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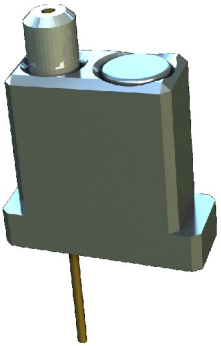
Fiber-optic Cannula

A fluid cannula is an assembly of a metal tube and a fluid tube receptacle, used for administering fluids when metal tube is inserted into the body. A venous cannula is inserted into a vein to obtain blood samples or to deliver medicines. The body of a cannula has a form that easily connects to or disconnects from the plastic tubing. The plastic tubing can be disconnected while the cannula remains attached to the body surface with the hollow needle (tube) inserted into the body for the later use. Similar to those fluid cannulas, biomedical and optogenetics applications need fiber-optic cannulas to introduce the laser or LED light into the body tissue. As an example, illuminating the neurons within the mouse brain with the blue or orange light has become an essential tool for studying the processes within genetically modified photosensitive neurons. In early days of optogenetics, researchers used a fluid cannula to insert the optical fibers into the brain tissue, where the metal tube was guiding the fiber to the neurons. After the experiment, the optical fiber was removed from the cannula only to be reinserted later. The optical fiber removal and re-entry could lead to infections and clogging of the fluid cannula.



Mono fiber-optic cannula Rectangular magnetic

Optic & Fluid Cannula - M3

With some exceptions, the fiber-optic cannula is typically used without the metal tube of the fluid cannula. It consists of a fiber-optic ferrule with some sort of fiber-optic receptacle on one side and the implantable fiber protruding from the other side. When the fiber-optic cannula is fixed to the body and the fiber implanted, the light can be delivered to the tissue and the fluorescence or scatter from the tissue can be captured. In these experiments, it is imperative that the connection between the delivery fiber and the cannula is light, small and simple to connect and disconnect. For a mono fiber delivery, the connection between the ferrules of the light delivery fiber patch cord and the fiber-optic cannula is achieved, in its simplest form, via

fiber-optic sleeve. The connector type connection is preferred but it is not always applicable. In some optogenetics experiments it is necessary to introduce two or more implantable fibers within a small, precise distance. Those applications call for the dual fiber-optic cannula that is easily connected to the matching delivery fibers.

The concept of fiber-optic cannulas with different optical fibers, receptacle types and fiber terminations is bound to be further fragmented. So far we carry *Mono fiber cannulas*, *Dual fiber cannulas, Two ferrules cannulas and hybrid cannulas*. In effect, we are developing hybrid cannulas that transmit combination of light, liquid and electrical signals. Tables 9,10 and 11 show different possibilities possible with each canula type.

Table 7: Silica multimode optical fibers

Core (µm)	Outer diameter (µm)	Numerical Aperture	Buffer color	Outer Layer	Fiber-optic code
50	70	**0.22**	yellow	Polymide buffer	**50/70-0.22**
100	125	**0.22**	yellow	Polymide buffer	**100/125-0.22**
100	125	**0.37**	yellow	Polymide buffer	**100/125-0.37**
100	150	**0.44**	clear	Silicone buffer	**100/150-0.44**
200	240	**0.22**	yellow	Polymide buffer	**200/240-0.22**
200	260	**0.22**	clear	Silicone buffer	**200/260-0.22**
200	230	**0.37**	clear	Hard polymer cladding	**200/230-0.37**
200	245	**0.37**	yellow	Polymide buffer	**200/245-0.37**
200	230	**0.48**	clear	Hard polymer cladding	**200/230-0.48**
200	245	**0.53**	blue	Hard polymer cladding	**200/245-0.53**
300	370	**0.22**	yellow	Polymide buffer	**300/370-0.22**
300	330	**0.37**	clear	Hard polymer cladding	**300/330-0.37**
400	480	**0.22**	yellow	Polymide buffer	**400/480-0.22**
400	430	**0.37**	clear	Hard polymer cladding	**400/430-0.37**
400	430	**0.48**	clear	Hard polymer cladding	**400/430-0.48**
400	475	**0.53**	clear	Hard polymer cladding	**400/475-0.53**

