ) of the laser is selected as the same λ of the excitation light of the fluorescent dye or protein at a local area in the cell, the selectivity of the irradiation will become better.

In order to develop the sight-on system, we first demonstrated a single fluorescent bead being aimed. Figure 1(a) shows that a single bead with a diameter of 24 μm in a 1D-fluorescent bead array yielded fluorescence (peak λ = 508 nm) by a micro-meter sized excitation light (λ = 488 nm) created by a capillary at Toho University. The photo was taken through a band pass filter with the center λ of 510 nm and the width of 20 nm so that the high intensity of the excitation light was suppressed by 10^{-6} times. Figure 1(b) is a laser beam profile at 1 mm- downstream from the capillary outlet. The profile was visualized by a thin layer of fluorescent beads of 2 μm in diameter formed on a microscope slide (Fig. 1(c).) The diameters of the rings in Fig. 1(b) were extracted automatically by homemade software and compared with those of Fraunhofer diffraction known as ring pattern by parallel light transmitted through a small aperture. The profile was also measured by a powermeter to obtain the density distribution in a laser spot. We estimated the spot size of the practical area and the maximum power density. The spot size possibly depends on the capillary shape. The obtained data as well as a simulation [2] will be used for the feedback to fabricate the better capillary shape.

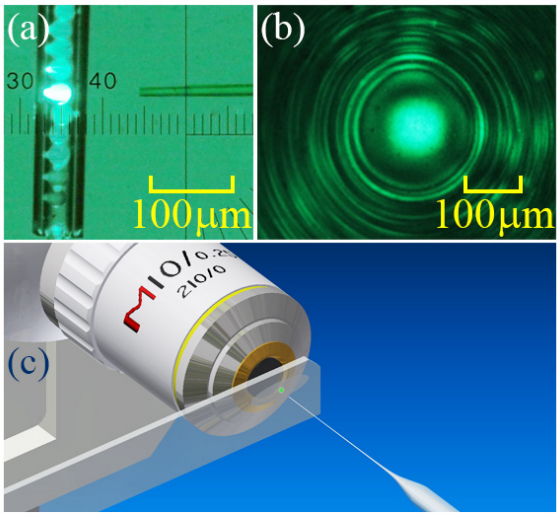

Figure 1. (a) A fluorescent micro-bead was spotlighted by an excitation light from a glass capillary. (b) A beam profile photo on a fluorescent screen. (c) The screen on a microscope slide was between the capillary tip and the objective lens.

References

[1] V. Mäckel *et al.* 2014 *Rev. Sci. Instrum.* **85** 014302
[2] W-G. Jin *et al.* 2015 *J. Phys. Soc. Jpn.* **84** 114301

[1] E-mail: tokihiro@riken.jp