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Advanced Ceramics

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Experts in Extrusion Technology for the Creation of Advanced Micro Ceramics

Pilot IS creates advanced micro ceramics through the application of core technologies like kneading, extrusion molding and firing which have been developed over decades of expertise in the manufacturing of leads for mechanical pencils.

These ceramics are high in density, strength and purity and have been finely molded and uniformly fired using specially developed extrusion molding equipment and firing expertise. The addition of secondary machining enables yields with high-precision (micron order) dimensional accuracy to both inside and outside diameters, and smooth (submicron order) surfaces.

Microporous Ceramics

Advanced extrusion technology enables the production of articles with a micropore aspect ratio of 200 or more

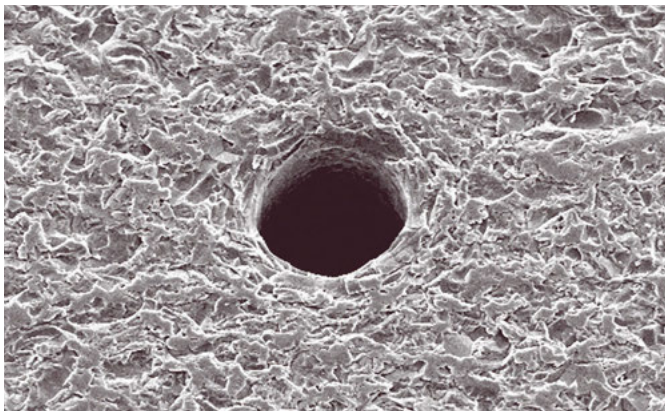
Characteristics:

High aspect ratio holes perforate a molded article in the extrusion direction. Typically, with fine holes (pores) of less than 1mm in diameter, it is difficult to achieve an aspect ratio (depth/inside diameter) of more than 5–10 using only machining. Extrusion molding technology, however, makes it possible to manufacture articles having micropore aspect ratios of 200 or more. Even articles with various thin or thick wall characteristics can be achieved.

Applications:

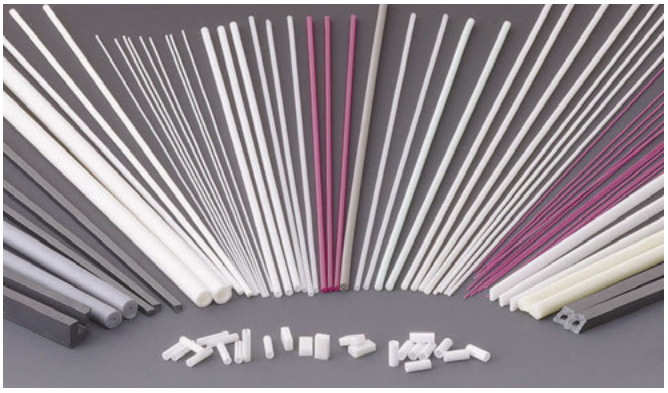
- Flow rate controllers
- Sensor holders
- Insulators (e.g., glass)

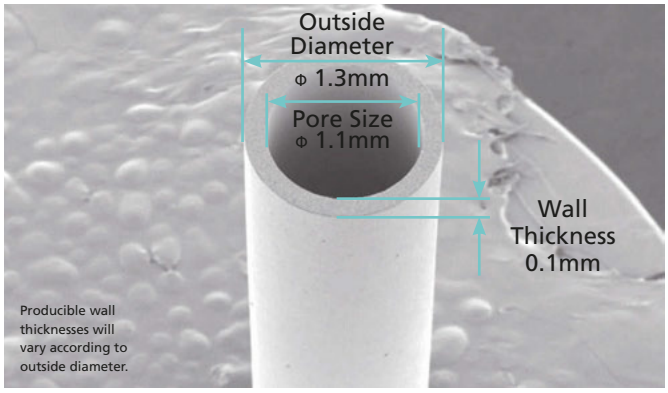
Ceramics Example



Pore size Φ 20 µm (enlarged photograph)