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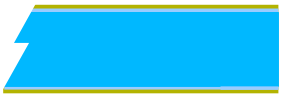
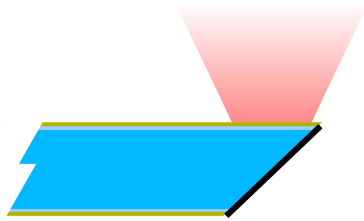
Table 8: Plastic optical fibers

Core	Outer diameter	Numerical Aperture	Buffer color	Fiber-optic code
240	250	0.63	clear	**240/250-0.63**
480	500	0.50	clear	**480/500-0.50**

Table 9: Fiber-optic termination codes for cannulas

Termination code	Description	Drawing	Specifications
FLT	Flat tip		
Axx	Angled tip		Standard angles: 45°; 60° Other angles on request (max 60°)
Bxx	Bi prism tip		Standard angles: 45°; 60° Other angles on request (max 60°)
Cxx	Conical tip		Rounded tip thickness: ~ 0.1x to 0.2x core diameter Standard angles: 45°; 60° Other angles on request (max 60°)
MA45	Mirror tip at 45°		

Note: Axx, Bxx, Cxx and Rxx are offered to facilitate the insertion of the fiber-optic in the tissue. However, they have little influence on the light spread.

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Mono Fiber-optic Cannula

The mono fiber-optic cannula is an assembly of a bare optical fiber, a fiber ferrule and a receptacle or a sleeve. One side of the ferrule is polished while the implantable part of the fiber protrudes from the opposite end of the ferrule. The ferrule is placed within receptacle or sleeve to allow connecting to the fiber-optic patch cord. The protruding fiber can be implanted into the body while the ferrule or the receptacle is attached to the skin. When the cannula is connected with the patch cord, it is possible to send the light signals to and from the tissue close to fiber tip. It is imperative for in-vivo optogenetics applications that the fiber-optic cannula allows for efficient, plug and play type connection with the fiber-optic patch cord.

A receptacle is a mechanical holder that defines the positions of the fiber tip and guides the connecting ferrule to the optical coupling position. For mono fiber-optic cannulas we offer Zirconia sleeves as the simplest form of receptacle, M2, M3 and rectangular magnetic receptacles. For more information refer to receptacle section.

N.B.: Zirconia sleeves are ordered separately.

The tolerance on the length of protruding fiber is better than 0.1mm.

ORDERING CODE: MFC_□□□/□□□-□□□_□□□_□□□_□□□

Fiber-optic code
See *Table 7* and *Table 8*

Length "L" (mm)

Receptacle code:
See *Table 10*

Fiber Termination code:
See *Table 9*

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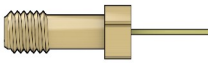
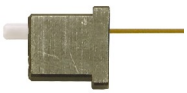
Table 10: Receptacle codes for mono fiber-optic cannula

Description	Picture	Termination code
Zirconia ferrule OD 1.25mm		**ZF1.25**
Metal ferrule OD 1.25mm		**MF1.25**
Zirconia ferrule OD 2.5mm		**ZF2.5**
Metal ferrule OD 2.5mm		**MF2.5**
Receptacle with M2 thread Titanium		**RM2**
Receptacle with M3 thread Titanium		**RM3**
Receptacle with M3 thread Peek plastic		**RM3(P)**
Rectangular Magnetic Receptacle Titanium		**RMR**

See receptacle section for details on mass and dimensions.

