Fiber Cross-Sectional Imaging by Controlled Low Coherence Light

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ABSTRACT

We couple a coherence-variable light beam into an optical fiber and observe the fiber cross-sectional images. The variation in the fiber imaging is explored as we change the degree of optical coherence of the incident light. Low coherence light is shown to be capable of improving the quality of the fiber images.

INTRODUCTION

As we launch the He-Ne laser light into a multimode optical fiber, the optical pattern at the fiber output endface is found to be split into many light spots, which are called fiber speckles [1,2]. They result from the fact that the laser light is of high optical coherence. The field interference of high-order modes produces the observed optical patterns.

EXPERIMENTAL SETUP

Figure 1 shows the setup used to transform the incident laser light and to demonstrate the optical coherence of the output light. We make use of a pair of lenses (f = 50 mm and f = 150 mm) to expand the He-Ne laser beam, and let the beam pass through another lens (f = 50 mm). Near the laser focus, we put a diffuser which can be driven by a fast rotating motor. After transmitting the diffuser, the laser beam is scattered into many light spots, which behave as many new point light sources. As the diffuser is rotating, all the light spots move and change randomly, such that the light intensity appears to be smoothly distributed. Nevertheless, the optical coherence decreases as a consequence of the fragmented beam shape [3]. This low coherence light source can be used to improve the cross-sectional imaging of optical fibers.

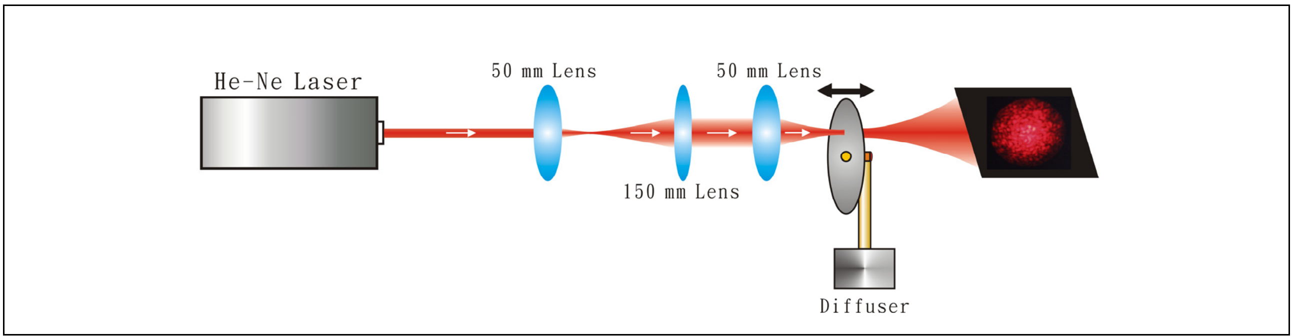

Fig. 1. The experimental setup for transforming a coherent laser light into a low coherence light.

EXPERIMENTAL RESULTS

We adjust the relative positions of the diffuser away from the laser focus and observe the far-field optical patterns (Fig. 2) of the transmitted light which are projected on a screen. From Fig. 2, we see that as the distance between the diffuser and the laser focus grows larger, the width of the laser beam hit on the diffuser becomes bigger and much more tiny light spots are scattered, reducing the optical coherence to a lower degree.

Moreover, we couple the reformed light beam of low coherence into the optical fiber, and explore how the output cross-sectional images are related to the degree of optical coherence in the cases of a stopped diffuser (Fig. 3) and a rotating diffuser (Fig. 4), respectively.

As shown in Figs. 3 and 4, when the diffuser is far from the laser focus, the observed fiber image reveals that the fiber core turns to be smoother and the fiber cladding becomes brighter. It implies that much more light can penetrate into the fiber cladding when the optical coherence of the input light is reduced lower.

