A STUDY FOR DEVELOPMENT OF CO LASER SCALPEL
CO LASER POWER TRANSMISSION BY INFRARED GLASS OPTICAL FIBER

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High intensity power transmission of CO laser throughout the flexible infrared glass optical fiber is revealed experimentally. 4.01 W propagated power is carried out through 200 μm of diameter of As_2S_3 chalcogenide glass optical fiber with 12.8 kW/cm^2 of light intensity at fiber end.

For up to 6 μm of wavelength infrared lasers, that is only for CO lasers, it is possible to employ the infrared glass materials of high mechanical strength for the transmission line. Thus, the laser scalpel with a flexible optical fiber can be realized by the use of the combination of CO lasers and the IR glass fibers. We have been studying the development of this new laser scalpel. In this paper, high intensity power transmission of CO laser through the flexible IR glass optical fiber is demonstrated as a fundamental research.

The IR glass fiber which is used in this experiment is made of As_2S_3 chalcogenide glass. The characteristics and the structure of this fiber are described in Table 1. The chalcogenide glass is one of the most low loss materials in the IR glasses. The transmission loss of this fiber is only 0.17 dB/m (about 4% decay in a meter). Its bandwidth for optical transmission is very wide, so that Nd-YAG laser light can be propagated through this fiber simultaneously.

The set-up for the power propagation experiment is illustrated in Fig. 1. The CO laser used in this experiment is the high power CO/Xe laser developed for this study. CO lasers have high power and high efficiency kinetics than CO_2 lasers essentially, however in general,

Table 1

Characteristics of
Chalcogenide Glass Fiber

Material	As_2S_3 glass	
Transmission Loss	0.17 dB/m at 5.35 μm	* ¹
Refractive Index	2.41 at 5.35 μm	* ²
Reflection Loss	29.2 % at 5.35 μm	
Fiber Structure	unclad	
Fiber Diameter	200 μm	

*¹ J. Opt. Soc. Am., 48, 633 (1958).

*² Jpn. J. Appl. Phys., 21, L75 (1982).

they are less powerful and less efficient at room temperature. We improve the performances of room temperature CO/Xe laser by the convective cooling technique. The discharge tube length of our device is 105 cm. 40.7 W of the maximum power and 20.7% of the maximum efficiency are carried out. These values indicate 20-30% increasing in laser power and efficiency. The CO laser beam is collimated into the fiber end by 2.54 cm of focal length of the ZnSe meniscus lens. The laser beam power and the propagated light power are measured by the calibrated laser power meters.

The results of the experiment shows in Table 2. 4.01 W of the continuous propagated power is attained with 12.8 kW/cm^2 of the light intensity at fiber output end. This light intensity is correspond to the case of 100 W light propagation into $1 \text{ mm}\Phi$ optical fiber. After 50 s of the duration for the light propagation, the degradation on the fiber can not be find out.

In conclusion, these results encourage the realization of the CO laser scalpel with the flexible IR glass fiber. In the furure design, since Nd-YAG laser and CO laser may transmitted through this kind of fibers simultaneously, the laser treatment system which has the cutting and/or coagulating capacity control(similar to the electric surgical unit) can be attained.

Fig. 1 Experimental Set-up

Table 2 Results of Experiments

Light Source	CO/Xe Laser
Fiber Length	128.0 mm
NA (external)	≈ 0.1
Output Beam Power	4.01 W at fiber end
Power Density	12.77 kW/cm^2
Transmit. (over all)	56.6 %
Duration	52.8 sec
Damage	None