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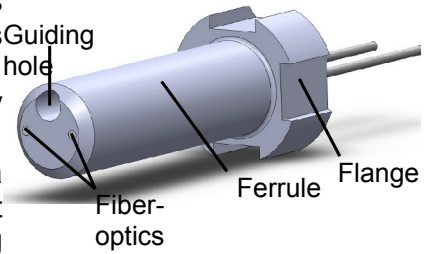
Dual Fiber-optic Cannula

A dual fiber-optic cannula provides two implantable fibers at a precise distance within a single ferrule. The tolerance on the protrusion for each fiber is less than 0.1 mm. These cannulas are perfectly suited for the applications where two brain centers close to each other are simultaneously optically stimulated or controlled.



The positioning of one mono fiber cannula at a time with the stereotaxic equipment has greater likelihood of 3D positioning errors (lateral and depth). Additionally, the diameter of the ferrules limits the minimum distance between the fiber tips. With dual fiber-optic cannula the insertion of the fiber is faster (single shot), the distance between the fiber tips is predefined and the protrusion depth is assured. The cannula includes a guiding hole to insure precise alignment when connecting to a dual fiber-optic connector (equipped with a guiding pin). The dual fiber cannula can be made for any distance in 0.7 to 1.7 mm range. If larger distances between the brain centers need to be covered, please refer to *Two Ferrules Cannulas*.

Our dual fiber-optic cannula has a typical transmission higher than 75% for each fiber.

ORDERING CODE: DFC_□□□/□□□-□□□_□□□_□□□_□□□

Fiber core diameter (µm)
See *Table 7* and *Table 8*

Length "L"(mm)
See convention in *Table 11*

Receptacle code:
See *Table 11*

Fiber Termination code:
See *Table 9* for available codes

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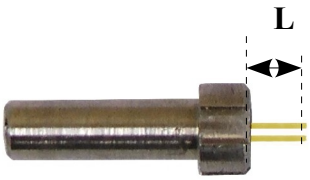
Table 11: Receptacle codes for dual fiber cannula

“Pitch” = Distance between the fibers (mm)	Picture	Receptacle code
0.7		**DF0.7**
1.0mm		**DF1.0**
1.2mm		**DF1.2**
1.5mm		**DF1.5**
Select distance (x) in 0.7 mm – 1.7 mm range		**DFx**

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Two Ferrules Cannula

The two ferrules cannula provides two implantable fibers, each within its own ferrule, at a precise distance exceeding 1.7 mm. The tolerance on the protrusion for each fiber is less than 0.1 mm. These cannulas are perfectly suited for the applications where two brain centers at a distance larger than 1.7 mm from each other are optically stimulated or controlled. The positioning of one mono fiber cannula at a time with the stereotaxic equipment has greater likelihood of 3D positioning errors (lateral and depth). With two ferrules cannula the insertion of the fiber is faster (single shot), the distance between the fiber tips is predefined and the protrusion depth is assured.

Two types of receptacles are currently available for the two ferrule cannula (see pictures on next page). They both consist of precision machined holders that house zirconia ferrules and determine the spacing between the ferrules centers. First type of two ferrule cannula connects to a pair of patch cords terminated with ferrules 1.25mm by using two zirconia sleeves (ID 1.25mm). In the other case, the holder also includes a pair of magnets, so that the cannula can connect to a pair of rectangular magnetic connectors.

The two ferrules cannula can be made for distances larger than 1.7 mm. For shorter distances between the brain centers, please refer to *Dual fiber-optic Cannulas*.

ORDERING CODE: TFC_□□□/□□□-□□□_□□□_□□□_□□□

Fiber-optic code
See *Table 7* and *Table 8*

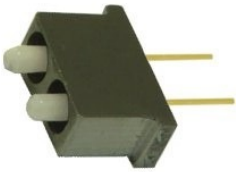
Length of fiber "L"(mm)

Receptacle code:
See *Table 12*

Fiber Termination code:
See *Table 9* for available codes

NOTE : Unless otherwise specified, an aluminum housing and 1.25mm zirconia ferrules are being used.

