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Propagation of visible light through tapered glass capillaries for microbeams

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Synopsis Towards production of microbeams, propagation of laser beams of visible light with wavelengths of 488, 633 and 670 nm through tapered glass capillaries has been studied. In conjunction with an optical lens upstream of the capillaries with outlet sizes ranging from 17 to 100 μm, transmission efficiency more than 80 % has been achieved for outlet diameters more than 40 μm.

Micrometer-sized ion beams produced by tapered glass capillaries are available for cell irradiations to investigate radiation effects and biological responses [1,2]. The advantages of this method are the confinement of large energy deposition within a small volume, an easy positioning of the beam spot on the target, and so on. In most irradiation experiments, fluorescent proteins have been used under excitation light which is sometimes harmful for living cells. In order to suppress the influence of the excitation light, there is a possibility of a micro-spot of the excitation light extracted from the capillary. However, microbeams of visible light and UV by the capillaries have not yet studied sufficiently.

We have started transmission experiments of visible light through tapered glass capillaries which are the same capillary for ion microbeams. A He-Ne laser with a wavelength λ of 633 nm and an Ar+ laser (λ = 488 nm) have been employed because the performances of the lasers are well-understood. Taper angle mapping for each tapered capillary [3] is useful to estimate the transmission efficiency. According to the maps, an optical lens whose focal point position was at large taper angle region was installed upstream of the capillary inlet so that the transmitted laser beam intensity increased drastically. The transmitted beam intensities through both tapered glass capillaries and straight glass tubes were measured by a power meter as ‘output’ and ‘input’ powers, respectively. Transmittance \( T(\%) \) defined as the ratio of the output power to the input power was obtained as a function of outlet diameter as shown in Fig.1. We found \( T \) increases rapidly with the outlet diameter for small diameters and is kept larger than 80% for diameters larger than 40 μm.

We will report on the details including the results without the lens, as well as the density enhancement as a function of the outlet diameters.

Figure 1. Transmittance of laser beam through the tapered capillary as a function of the outlet diameter with the optical lens.

References

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