Note: Simple vacuum feedthrough for optical fiber with SubMiniature version A connectors at both ends

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We present a simple way to insert an optical fiber, with existing standard SubMiniature version A connectors on both ends into a vacuum system. The fitting is tested in scanning electron microscope, at working pressures down to 2×10^{-5} mbar for cathodoluminescent measurements. With slight modifications this fitting could be successfully adapted for optical fiber insertion into pressurized systems. © *2014 AIP Publishing LLC*. [http://dx.doi.org/10.1063/1.4891315]

During the development of our cathodoluminescent attachment to a Scanning electron microscope (SEM)[1] we choose to guide the light signal to the spectroscope (Avantes, Avaspec-2048 TEC-2)[2] through an optical fiber. The construction requires standard SMA (SubMiniature version A) connectors on both ends of the fiber—for connection to the spectroscope from one side (outside of the microscope) and the light collection system at the other side (located inside the vacuum chamber).

One solution is to use two fibers and a conventional commercial optical vacuum feedthrough, but it has certain drawbacks. First, it leads to inevitable losses at the connection points between the fibers and the feedthrough. Second, it requires good matching of the numerical apertures and diameters of the two fibers to those of the optical feedthrough, otherwise optical losses will dramatically increase. Therefore, we decided to look for a way to insert a single fiber with existing SMA connectors on both ends. The mounting of connectors after the fiber insertion into the chamber, if not impossible, would be very hard.

The optical fiber insertion into a vacuum system is a standard way for transferring light for many experiments. Several suggestions for continuous optical fiber insertion have been proposed in the literature. For example, the space between the fiber and the chamber wall can be sealed by ultraviolet curing adhesive[3] or epoxy resins.[4,5] These mounts are not demountable and fast fiber replacement is not possible. Proposed demountable solutions are feedthroughs with heat shrink tubing,[6] Swagelok type fittings[7] with Teflon,[8] or/and aluminum ferrule.[9] However, none of these constructions allows using optical fiber with existing connectors on both ends.

Here, we present a simple method to insert an optical fiber, with existing connectors on both ends into vacuum system. In addition, the proposed feedthrough is easily demountable, allows simple replacement of the optical fiber and is not related to the specific fiber characteristics such as numerical aperture and diameter.

The insertion of the optical fiber through the vacuum chamber wall of the SEM is made through one of the standard flanges on the wall (Fig. 1).

First, a conic opening is drilled in the flange. The smaller diameter of the conic opening is slightly bigger than the diameter of the fiber's SMA connector. Then, the one end of the fiber (together with the SMA connector) passes through that opening. To seal the opening we use a conic silicone rubber plug, with longitudinal slit reaching the plug's axis. The fiber is inserted into the slit of the plug and then the plug is placed in the conic opening. The plug and its slit are lubricated with vacuum grease in advance. A pressing plate with a slit is put at the outer side of the flange. It is pressed to the flange with four screws in order to push the plug to the flange and ensure better sealing. The screws are tightened by hand. During pump out of the chamber, the plug seals the opening under the influence of the vacuum, penetrating a few millimeters inwards. Afterwards, we tighten the pressing plate again by hand.

The flange is made of brass (Fig. 2). The conic plug (autoclavable) is conventionally used for laboratory glassware. The acute angle of plug's trapezoidal section is 85°. The conic opening is drilled to have the same acute angle as the silicone plug. The plug is few millimeters thicker than the flange thickness, in order to allow pressing of the plug after its deformation due to the vacuum. Since the plug is transparent, after

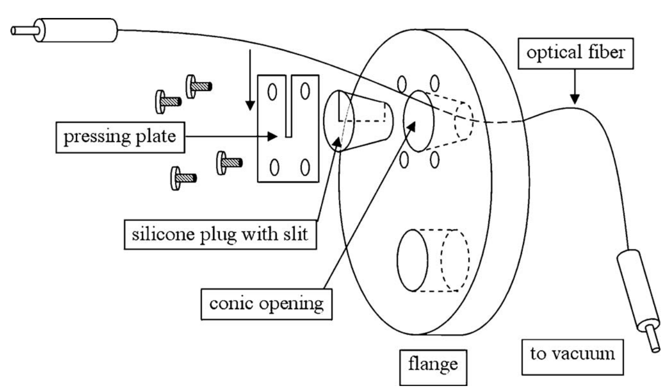

FIG. 1. Scheme of the proposed feedthrough allowing insertion of an optical fiber with existing connectors on both ends into a vacuum system.