Table 12: Termination codes for two ferrules cannula

Center-to-center distance between ferrules (mm)	Picture	Termination code
Sleeve connection		
2.0 mm		**TF2**
2.5 mm		**TF2.5**
3.0 mm		**TF3**
3.5 mm		**TF3.5**
4.0 mm		**TF4**
Other (x)		**TFx**
Magnetic connection		
3mm		**TM3**
4mm		**TM4**
Other (x)		**TMx**

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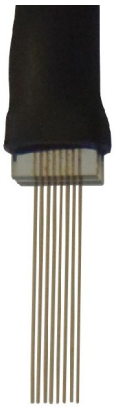
Fiber-optic Cannula Arrays



Basically this product can be described as a loose fiber optic bundle

with FC/PC connectors on loose end and V-groove based fiber-optic cannula array on the other end.

ORDERING CODE:

FCA1x8_□□□/□□□-□□□_□□□_□□□_□□□_□□□

Fiber-optic code
See *Table 7* and *Table 8*

Protrusion of fiber "L"(mm)

Fiber-optic pitch (um):
See *Table 12*

Overall fiber length (mm)

Termination Code for Multiple connectors side
See *Table 4* for available codes

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Hybrid Cannula

As convergence of different techniques for cell monitoring (optogenetics, electrophysiology) and fluid administration gathers speed, we are determined to facilitate this trend by providing photonics hardware products such as new hybrid cannula types.

Optic & Fluid Cannula

The basic idea behind the optogenetics is the introduction of the virus born proteins like channelrhodopsin-2 to targeted cells or neurons and the illumination of the same through fiber optic tip. So far this has been a two step process with two different cannulas with inherent imprecision. Led by a request from Brain Science Institute, RIKEN in Japan, we have designed a hybrid cannula with a metal tube that guides the optical fiber and restricts liquid delivery around the fiber tip. The design of the hybrid cannula in one version is based on an M3 receptacle, a metal tube and a side hole to receive liquid injection tube. In other incarnations of hybrid cannula we use our rectangular magnetic receptacle and similar side opening for receiving the injection tube. If users want to target the cells around the fiber tip, the length of the tube and the length of the fiber have to be the same.
All our mono fiber-optic cannulas have a typical transmission higher than 80%.

ORDERING CODE:

OFC_□□□/□□□-□□□_□□□_□□□_□□□

Fiber-optic code
See *Table 7* and *Table 8*

Length “L” (mm)
See convention in *Table13*

Receptacle code
See *Table13* for available codes

Fiber Termination code
See *Table 9* for available codes

More information on www.optogenetics-at-doric.com.

Table 13: Receptacle codes for Optic & Fluid Cannula

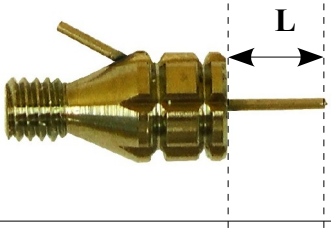
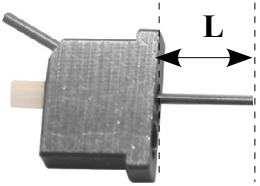
Description	Picture	Termination code
Receptacle with M3 thread		RM3
Rectangular Magnetic Receptacle		RMR

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Table 14: Technical specifications of fiber-optic cannulas