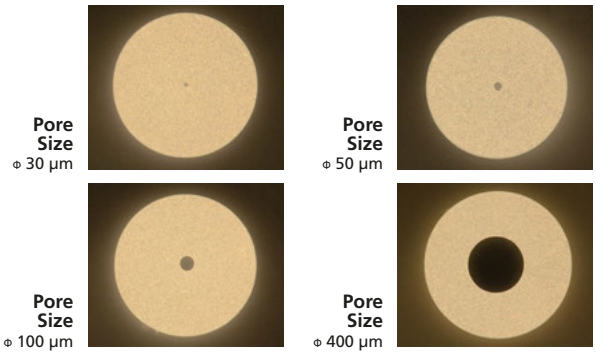
Thin-walled Capillaries Examples





When extrusion molding a thin-walled capillary, molding is considered difficult due to deformations and thickness deviations. However, Pilot IS molding and firing technologies make it possible to produce capillaries with a wall thickness of 0.1mm and a length of 100mm (when outside diameter is Φ 1.3mm).

Alumina Ceramics Production Examples



Examples of pore size when outside diameter is Φ 1.0mm

Material	Finished Outside Diameter		Finished Inside Diameter		Concentricity (µm)
	Dimensions (mm)	Tolerance (µm)	Dimensions (mm)	Tolerance (µm)	
Alumina Al2O3	Φ 0.50	± 10	Φ 0.200	± 10	30
Zirconia ZrO2	Φ 1.00	± 10	-	-	-
Zirconia ZrO2	Φ 1.40	± 10	Φ 0.120	± 5	20
Alumina Al2O3	Φ 1.60	± 30	Φ 0.100	± 5	30
Zirconia ZrO2	Φ 2.60	± 10	Φ 0.120	± 5	20

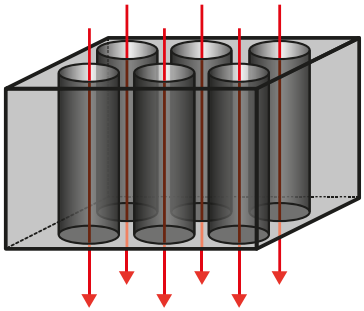
Microporous Ceramics examples

Uniform Porous Ceramics

Original technology enables the production of large numbers of through-holes in the extrusion direction

Characteristics:

Pilot IS can produce porous ceramics where even hard-to-stabilize flow rates are achieved by through-holes formed in the extrusion direction. Tiny, high-precision and uniform holes are applied to achieve gas and liquid flow rate control. Unlike a typical porous body, extrusion-molded holes pass through the molded article linearly, enabling a uniform, stable flow rate, while minimizing pressure loss.



Applications:

- Semiconductor manufacturing equipment
  - Filters
  - Nozzles
  - Baffle plates
  - Flow rate controllers
  - Microreactors

Production Examples

Outside Diameter
Φ 4mm
Pore Size
Φ 0.25mm
91 holes

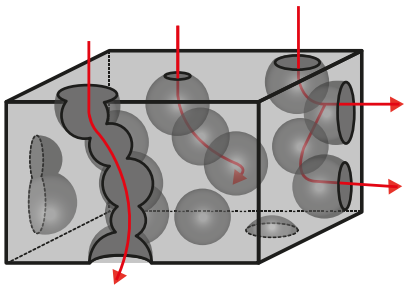
Outside Diameter
Φ 3.8mm
Pore Size
Φ 0.7mm
6 holes

Non-Uniform Porous Ceramics

Random pores are achievable using extrusion molding

Characteristics:

Porous ceramics can also be produced using micro-extrusion molding. Porosity of up to 70% can be set arbitrarily.

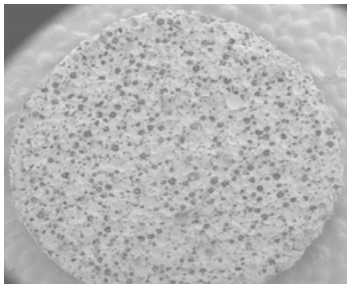


Applications:

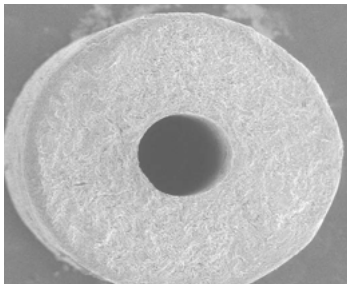
- Filters
- Liquid holders
- Adsorption parts