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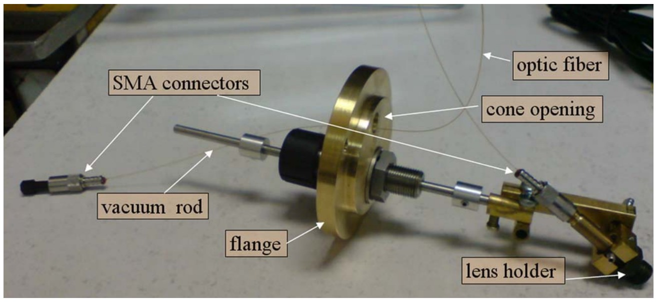

FIG. 2. The feedthrough for our cathodoluminescent measurements made using the proposed fitting allows insertion of an optical fiber with existing SMA connectors on both ends into a vacuum chamber.

assembling the feedthrough, the outer side of the plug should be appropriately covered for light penetration suppression, for example, by black tape. On the figure the vacuum rod is also shown, which serves to hold the light collecting system and for calibration purposes.

The proposed method was used for cathodoluminescent measurements in the high vacuum chamber of a scanning electron microscope. During our work with the microscope for more than a year after the installation of the proposed attachment, we have not observed any noticeable vacuum degradation, neither in relation to the time for reaching the initial working pressure (2×10^{-4} mbar), nor in relation to maximum attainable working pressure (2×10^{-5} mbar).

As an example, a typical cathodoluminescence spectrum of GaN monocrystal, measured with the presented feedthrough, is shown in Fig. 3. The measurement is done at room temperature with electron acceleration voltage 20 kV at 1.1 k magnification and spectrometer acquisition time 500 ms. The characteristic peaks due to band (3.4 eV) and defect-assisted (2.2 eV) transitions are clearly seen and agree well with the literature data.[10]

In conclusion, the proposed feedthrough allows insertion of an optical fiber, with existing connectors on both ends into a vacuum system. Additionally, the feedthrough is easy to mount and allows convenient and fast exchange of the optical fiber in case of fiber damage or need to work with a different fiber.

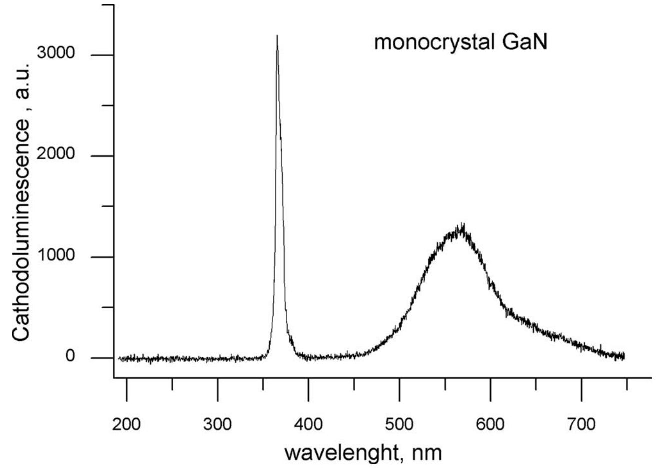

FIG. 3. Cathodoluminescence spectrum of GaN monocrystal measured with the presented feedthrough (T = 300 K).

We believe that the proposed method can also be successfully used for optical measurement in pressurized chambers up to 1 atm difference to outer pressure, by simply inverting the cone plug and angle direction of the opening in the flange.

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