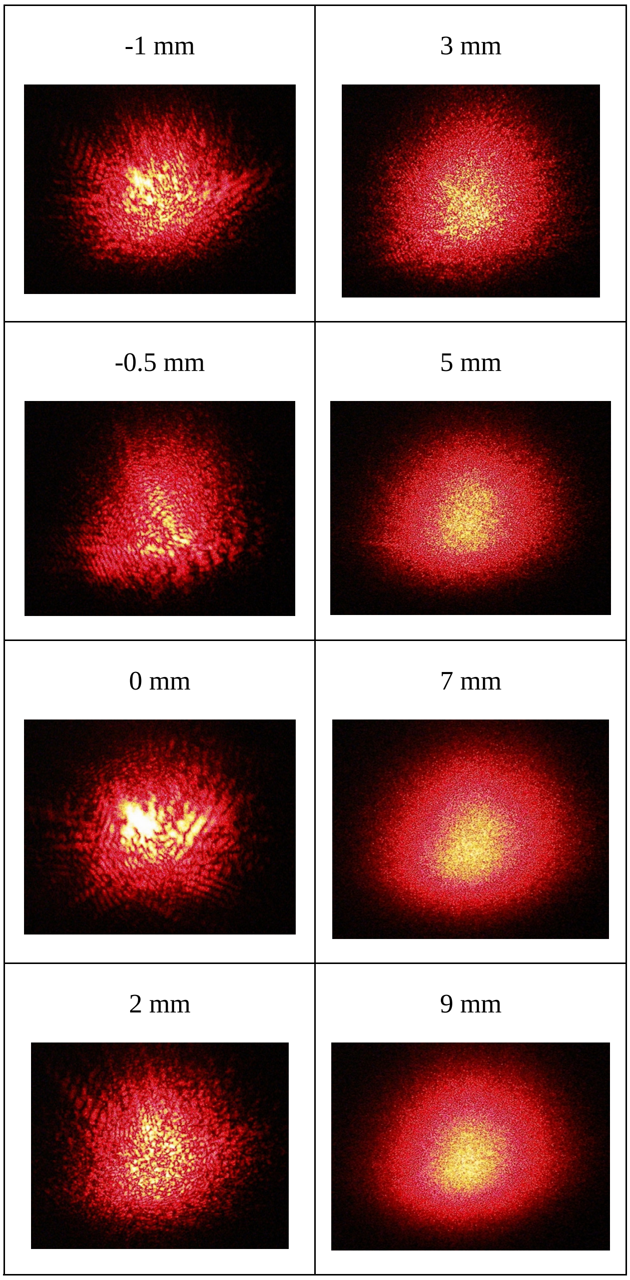

Fig. 2. The variation of far-field optical patterns with the distance between the diffuser and the laser focus.