Production Examples

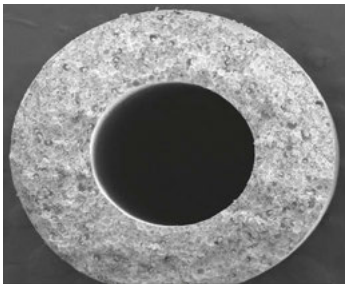
Outside Diameter
Φ 4.6mm



Outside Diameter
Φ 2mm
Pore Size
Φ 0.6mm



Outside Diameter
Φ 2.3mm
Pore Size
Φ 1.1mm



Specialty Shaped Ceramics

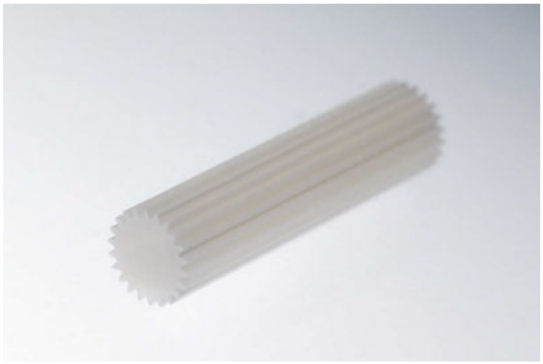
The production of articles with unique, disparate external and internal shapes for specialized needs

Characteristics:

Progress in Pilot IS Advanced Ceramic technology has made it possible to combine an abundance of different external and internal shapes, which can be utilized in new applications. For example, articles having a rectangular external shape and a circular internal shape, or a gear-like external shape and a circular internal shape are possible.

Production Examples






Secondary Machining

Submicron machining measurement technology allow for high-precision finishing of ceramic articles

Characteristics:

Pilot IS Advanced Ceramics can be subjected to high-precision submicron processing for:

- Outside-diameter machining
- Pore machining for pore sizes of Φ 40 µm or more
- Enhanced surface finishing

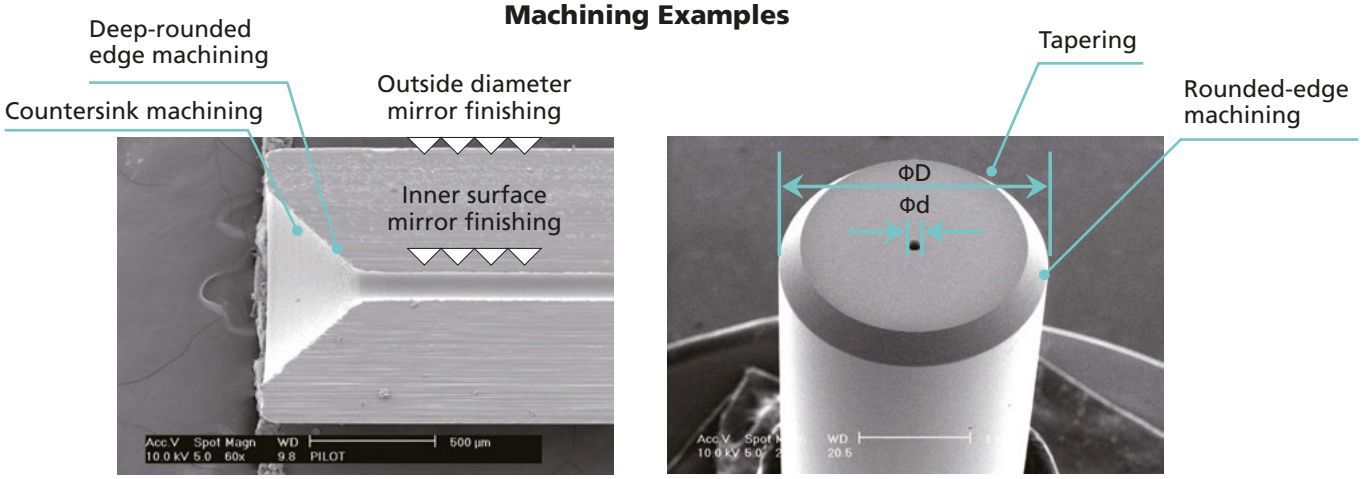
Applications:

- Electrode guide for electric discharge machines
- Sliding shaft components
- Rotating shaft motor components
- Ferrules for fiber-optic communications and device components
- Positioning pins
- Liquid chemical plungers

Outside Diameter	Inside Diameter	Concentricity
Φ 2.5±0.001	Φ 0.06 ± 0.001	0.005
Φ 2.5±0.001	Φ 0.05 ± 0.001	0.005
Φ 2.4995±0.0005	Φ 0.125 + 0.001 - 0	0.0014
Φ 2.4995±0.0005	Φ 0.080 + 0.001 - 0	0.0014
Φ 2.4995±0.0005	Φ 0.050 + 0.001 - 0	0.0020
Φ 1.249±0.0005	Φ 0.050 + 0.001 - 0	0.0020

Machining examples (Units: mm)

Machining Examples



Component Assembly

Precision assembly of composite articles

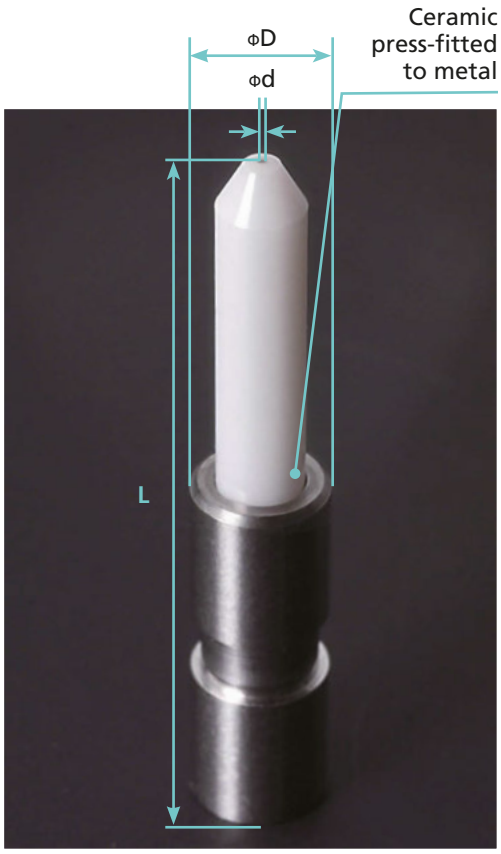
Characteristics:

Pilot IS Advanced Ceramics can be joined and assembled to different types of materials, such as metals and plastics. Pilot IS produces composite products of ceramic and metal using adhesive bonding and press-fitting.

By producing optical communications ferrules with pore sizes that match user requirements, Pilot IS can assemble optical connectors, optical devices, and a variety of ceramic components to optical fibers that have specific outside diameters.

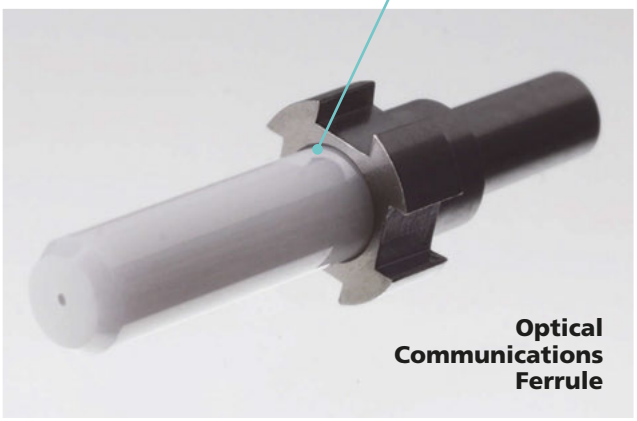
Applications:

- Optical communications ferrules and cords, various master cords and device cords
- Electrode guides for electric discharge machines
- Positioning pins and guide pins
- Plungers



Metal Outside Diameter (D)	Ceramic Pore Size (D)	Concentricity	Length (L)
Φ 4 $^{+0}_{-0.005}$	Φ 0.1 ± 0.001	0.005	22
Φ 4 $^{+0}_{-0.005}$	Φ 0.090 ± 0.001	0.005	22
Φ 4 $^{+0}_{-0.005}$	Φ 0.080 ± 0.001	0.005	22
Φ 4 $^{+0}_{-0.005}$	Φ 0.060 ± 0.001	0.005	22
Φ 4 $^{+0}_{-0.005}$	Φ 0.050 ± 0.001	0.005	22

Machining examples (Units: mm)



Optical Communications Ferrule

Optical Communications Cord

Ceramic Raw Materials

Extrusion molding technology enables the production of precise, small-diameter parts

Characteristics:

Extrusion molding enables Pilot IS to offer products with stable diameters.

