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FUSED SILICA CAPILLARY TUBING: THE OPTICS OF LIGHT GUIDING CAPILLARY

Fused silica capillary tubing is increasingly finding use in wave guiding applications. This application note discusses wave guiding optics in light guiding capillary.

BY JOE MACOMBER

INTRODUCTION

Fused silica capillary tubing in its normal construct is a hollow silica tube with a polymer coating applied to the outer surface. The primary coating function is to offer abrasion resistance during use. However, the coating material properties as well as the unique radial composition of the glass itself can result in capillary that will act as both a traditional fluid conduit and a light propagating wave guide. These are referred to as light guiding capillary. Any low refractive index (RI) layer, such as Fluorine doped silica or a fluorinated organic polymer, applied over a pure fused silica tube will result in a light guiding capillary wave guide. Light guiding capillary with a doped silica cladding has been discussed previously (1). Common low RI polymer coatings for capillary have been reviewed (2). The light guiding optics of these capillary is discussed.

ANNULAR WAVE GUIDING CAPILLARY

With the correct RI combination of light guiding capillary and internal fluid, light will propagate axially in only the fused silica annular core (B in Figure 1). The RI of the cladding (A) must be lower than that of the annular core (B), but higher than that of the fluid inside of the capillary (C). Comparatively from Figure 1, the refractive indices are as follows: B > A > C. Polymicro's doped silica clad LTSP capillary filled with water is a good example of this arrangement. The unique property of this combination is that along the internal surface of the capillary an evanescent field exists. Any molecules within this field will interact with the propagating light, allowing for spectroscopic analysis. The thickness of the field is ~4 times the wavelength of the light. Evanescent sensors of this design have been constructed (3).

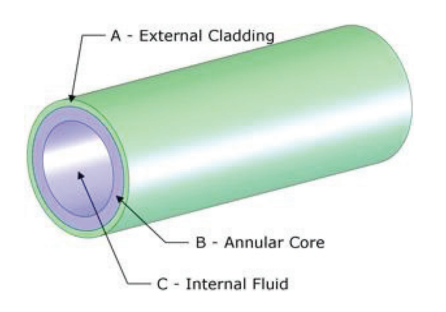

Figure 1: Light guiding capillary construct showing the external cladding (A), the annular core (B), and the internal fluid (C).

NON-ANNULAR WAVE GUIDING CAPILLARY

A different scenario exists when the refractive index of the cladding is lower than that of both the annular core and the internal fluid, i.e. B > C > A. In this case, the annular core becomes merely a substrate to retain the internal fluid and to support the outer low RI coating. An example would be Polymicro's TSU coating filled with water. Light propagates in not only the annular silica wall, but in the water filled i.d. This allows for complete spectral sampling of the entire internal volume of the capillary.

The same effect is seen if one removes the coating completely. Air makes an excellent cladding due to its low RI. Care should be taken with such a design, as uncoated capillary is fragile and the outer surface is prone to damage which can impact the optics.

LAUNCH OPTICS

An often overlooked consideration is launch optics. In the annular wave guide, light should be launched into the annular core (B). As Snell's Law predicts, the majority of non-zero mode light launched into the internal volume of the capillary will be lost. Care should be taken to design the launch optics to maximize input of the light into the annular core. The opposite is true for non-annular wave guiding. In this case, the light can be launched across the entire end face of the capillary. If an optical fiber is employed it can be inserted into the capillary with good results.

CONCLUSION

This note discusses the use of light guiding capillary and considerations such as launch optics. For assistance with your specific application please contact a Polymicro Technical Sales Specialist.

REFERENCES

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