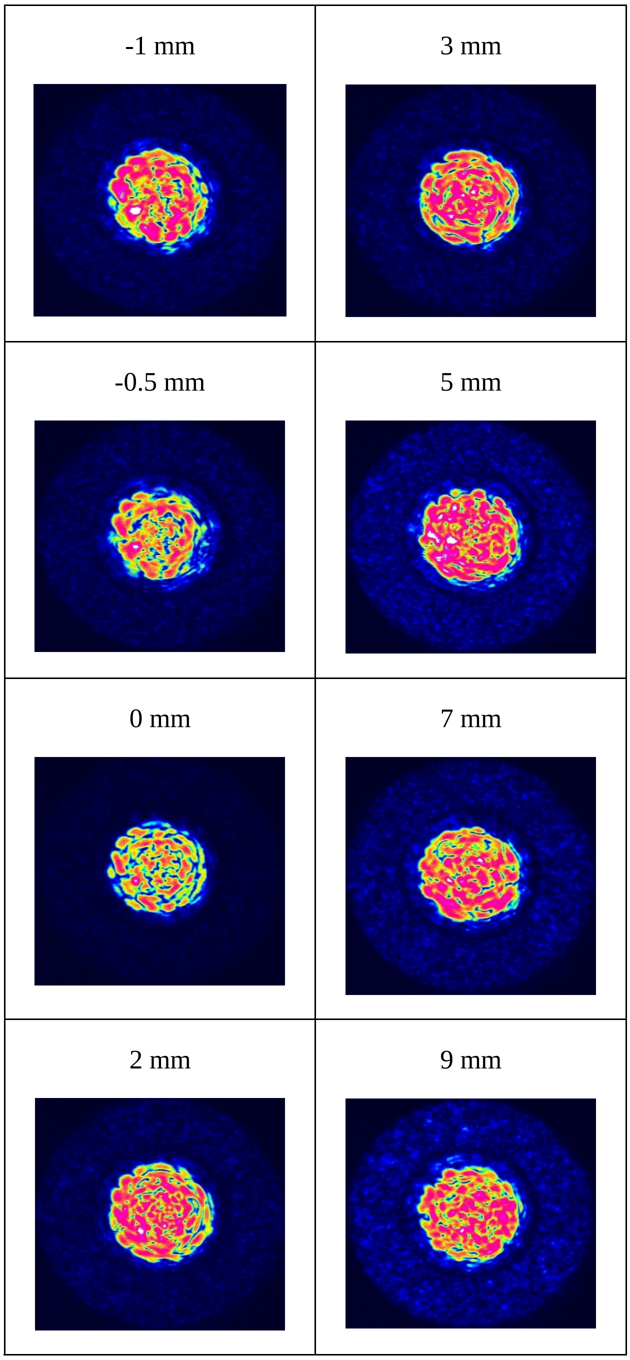

Fig. 3. The variation of observed fiber speckles with the distance between the diffuser and the laser focus when the diffuser is stopped.

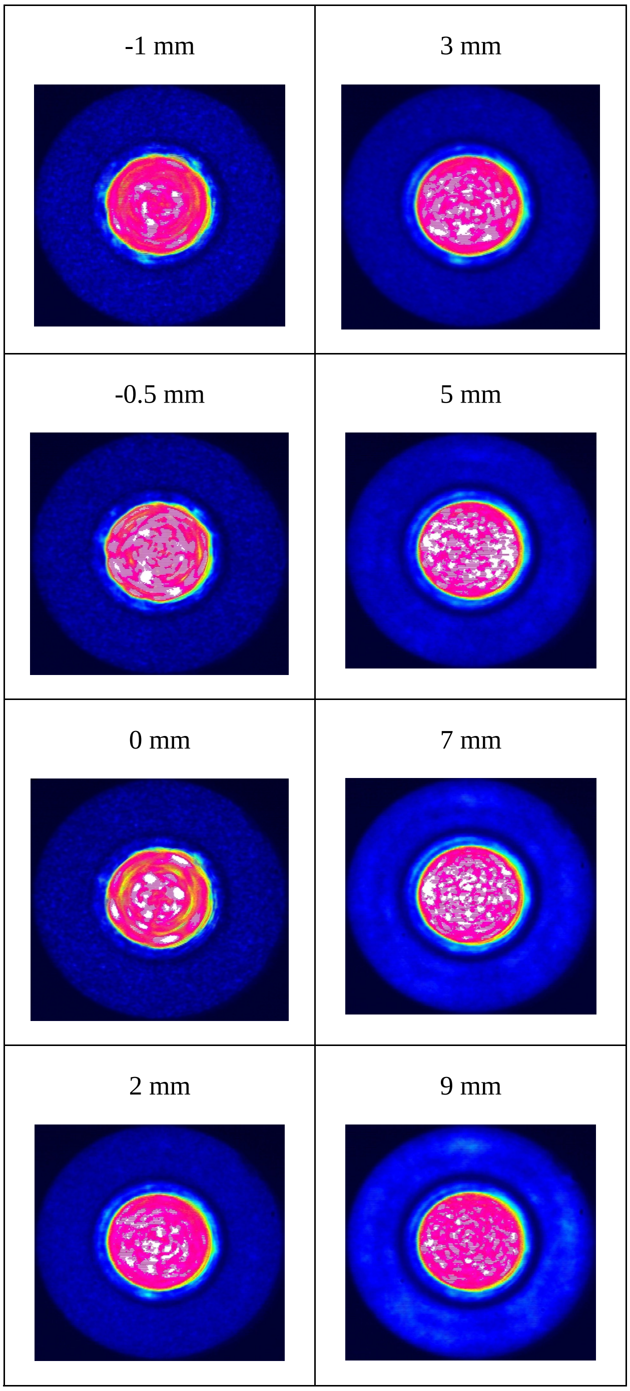

Fig. 4. The variation of observed fiber images with the distance between the diffuser and the laser focus when the diffuser is rotating.

CONCLUSION

When we pass the focused laser beam through a distance-variable rotating diffuser, we can control the coherence level of the transmitted light as well as the spot size of the speckles. If we couple this manually controlled low coherence light into the optical fiber, we can obtain the fiber cross-sectional images of higher quality.

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