Material compounding and firing expertise ensure the precision of outside diameters and surface roughness, reducing the need for post-firing machining and providing greater cost benefits.

Applications:

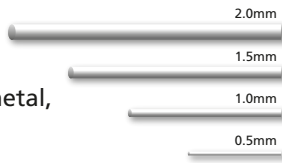
- Various raw materials for machining
- Positioning pins and sliding shafts
- Substitutes for metals and resins

Zirconia Rods

Extensive manufacturing focus and expertise using long shapes with fine cross sections

Characteristics:

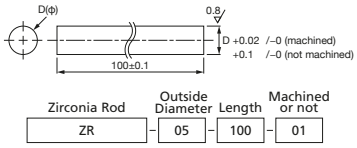
- Toughness that exceeds that of other ceramics
- Stronger than metals, other alloys, etc.
- Thermal expansion coefficient on par with that of metal, and suitability for use in combination with metals
- Lower thermal conductivity than other ceramics
- Resistance to chemicals (with the exception of hydrofluoric acid, sodium hydroxide, nitric acid and hydrochloric acid)



Centerless machining is available when high-precision finishing is required.

Non-standard shapes are possible. Inquire for details.

Specifications:



Product Name	D (mm)	Tolerance (mm)	No. of Rods	Remarks
ZR-05-100-01	0.5	+0.02/-0	100	Centerless
ZR-05-100-02	0.5	+0.1/-0	100	Non-centerless
ZR-10-100-01	1.0	+0.02/-0	100	Centerless
ZR-10-100-02	1.0	+0.1/-0	100	Non-centerless
ZR-15-100-01	1.5	+0.02/-0	100	Centerless
ZR-15-100-02	1.5	+0.1/-0	100	Non-centerless
ZR-20-100-01	2.0	+0.02/-0	100	Centerless
ZR-20-100-02	2.0	+0.1/-0	100	Non-centerless

Representative Characteristics of Extrusion Molded Articles

Material Characteristics		Unit	Alumina				Zirconia	
			A		B			
			Measured Value	Test Piece Shape (mm)	Measured Value	Test Piece Shape (mm)	Measured Value	Test Piece Shape (mm)
Mechanical	Content	%	99.8	ϕ 1.0 (cylindrical column)	-	-	-	
	Density	Kg/m3	3.9 ×103	ϕ 0.47-ϕ 0.24 (cylinder)	3.9 ×103	ϕ 1.6-ϕ 0.1 (cylinder)	6.05 ×103	ϕ 1.0-ϕ 0.7
	Vickers Hardness (HV1)	GPa	15.7	ϕ 1.0 (cylindrical column)	17.1	ϕ 1.6-ϕ 0.1 (cylinder)	13.5	ϕ 1.3 (cylindrical column)
	Three-point bending strength	MPa	390	3 ×4 ×37 (rectangle)	430	3 ×4 ×37 (rectangle)	1000	3 ×4 ×37 (rectangle)
	Young's modulus	GPa	340	1.2 ×4 ×37 (rectangle)	370	1.2 ×4 ×37 (rectangle)	200	1.2 ×4 ×37 (rectangle)
Thermal	Coefficient of Linear Expansion (40-400°C)	×10-6/°C	7.3	ϕ 5-10 (cylindrical column)	7.3	ϕ 5-10 (cylindrical column)	10.6	ϕ 5-10 (cylindrical column)
	Coefficient of Linear Expansion (40-400°C)		8.1	ϕ 5-10 (cylindrical column)	8.1	ϕ 5-10 (cylindrical column)	11.1	ϕ 5-10 (cylindrical column)

Reference values based on our measurements using test pieces

Quick Reference

Core Capabilities

Extrusion
We have the ability to utilize our extrusion molding technology and expertise developed over decades in the manufacturing of leads to create advanced micro ceramics.

