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The analysis of optical fiber connectors interferometric measurements results

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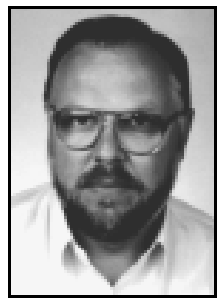

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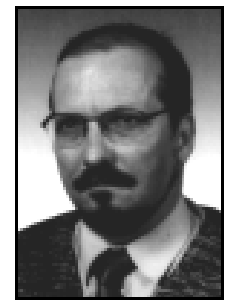

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Abstract

In this paper are presented the interferometric parameters of optical connectors and results of interferometric measurements for various types of connectors. The geometrical parameters are defined according to the IEC international standards. The presented results show important meaning of the spherical height parameter on results of climatic test. The results of measurements are presented for N = 971 angle connectors: FC-APC, SC-APC, E2000-APC.

Keywords: optical fiber connector, ferrule, spherical height.

Analiza wyników pomiarów interferometrycznych telekomunikacyjnych światłowodowych złącz rozłącznych

Streszczenie

W pracy zaprezentowano parametry interferometryczne światłowodowych złącz rozłącznych oraz wybrane wyniki pomiarowe dla różnych typów złącz. Parametry geometryczne czoła ferruli są zdefiniowane zgodnie ze standardami IEC. Przedstawione wyniki wskazują na istotne znaczenie parametru wysokości sferycznej na wyniki testów klimatycznych. Zaprezentowane wyniki dotyczą próby 971 złącz kątowych FC-APC, SC_APC, E2000-APC.

Słowa kluczowe: złączka optyczna, ferrula, wysokość sferyczna.

1. Introduction

The discussion about the interferometric method and optical connectors measurements was presented by authors in papers [1-4].

The FC, SC, E-2000 connectors are very popular in optical network applications , but it is possibility to find such optical connectors like F-3000, LC, MT-RJ, MU, DIN, AVIO/AVIM, MFS, MPO, MTP, D4, F-SMA, ESCON, FDDI, VFO, EC/RACE, HRL-11. The polished ferrule quality is classified according one of standards: PC , SPC and UPC types for the flat optical connector and for angle optical connector (AP). The telecommunication parameters depends on geometrical quality of the ferrule endface. The ferrule in FC optical fiber connector is presented on Fig. 1.

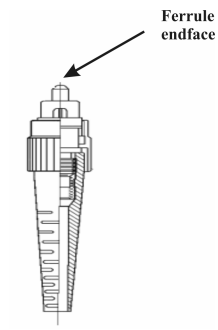

Fig. 1. The construction of FC optical fiber connector
Rys. 1. Budowa złączki światłowodowej FC

2. The geometrical parameters of ferrule endface

The geometrical parameters are defined by IEC standard [5-11]. The important interferometric parameters are shown in table 1.

Tab. 1. The measuring interferometric parameters of ferrule endface

Radius of curvature	IEC 61300-3-16
Spherical fiber height	IEC 61300-3-23
Planar fiber height	
Apex offset	IEC 61300-3-15
Highest point on ferrule endface (Vertex)	
Angle deviation (8^0)	IEC 61300-3-17
Ferrule endface angle	
Key error	IEC 61300-3-18
Fiber roughness (Ra)	IEC 61300-3-23
Fiber roughness (Rq)	
Ferrule roughness (Ra)	
Ferrule roughness (Rq)	
Hole diameter of ferrule	IEC 61300-3-36

Rq - root mean of the squares between the fitted sphere and raw data
Ra - the average difference between the fitted sphere and raw data

The endface angle of ferrule θ is the angle between the tangent plane to ferrule endface and the plane perpendicular to the fiber axis [5].

The eccentricity of ferrule (apex) is the distance between the ferrule axis and the highest point of ferrule endface (vertex). The parameter is shown on Fig. 2. The endface curvature radius (Fig. 6) depends on polishing procedures. The high value of radius can betray an abnormal selection of polishing papers in the manufacturing process.

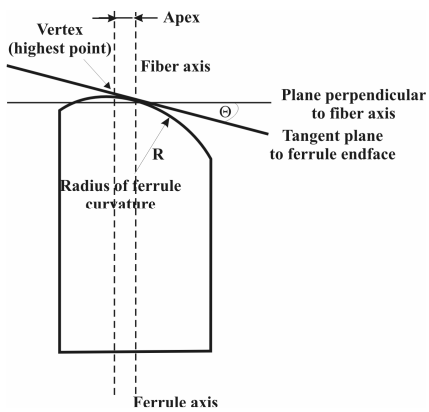

Fig. 2. The definition of ferrule endface parameters
Rys. 2. Parametry czoła ferruli

The key accuracy is the parameter which describes mismatch ferrules and the mechanical part of connectors. The parameter is defined by the α angle between two planes: one plane passes through ferrule axis and the second plane has the normal to the ferrule mating surface.