Part	Mass [mg]	Max OD [mm]	Length [mm]
1.25mm ferrules			
Zirconia ferrule 1.25mm	50	1.25	6.5
Zirconia ferrule with MU flange	120	2.5	12
Metal ferrule 1.25mm	50	1.25	6.5
2.5mm ferrules			
Zirconia ferrule 2.5mm	350	2.5	10.5
Zirconia ferrule 2.5mm with FC flange	Not measured	4.5	16
Metal ferrule 2.5mm	400	2.5	10 or 12.5
Dual ferrule 2.5mm	Not measured	4.0	10 + 1.5 (pin)
Sleeves			
Zirconia sleeve ID=1.25mm	20	1.6	6
Zirconia sleeve ID=2.5mm	80	3.2	12
M2			
M2 receptacle - titanium	?	2	6
M2 receptacle - plastic	?	2	6
M2 screw - titanium	?	4	3.2
M2 screw - plastic	?	4	3.2
M2 protective cap	?	4	2.5
M3			
M3 receptacle - titanium	300	4	7.6
M3 receptacle - plastic	100	4	7.6
M3 screw - titanium	90	4	4.5
M3 screw - plastic	30	4	4.5
M3 protective cap	40	4	4.5
Rectangular magnetic			
Rectangular Magnetic receptacle	180	5x2	~8
Rectangular Magnetic connector	150	5x2	5
Cannula assemblies			
1.25mm Zirconia ferrules (x2) + sleeve	120	1.6	13
1.25mm metal ferrules (x2) + sleeve 1.25	120	1.6	13
2.5mm Zirconia ferrule (x2) + sleeve 2.5mm	780	3.2	21
2.5mm metal ferrules (x2) + sleeve 2.5mm	880	3.2	21

Dual ferrule (x2) + sleeve 2.5mm	Not measured	4.5	20
M3 receptacle titanium + M3 screw titanium + Zirconia ferrule with flange	500	4	~11
M3 receptacle plastic + M3 screw plastic + Zirconia ferrule with MU flange	250	4	~11
Rectangular magnetic receptacle + Rectangular magnetic connector	330	5x2	10

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Receptacles for optogenetics

Connecting a fiber-optic cannula and a fiber-optic patch cord requires matching the receptacle on the cannula side and the connector on the patch cord end. The receptacle is the female part of the fiber-optic connection that contains a centered fiber tip, guides the connecting ferrule to the optical coupling positions and fastens it in place. In fiber optics, there are many different types of receptacles. However, here we show only those specific to our optogenetics products like Zirconia sleeve, M3 and rectangular magnetic receptacles. Other receptacle types like SMA, FC/PC are too big to be used for fiber-optic cannulas.

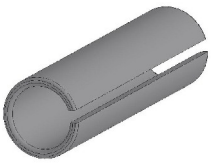
Zirconia sleeve as receptacle

The simplest form of receptacle consists of an implantable fiber glued in a Zirconia or a metal ferrule inserted in a Zirconia sleeve. The matching ferrule from the patch cord side is simply inserted in the sleeve.

Connecting 1.25mm ferrules with Zirconia sleeve
Connecting dual ferrules with Zirconia sleeve

Two versions of Zirconia sleeve receptacles are available:

Inner diameter	Outer diameter	Length
1.25 mm	1.6 mm	6.8 mm
2.5 mm	3.2 mm	11.4 mm



Zirconia sleeve

ORDERING CODE : SLEEVE_ZR_□□□

Inner diameter(mm)
1.25, 2.50

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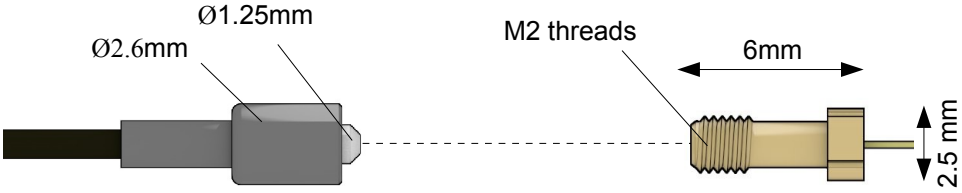
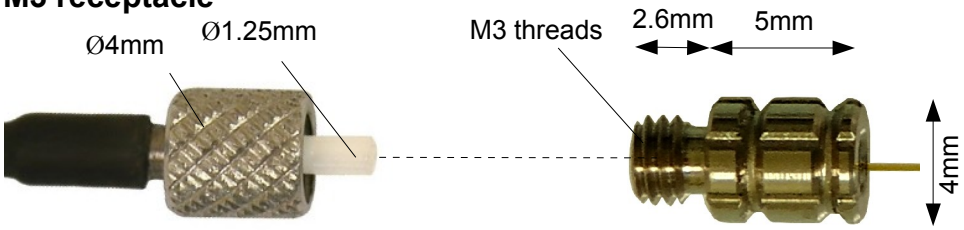
M2 receptacle