Small Diameters
We specialize in small diameter sizes that are traditionally difficult to manufacture in the form of rods and pipes.

Micropores
We have the ability to form anything from a single pore to multiple pores by extrusion.

Precision
We provide high-precision products because we have optimized all processes, including raw materials.

Technical Specifications

ID:	From ø0.005 mm
OD:	ø0.2 mm– ø10 mm
Length:	Up to 120 mm
RA:	As requested
Tolerance:	As requested
Straightness:	As requested

Materials

Alumina
Excellent insulation and heat resistance, good thermal conductivity and extreme chemical resistance.

Zirconia
High strength (toughness), excellent thermal properties and aesthetics.

Aluminum Nitride
High thermal conductivity and electrical insulation properties that prevent distortion from heat.

Yttria Stabilized Zirconia (YSZ)
Oxygen-ion conductivity, excellent heat-shielding properties and doped with 8mol yttrium oxide.

Frequently Asked Questions

Q: How does Pilot IS produce ceramics?

A: We use our integrated manufacturing plants in Japan and apply mechanical pencil lead extrusion molding techniques and expertise.

Q: What kinds of ceramics can Pilot IS make?

A: Using extrusion molding technology, we can produce ceramics that have extremely small holes and shapes that are long and thin.

Q: What raw materials does Pilot IS use?

A: We mainly focus on high-purity alumina, but also zirconia, aluminum nitride and yttria stabilized zirconia.

Q: What is the production lead time?

A: Pilot IS can produce most ceramics* in 60 – 90 days after receiving a purchase order.
**The lead time is based on the product dimensions.*

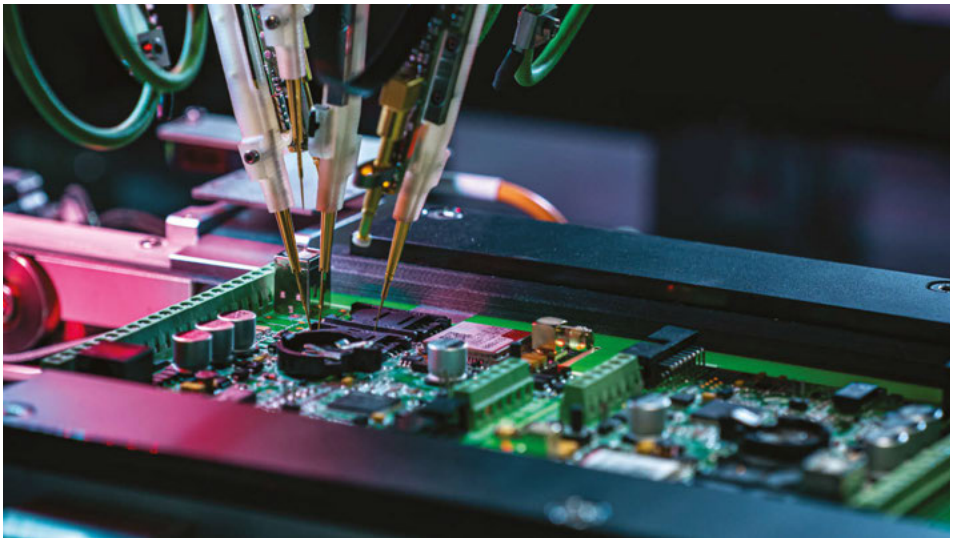
Q: Where are advanced ceramics from Pilot IS made?

A: All of our ceramics are made by Pilot IS in our facilities in Hiratsuka, Japan.

Q: What straightness and tolerances can Pilot IS achieve?

A: Please contact us at pilot-is.com.

Industries Served



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PILOT | iS Innovative Solutions

Pilot Corporation brings over 100 years of manufacturing innovation and experience to the global marketplace. This heritage is the cornerstone of Pilot Innovative Solutions (Pilot IS) offering exceptional technological advancement and precision that comes from a century of ground-breaking engineering.

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The specifications and appearance of the products described in this catalog may be changed without notice for the sake of improvement. Specifications are as of 2023.