The parameters which determinate the fiber position relative to ferrule endface are essential to transmission and mechanical properties: the effect of the vibration on fiber connectors or the temperature endurance. Two important parameters are measured for this case: the spherical height and the planar height.

The spherical height is calculated from the spherical profile of ferrule endface in approximation to a spherical sector (Fig. 2, 3). This parameter is described by the protrusion (+w) and the undercut (-w). The interferometric measurements allows to calculate: fiber roughness and ferrule roughness.

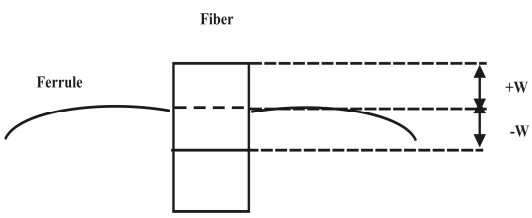

Fig. 3. The definition of spherical height (+w protrusion, -w undercut)
Rys. 3. Wysokość sferyczna (+w wysunięcie, -w podcięcie)

3. Measurements results

The measurement setup bases on the Michelson interferometer setup. The setup is described in published papers [1, 4] and it is shown on Fig. 4.

The interferometric parameters are calculated from four interference images of ferrule endface. The images were recorded for phase missmatches φ=0 ,π/2, 3/4π, π which is realized by the movable piezoelectric mirror.

The requirements for geometrical parameters of optical fiber connectors according IEC standard [5-11] :

- the eccentricity of ferrule (apex): less than 500nm,
- the spherical height: w less than ± 100nm,
- the endface angle of ferrule: less than $\pm 0.2^0$,
- the endface curvature radius: 5÷12mm for APC connectors, 5÷25mm for PC connectors,
- the keying accuracy: less than $\pm 0.5^0$.

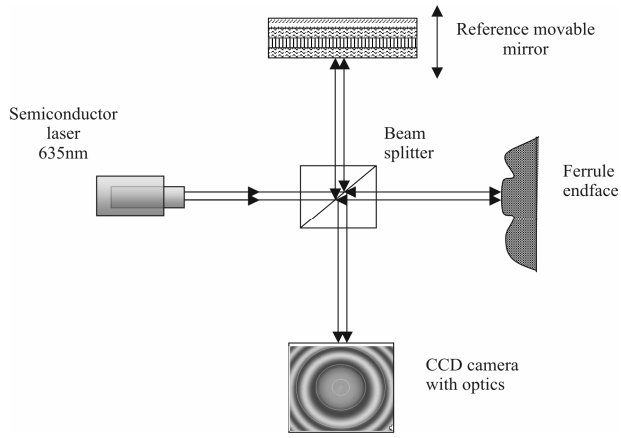

Fig. 4. The measurement setup based on the Michelson interferometer
Rys. 4. Układ pomiarowy na bazie interferometru Michelsona

The results of measurements are presented for N=971 angle connectors: FC-APC, SC-APC, E2000-APC connectors. The spherical height parameter was monitoring in the climatic test for 3 quality groups of optical connectors. The climatic test: five temperature cycles for -40^0C and $+70^0$C according to IEC,ITU-T, Bellcore standards [5-13].

The results for the climatic test are presented on Fig. 5-6.

