These are "how to do it" papers. They should be written and illustrated so that the reader may easily follow whatever instruction or advice is being given.

Ultraviolet curing adhesive-based optical fiber feedthrough for ultrahigh vacuum systems

J.-F. Clément,[a] D. Bacquet, and P. Szriftgiser
Laboratoire de Physique des Lasers, Atomes et Molécules, Université des Sciences et Technologies de Lille, UMR 8523 CNRS, CERLA, F-59655 Villeneuve d'Ascq Cedex, France

(Received 31 March 2010; accepted 17 May 2010; published 24 June 2010)
[DOI: 10.1116/1.3448023]

I. INTRODUCTION

We present an inexpensive, simple, and robust method of making an optical fiber feedthrough for ultrahigh vacuum (UHV) systems. This system is particularly devoted for cold atom experiments. A drilled standard UHV DN16CF flange allows us to pass a fiber inside an UHV chamber. An optical ultraviolet (UV) curing adhesive is simultaneously used for holding the fiber through the flange and as a vacuum sealant. A vacuum down to 10^{-9} mbar is currently observed, while the optical insertion loss of the feedthrough is monitored and does not exceed 0.01 dB. In most of light-matter interaction experiments, laser light must pass through ultrahigh vacuum chambers. Although light beams can be propagated in free space through glass view-ports, more and more recent cold atom experiments use optical fibers to carry (or collect) light to (or from) a well defined area. This covers a wide variety of experiments such as atom-surface interactions[1,2] or atomic samples guided inside hollow-core fibers.[3,4] This kind of experiments requires continuous fibers through the vacuum-atmosphere interface. A feedthrough for optical fiber based on a Teflon ferrule has been successfully demonstrated.[5,6] However, this technique has several drawbacks. It requires a very high drilling precision, and as a consequence, must be accurately designed for a specific fiber diameter. As the ferrule must avoid any leaks, a constraint is applied to the fiber, which can induce birefringence and excess losses. Furthermore, as the polymer coating of the fiber ages under mechanical constraints, leaks might appear with time. We have developed a simple method to realize an optical fiber feedthrough completely free of those problems. It is based on a commercially available UV curing adhesive. The realization is easy and does not require accurate mechanical pieces. A multiple-fiber configuration is also achievable.

II. METHOD

We used a commercial optical UV curing adhesive (Dymax OP-61-LS) designed for positioning optical devices. It can bond different substrates such as glass, metal, or plastics. Several properties of this adhesive are required for our UHV optical application. According to the manufacturer, the selected adhesive has a low linear shrinkage during UV cure (less than 0.1%) so that negligible constraint will be applied to the fiber during the curing process. It also has a low movement during thermal excursions allowing modest baking. Finally, it is specified as low outgassing.

A section of bare SMF-28 fiber is threaded through a drilled stainless DN16CF flange (see Fig. 1). Except a careful cleaning, no treatment has been applied to the fiber; in particular, the polymer coating has not been removed. Two holes (with a 2 mm diameter) are made in the flange to create a loop with the fiber inside the vacuum chamber. This allows us to continuously monitor the optical power transmission of the fiber through all the process. The two holes are opened out in the external side of the flange to make easier adhesive application. In order to facilitate the UV curing sequence, successive thin layers are applied in the holes. A typical UV curing time exposure lasts 3 min, made by an UV spot curing light source (EFOS Acticure, 24 $\mathrm{mW.cm^{-2}}$).

With this method, single fibers with almost any diameter can be fitted, as well as bundles of fibers.[7] It thus allows us to avoid an additional optical fiber-to-fiber connection and transfer directly light into UHV systems. One must, however, be aware that once the curing process has occurred, the fiber cannot be removed from the flange without being destroyed. This is the main drawback of this technique. Nevertheless, the flanges used for our tests could be used again as a part of the feedthrough after heating it up to above 150 °C.

III. RESULTS

A. Vacuum test

We tested our feedthrough under UHV conditions: the optical fiber feedthrough is fixed at a vacuum system: a simple four-way cross links the feedthrough with a 25 l/s ion pump and a pressure gauge. After evacuating by a leak checker for 2 h, the ion pump is turned on. We checked for leaks in the optical fiber feedthrough by connecting the vacuum system

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[a] Electronic mail: jean-francois.clement@phlam.univ-lille1.fr

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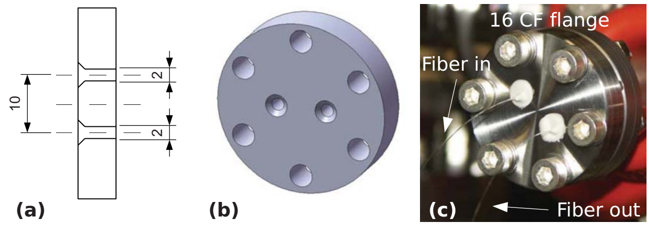

FIG. 1. (Color online) Optical fiber feedthrough design: (a) Cross section of the DN16CF flange designed for a double fiber configuration. Dimensions are in millimeters. (b) Schematic of the modified DN16CF flange. (c) Illustration of the feedthrough sealed to our vacuum system.

to a helium leak checker. No leak could be detected, even with the highest sensitivity. Without baking the test vacuum system, we measured a final pressure of 10^{-9} mbar. We also checked the opportunity of baking the vacuum system. We baked out the vacuum system at 100 °C for 6 h, while taking care to not exceed 50 °C in the vicinity of the feedthrough. We then observed a similar final pressure as in the procedure without baking. One could note that it is likely that the adhesive could undergo a temperature well above 50 °C; however, to prevent any damage, we restricted our tests to this value.

B. Optical test

As previously mentioned, a 30 cm fiber loop is inserted in vacuum. We have also tested the transmission of the optical fiber threaded through the modified flange at each step of our assembling procedure. A 1529 nm laser light from a commercial stabilized distributed feedback laser diode is injected in the fiber at a low power value of 5 dBm. The other end of the fiber is connected to a high precision optical power meter. We observed an almost constant optical transmission during the assembling, fixing, curing, and baking stages in our testing procedure. The optical power decreased by less than 0.02 dB, giving an insertion loss upper limit of 0.01 dB per feedthrough.

IV. CONCLUSION

In summary, we have designed and tested an inexpensive and reliable optical fiber feedthrough for UHV systems. We observed final pressures in our vacuum system compatible with cold atom experiments. This method simplifies greatly conception of UHV-compatible optical fiber feedthrough. It also does not involve any mechanical constraint on fibers and thus keep optical properties of the injected light.

ACKNOWLEDGMENTS

The authors acknowledge M. Le Parquier and T. Vitse for technical assistance. This work and one of the authors (J.-F.C.) are supported from the project ”MICPAF” (Grant No. ANR-07-BLAN-0137-01) funded by the French Agence Nationale de la Recherche.

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