

PROGRESS ON A HERMETIC PIGTAILED TRANSCEIVER PACKAGE AND UNIFERRULE

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Introduction

Figure 1(a) shows a typical optical fiber subassembly (OFSA) that routes optical signals from the edge of a card to an optical transceiver in the center of the board. Most avionic transceivers consist of multiple transmit (Tx) and receive (Rx) channels, so an OFSA will generally have multiple optical fibers embedded in a ribbon. The multi-fiber ribbon is terminated at the card edge with a mechanical transfer ferrule (MT-ferrule). At the transceiver end, the ribbon is split so that Rx and Tx fibers are terminated in a separate feedthrough. This paper reports recent success at nanoPrecision Products Inc. (nPP) in the development of a hermetic feedthrough that is manufactured by a high-precision stamping process and applied in OFSA as shown in Fig. 1(b).

It is preferable for the feedthrough to provide a hermetic seal so that contents of the transceiver package remain protected in vacuum environment. This can be difficult to achieve reliably in the harsh environment of avionic applications; thermal expansion and contraction during flight causes the hermetic seal to fail. Hermeticity substantially increases the cost of manufacturing and necessitates expensive qualification tests to assure that hermeticity is maintained despite severe thermal shock cycles.

Design of a hermetic feedthrough

Figure 1(c) shows a photograph of nPP's patent-pending hermetic feedthrough (uniferrule), which will be manufactured in both single- and multi-mode versions. The prototype shown in Fig. 1(c) is 4 mm wide, 2 mm tall, and 8 mm long. It accommodates four fibers, and it is identical for both the Rx and Tx legs of the OFSA. The feedthrough is an assembly of two Kovar components. Since the transceiver package is also made of Kovar, the transceiver and feedthrough share the same coefficient of thermal expansion (CTE). The components are gold plated so that they may be hermetically soldered into the wall of the transceiver as shown in Fig. 1(d). The bottom component receives the optical fiber ribbon and accurately positions the ends of the fibers using nPP's patent-pending u-shaped grooves. The fibers are elastically constrained in the u-grooves with the top component. The top and bottom components are manufactured with nPP's high-precision stamping processes, and the two are joined together by soldering.

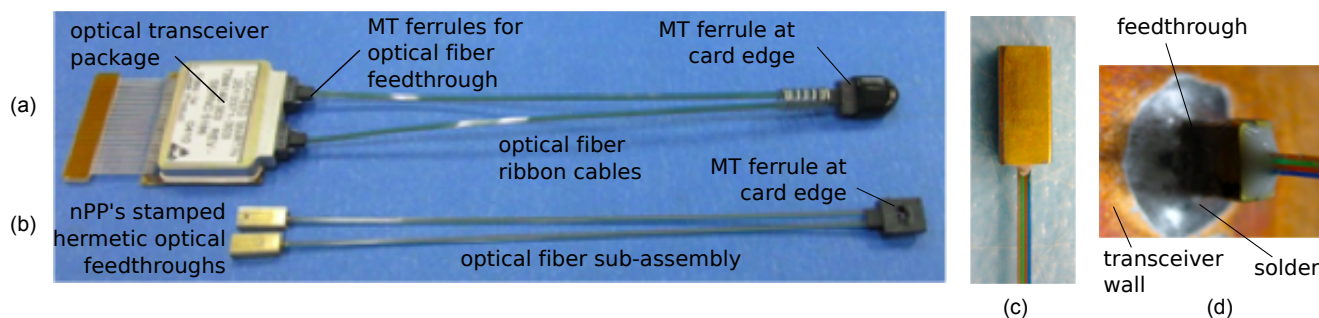


Figure 1: Optical fiber subassemblies (OFSA) (a) conventional OFSA with feedthrough, ribbon cable, and MT ferrule and (b) nanoPrecision Product's OFSA with stamped, hermetic feedthroughs (c) stamped feedthrough, terminated with ribbon cable, and (d) solder seal of feedthrough into transceiver side-wall.

Results from prototype testing and evaluation

nPP stamped and assembled a batch of 20 prototype feedthroughs of the design shown in Fig. 1(c). The u-grooves that locate the fibers were stamped with a punch that had u-shaped protrusions on its face. The prototype punch was manufactured by wire electro-discharge machining (EDM) and measured with a stylus profilometer (Taylor Hobson, Talysurf). Profilometer traces were used to determine the true-position of the u-shaped features on the punch. Several traces were collected along the length of the u-shaped features. The mean true-position error for the second, third, and fourth groove protrusions was 1.5, 2.5, and 1.3 μm , respectively. This degree of error is adequate for multi-mode applications, but single-mode applications require placement of the optical fibers to sub-micron accuracy. nPP expects to meet this requirement with a new punch that will be ground with nPP's proprietary micro grinding process prior to oral presentations.

The punch was used in a stamping process that accounted for elastic spring-back and warping of the part due to plastic flow of the Kovar. The feedthroughs and optical fiber ribbon were assembled with a reliable soldering process, and the optical fibers were terminated inside the feedthroughs. The end face of the ferrule was mechanically polished prior to soldering the feedthrough into the transceiver sidewall.

The errors in the location of the fiber cores of assembled uniferrules were measured experimentally. This was done with a vision-based coordinate measuring machine (Micro-Vu). The uniferrule was backlit so that light was injected into the fibers, and the illuminated cores could be seen at high magnification. The center of the cores within the first and last fibers provided datums for the measurement. The line connecting the two centers defined the x -axis. The midpoint of the line defined the origin, and the y -axis was defined as a line perpendicular to the x -axis at the origin. The positions of the centers of the fiber cores were measured with respect to the origin of the coordinate system. The CMM utilized an edge-detection algorithm to find the center of the core. We measured a number of prototypes, and the true position error of the fiber cores was better than 3 μm . This error corresponds closely with the error measured in the punch that was manufactured by EDM.

Hermeticity is the most difficult specification to meet for the optical fiber assembly. We measured the hermeticity of the assembled feedthroughs with a helium leak detector per MIL-STD-883 method 1014, test condition A4, for unsealed packages. Fifteen units were measured, and the leak rate of all the devices was below 1×10^{-10} cc/s.

We performed thermal shock tests for 170 cycles on the uniferrules per MIL-STD-883, Method 1010, Condition B. This test requires 170 cycles of transferring the components between two chambers, one at -55°C and the other at 95°C , in only 10 seconds. Thermal shock is the most stringent environmental test of reliability because it accelerates failure through rapid thermal expansion/contraction. Four stand-alone ferrules and six ferrules soldered into packages passed the test, and this exceeds the customer's requirement of 160 cycles. We continued cycling the parts in order to test the feedthroughs until failure. We measured the leak rate after every set of 170 cycles, and then we continued testing any units that passed the leak test (survivors). All six passed a total of at least 340 cycles. Five passed and one failed after total of 510 cycles. Three passed and two failed after total of 680 cycles. Three passed and zero failed after total of 850 cycles. One passed and two failed after total of 1020 cycles.

Conclusion

These optical and hermeticity tests prove that nPP's novel design and packaging processes can provide a multi-mode, hermetic uniferrule for optical fiber subassemblies. Other reliability tests such as mechanical vibration and fiber pull-tests are underway, and nPP is fabricating a new punch that should enable more accurate fiber placement for single-mode applications.

Acknowledgement

The authors acknowledge the financial support of the Navy SBIR Office (N091-039, Contract No: N68335-09-C-0277).