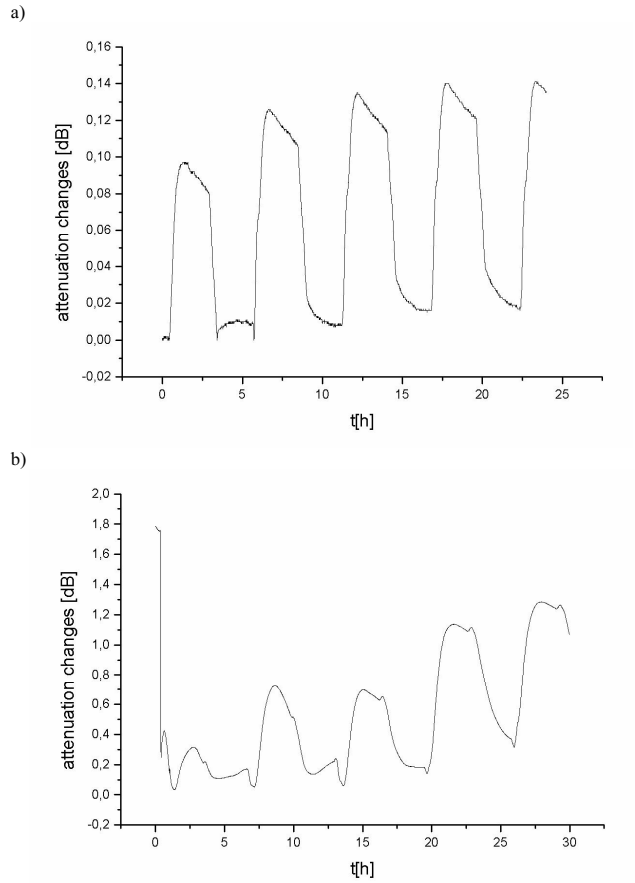

Fig. 5. Results of climatic test optical connectors: connector with spherical height w=120nm (a), connector with spherical height w=17nm (b)
Rys. 5. Wyniki testu klimatycznego złącz światłowodowych: a) złączka z wysokością sferyczną w=120nm, b) złączka z wysokością sferyczną w=17nm

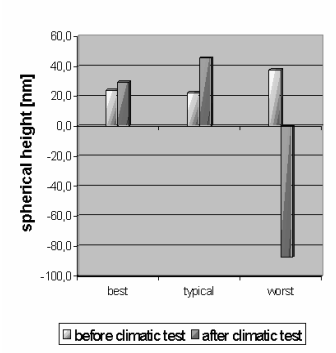

Fig. 6. The results of spherical height changes of optical fiber connectors for three quality groups during the climatic test
Rys. 6. Wyniki zmian wysokości sferycznej badanych złącz światłowodowych w trzech jakościowych grupach podczas testu klimatycznego

4. Conlusions

The interferometric parameters of angle optical connectors were analyzed. Measurements results were presented on figures 5-6. The spherical height plays important role for insertion losses and reflectance of optical connectors. This problem is important for ageing processes of installed connectors in communication optical fiber lines. The climatic tests with the connection of interferometric measurements show on problem of ferrule protrusion and undercut monitoring. Before climatic test transmission parameters and interferometric parameters have values correctly according to IEC standard (Fig. 6).

The ageing process is the aim of future research works.

5. References

[1] Gajda J., Niesterowicz A., Żegliński G.: Interferometryczne urządzenie do pomiaru jakości światłowodowych złączek rozłącznych. Poznańskie Warsztaty Telekomunikacyjne '2000: referaty, Poznań: PP, 2000. S. 2.1-1 - 2.1-5, 2000.

[2] Gajda J., Niesterowicz A., Żegliński G.: Badania interferometryczne złączek światłowodowych. Krajowe Sympozjum Telekomunikacji '2001. [T.] C. 4. Problemy sieciowe; 5. Systemy komutacyjne, 2001.

[3] Gajda J., Niesterowicz A., Żegliński G.: Interferometryczna ocena jakości wykonania złącz rozłącznych. VII Sympozjum Techniki Laserowej: Komunikaty, Szczecin: Wydaw. Uczelniane Politechniki Szczecińskiej, 2002.

[4] Żegliński G., Niesterowicz A., Gajda J.: The geometrical parameters measurements of optical fiber connectors. Laser Technology VIII: Applications of Lasers, edited by Wieslaw L.Wolinski, Zdzislaw Jankiewicz, Ryszard S. Romaniuk. Proc. of SPIE Vol. 6598, 659810, (2007). Proc. of SPIE Vol. 6598 659810-1.

[5] IEC 61300-3-15 (1995-02). Fiber optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-15: Measurements - Eccentricity of a convex polished ferrule endface

[6] IEC 61300-3-16 (1995-05). Fiber optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-16: Examinations and measurements - Endface radius of spherically polished ferrules.

[7] IEC 61300-3-17 (1999-09). Fiber optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-17: Examinations and measurements - Endface angle of angle-polished ferrules.

[8] IEC 61300-3-18 (1995-05). Fiber optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-18: Examinations and measurements - Keying accuracy of an angled enfdface connector.

[9] IEC 61300-3-23 (1998-04). Fiber optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-23: Examinations and measurements – Fiber position relative to ferrule endface.

[10] IEC 61300-3-36 (1998-04). Fiber optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-36: Examinations and measurements –Measurement methods for inside and outside diameter of fiber optic connector ferrules.

[11] EN-186500 (1998-07). European Standard. Product specification for connector set to be used in single mode optical fiber communication systems.

[12] ITU-T Recommendation L.12: Optical fiber joints.

[13] GR-326-CORE, Issue 1. All assemblies meet EIA 455 standards.

Artykuł recenzowany