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Title	KrF Excimer Laser Delivery by Low-OH Silica Fiber
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Citation	電気材料技術雑誌. 2000, 9(2), p. 157-158
Version Type	VoR
URL	https://hdl.handle.net/11094/81633
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KrF Excimer Laser Delivery by Low-OH Silica Fiber

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Introduction

Excimer laser applications need an efficient beam delivery system. While silica fiber delivery system is well established for the visible or near-infrared lasers, some problems have to be solved for ultra-violet lasers. The high-OH silica fiber was used as the delivery system for excimer lasers, but its efficiency decreased remarkably at the initial stage of laser delivery.

In our experiments using low-OH silica fiber, the increase of the delivery efficiency was observed. In this paper, the improvement of the delivery properties is reported.

Experimental setup

Figure 1 shows the experimental setup for the excimer laser delivery by optical fiber. The excimer laser (Questek) was operated at the wavelenght of 248nm and the repetition rate of 1pps. The laser beam was focused onto the input end of silica fiber with the core diameter of 400μm and OH content under 10ppm. The fiber length was 40cm. The incident laser intensity was typically 0.6J/cm^2 on the input end of the fiber. The deliveried laser beam was observed using the television camera system (Hamamatsu Photonics, C2741-05 & DVS-3000) in order to estimate the laser energy.

The fluorescence from the fiber during laser delivery was monitered using the video camera (Canon, A-1) and its spectrum was observed using the monochromator (JASCO, CT-50C) and photomultiplier.

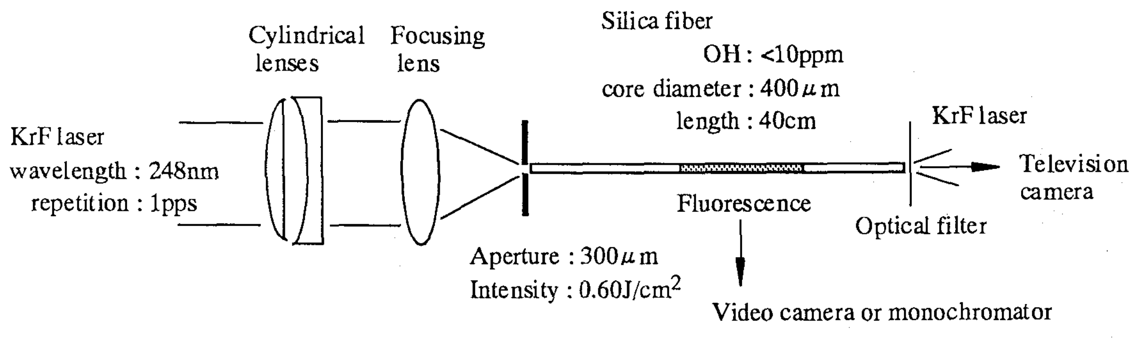

Fig.1 Experimental setup for the measurement of KrF laser delivery properties

Experimental Results

Figure 2 shows the relation between the deliveried laser pulse energy and the number of laser pulses. The deliveried energy was not detected at the initial stage of laser delivery. The energy enhanced remarkably at the 1800th ~3000th pulse and saturated above the 3000th pulse.

The photographs of the fluorescence in visible region from the fiber were shown in Fig.3. The values at the bottom of Fig.3 mean the distance from the input end of the fiber. The fluorescence was observed only near the input end at the initial stage. With increasing the number of laser pulses, the fluorescence region was shifted to the output end. At about 1800th pulse, the fluorescence region reached the output end, and fluorescence disappeared all over the fiber above the 3000th pulse.

The fluorescence spectrum in 2.0~6.0eV photon energy region was shown in Fig.4. The two components were observed : the one was centered at 2.75eV and the other was at 4.50eV. The former disappeared above 3000th pulse, but the latter was still observed.

