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3D LASER MICROVISION

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1 INTRODUCTION

3D Laser Microvision is a high–resolution short–range laser radar. The aim of the Laser Microvision is to make a perspective of an object with μm order spatial resolution. These features may well serve the requests of high–resolvable diagnosis and estimate technology in the field of fine processing and micro–optics. Also, in bio–medicine, by feeding the probe beam of this device collinearly with the cutting laser beam, a new laser knife that can monitor the depth of cut during surgery may be possible.

Our radar gathers information about an object in the wavenumber domain, and then processes this information to generate an image of the object. The spatial resolution of this type of radar is limited by the amount of sweep of wavelength. As long as we use a wavelength tunable laser currently available on the market, the ultimate resolution is at most 10 μm order. To overcome this difficulty, that is, to realize μm order resolution, we have studied sophisticated signal processing methods, for example, neural network, MUSIC and dynamic programming methods and we have shown their effectiveness [1].

This paper describes the principle of operation of the Laser Microvision and presents some experimental results. The performance characteristics of the Laser Microvision, spatial resolution of about 20 μm, and measurement accuracy of ± 5 μm were experimentally verified.

2 THE PRINCIPLE OF OPERATION

The optical system of the Laser Microvision is shown in Fig.1. It is a type of Mach–Zehnder interferometer.

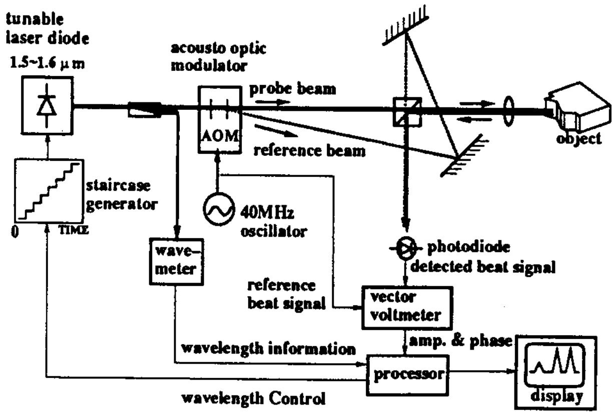

Figure 1: Optical system of Laser Microvision

At one fixed wavenumber, the amplitude and phase of the reflected probe beam are precisely measured by utilizing heterodyne interferometry. By stepwise changing the wavenumber of the light source, the Laser Microvision measures the wavenumber spectrum of the signal which would be obtained if the object was hit with a spatially localized pulse. The number of wavenumber steps determines the maximum spatial range. Fourier transforming the data obtained in the wavenumber domain into the spatial domain generates the image of the object.

scanning range of wavelength 1.5 μm to 1.6 μm	spatial resolution 12.0 μm
number of wavenumber steps 512	maximum spatial range 6mm

Table 1: Typical measurement conditions and performance of the Laser Microvision

Table 1 shows our typical measurement conditions and performance of the Laser Microvision when Fourier transform was used.

3 EXPERIMENTAL RESULTS

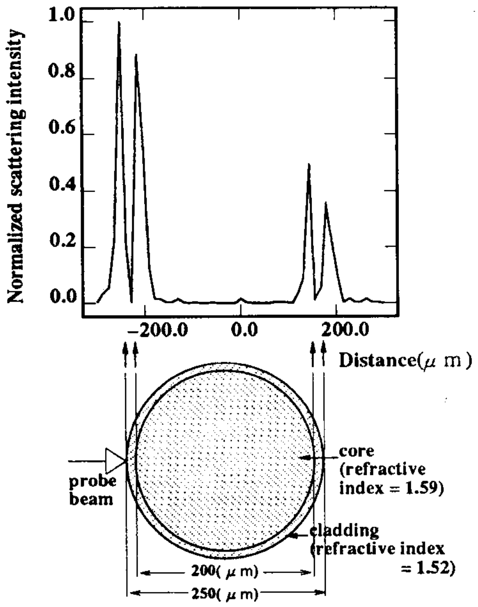

Figure 2: Image of an optical fiber

Figure 2 shows the image obtained of an optical fiber with the above mentioned measurement conditions. In Table 2, the real and measured values of the optical thickness(geometrical thickness × refractive index) of the core and cladding are compared. In the case of the cladding, the agreement between the measured and real values is good. In the case of the core diameter, however, the discrepancy may be due to the misalignment of the probe beam with the meridiconal of the fiber.

	real	measured
core diameter	318 μm	360 μm
cladding layer thickness	38 μm	36 μm

Table 2: Real and estimated values of the optical thickness of the fiber

Figure 3 shows the displays of the Laser Microvision when a surface mirror was set at various positions. To determine the accuracy, the mirror was moved 10 μm for each measurement. The corresponding positions of each measured peak are given in the figure. The origin of distance corresponds to the point where the path length of the probe beam coincides with that of the reference beam. We can conclude from these results that the measurement accuracy of the Laser Microvision is as good as ± 5 μm.

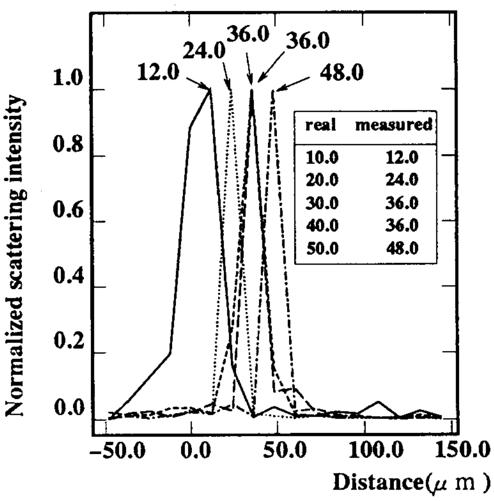

Figure 3: Radar displays when a surface mirror was set at various positions

4 CONCLUSIONS

3D Laser Microvision and its performance was introduced. We experimentally verified spatial resolution to be about 20 μm and measurement accuracy to be ± 5 μm.

The reduction of the measurement time is one of the most important research subjects to make this device more attractive. Major portion of the measurement time is taken up by mechanically tuning the laser cavity and controlling the system by a PC. So we are now studying the realization of electrically tunable light source and developing a special–purpose computer to control the system.

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References

[1] F.Taga, H.Shimotahira, K.Iizuka. "An approach to an ultra resolution fault locator," *to be presented in this conference.*