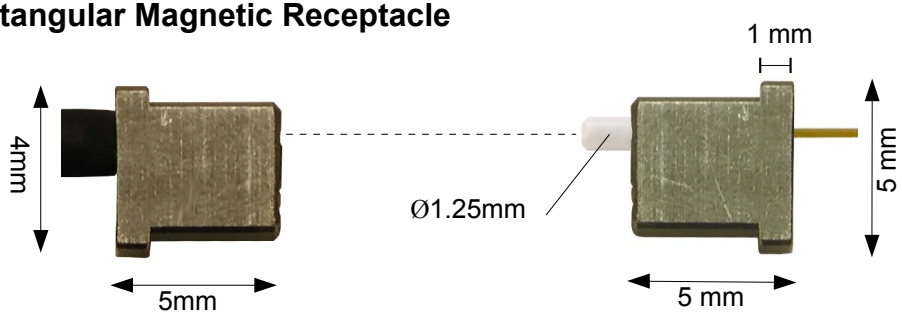
M2 connector *M2 receptacle*

M3 receptacle



M3 connector *M3 receptacle*

Rectangular Magnetic Receptacle



Rectangular magnetic connector *Rectangular magnetic receptacle*

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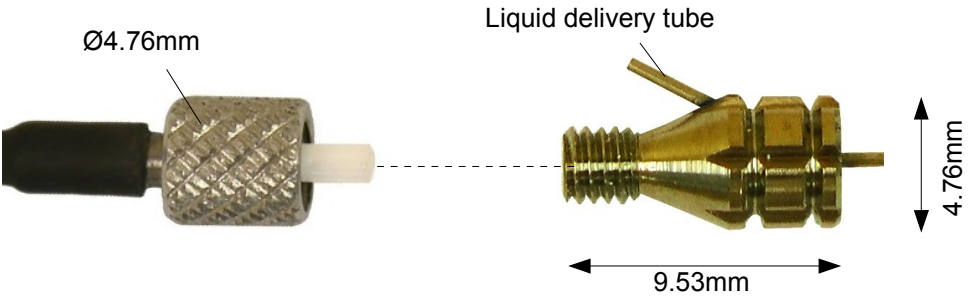
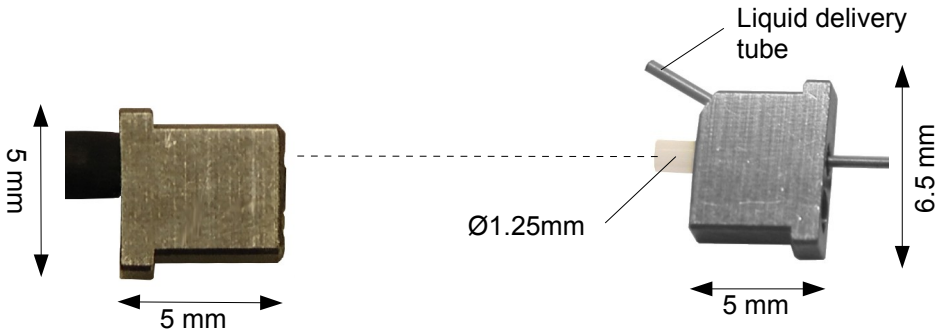
Optic and Fluid Cannula with M3 receptacle



Optic connector – M3

Optic & fluid receptacle – M3

Optic and Fluid Cannula with rectangular magnetic receptacle



Optic & fluid connector Rectangular magnetic

Optic & fluid receptacle Rectangular magnetic

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