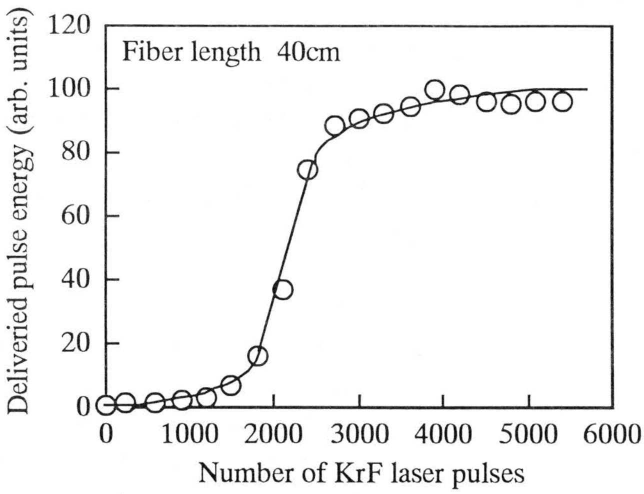

Fig.2 Deliveried energy of KrF laser pulse vs. number of laser pulses.

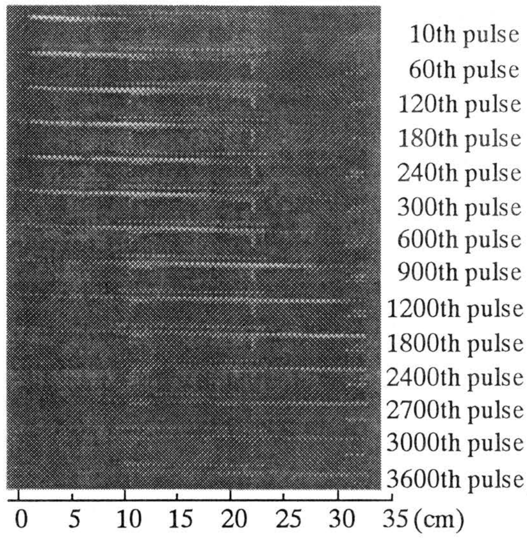

Fig.3 Photographs of the fluorescence

Discussions

The delivery properties of the low-OH silica fiber is supposed to be related to the fluorescence. The fluorescence centered at 2.75eV is reported to originate in neutral oxygen vacancies.[1] This defect may be changed to another defect by absorbing the KrF laser lights. This phenomenon, photo-bleaching, is also supported by the absorption spectra of the KrF-laser-irradiated silica rod samples in another our experiments.

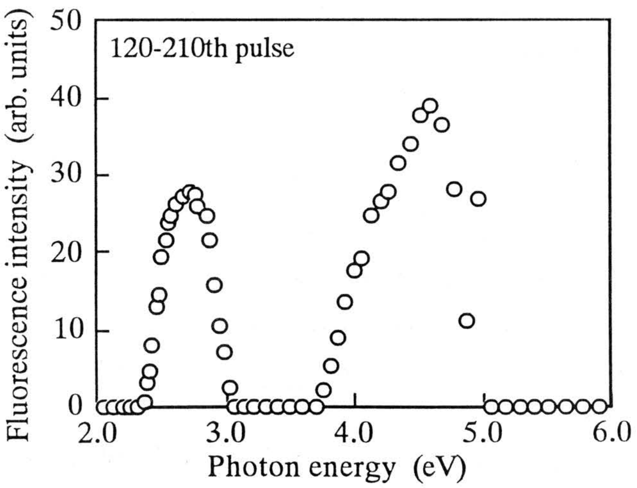

Fig.4 Fluorescence spectrum from the fiber

Summary

The fluorescence from low-OH silica fiber was experimentally observed in KrF excimer laser delivery. The fluorescent region was localized near the input end of the fiber at initial stage of laser delivery and shifted to the output end with increasing the number of laser pulses. As the fluorescent region reached the output end, deliveried laser light was remarkably enhanced. This enhancement would be induced by the KrF-laser-bleaching of the defects in the core glass.

References

1) R. Thomon et. al. : Phys. Rev. Lett. **62**, 1388 (1989).