Analysis of Effects of Trench Position on the Bending Loss of Bend-insensitive Optical Fibers

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ABSTRACT
We present the analysis of trench-assisted single mode fiber for showcasing the significance of position of trench in the fiber to minimize the bending loss.
1. INTRODUCTION

WITH the ongoing deployment of FTTH applications, bend insensitive optical fibers has gained much attention [1-3]. Design and development of such fibers is very challenging in terms of cutoff and reduced bending loss, which should follow recommendations of ITUT and still behave like a single mode optical fiber [4]. Generally, trench assisted fiber designs are preferred for bend insensitive optical fibers as the fundamental mode field is unaffected due to low index trench if the trench is sufficiently separated from the core. Thus, position of trench is very important in deciding the design parameters of the bend insensitive optical fiber (BIF). In the current communication, we discuss the effect of trench position on the bending loss characteristics of the BIF.

2. EFFECT OF BENDING ON THE FUNDAMENTAL MODE FIELD

As the bending radius of fiber is decreased, the LP_{01} mode starts to behave less and less confined to the core of optical fiber. As shown in Fig. 1, the field which is symmetrical in case (a), leaks out of core as illustrated in cases (b) and (c), which causes the bending loss.

![Fig. 1. Typical profile of the bend insensitive optical fiber.](image1)

![Fig. 2. Variations in the fundamental mode of bend insensitive optical fiber for change in the bending radius: (a) 25 mm, (b) 5 mm, and (c) 3 mm. Trench is separated by core radius distance from the edge of core, trench width is equal to core diameter and trench index = 1.44.](image2)
3. RESULTS AND DISCUSSION

The finite difference tool was used to simulate the trench-assisted bend insensitive optical fiber. The trench width was fixed at core diameter and the index was fixed at 1.44. Core parameters were similar to standard single mode optical fiber. Results for separation of trench from the edge of the core are shown in Fig. 3. It can be seen that the bending loss increases with increasing the bending radius. Another interesting thing is the decrement in the bending loss with increasing the separation of trench from the core. This may seem contrasting to the popular belief that bringing trench nearer to the core should decrease the bending loss. It can be explained this way. Comparatively, high bending loss for a specific mode appears when the mode is approaching its cutoff point, i.e., effective index, $n_{\text{eff}} \sim n_{\text{cladding}}$, where mode becomes leaky and is lost. If $n_{\text{eff}} > n_{\text{cladding}}$, then bending loss will be lower than the cutoff condition. Now when the fiber with trench is bent, $n_{\text{cladding}} > n_{\text{eff}} > n_{\text{trench}}$ condition appears causing the leakage loss. If the trench is away, then this condition occurs earlier than when the trench is nearer to the core. Thus, bending loss decreases with increasing the trench separation distance from the core. It has also been observed experimentally that the cable cutoff wavelength of the BIF is increased with high trench separation, justifying the fact that trench separation decreases the bending loss (It is noted that, low bending loss means high cable cutoff wavelength).

![Bending radius vs Bending loss graph]

Fig. 3. Effects of trench separation on the bending loss of BIF.

5. CONCLUSION

The trench-assisted optical fiber (BIF) with its trench separation from the core varied has been analyzed and it has been found that the increase in the trench separation increases the bend insensitivity of BIF. However, such fiber has a drawback of increased cable cutoff wavelength, thus causing failures in fulfilling ITU-T suggestions.
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