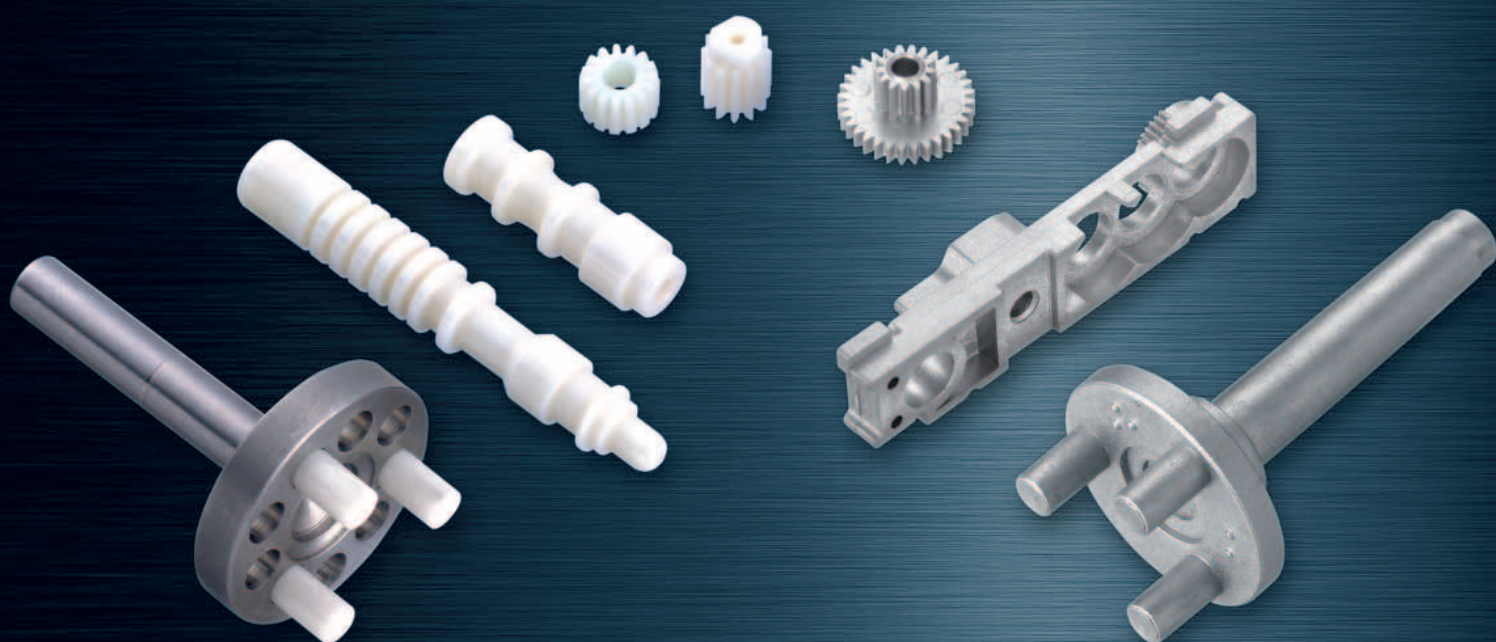


# Innovative CIM / MIM components

maxon ceramic

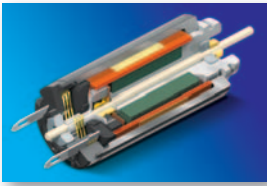


EDITION 04/2006

**maxon motor**  
driven by precision

# Ceramic – A Material of the Future.

Ceramic is becoming more important in applications where other materials reach their limits. The successful application in medical and dental technology as well as in astronautics, for use as cutting tools and as components in high quality drive technology shows the impressively wide performance spectrum of this innovative material.



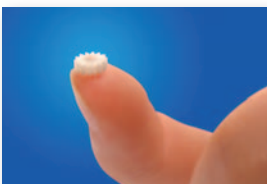
The shaft of this Ø6 mm microdrive is made of high-tech ceramic material which is superior to steel in many respects. At Ø0.8 mm it's as thin as a pencil lead.



The innovative use of high-tech ceramic material in planetary gearheads increases the performance and service life of our gearheads threefold.



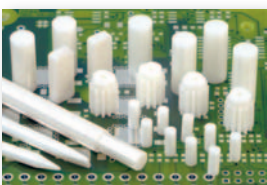
Miniature spindle drives provide linear motion in the smallest equipment. Requiring minimal space, their life expectancy is similar to that of expensive ball screws.



Pinion with module <math>< 0.5</math> without machining is state of the art.



Thread guides and nozzles are temperature-resistant and are highly wear-resistant.



Components made of high-tech ceramic material are excellent insulators and protect key electronic components.



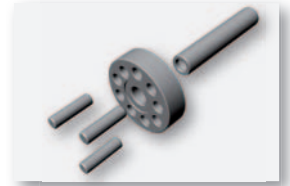
Granulate



# MIM technology – An intelligent solution.

Solid and complex-shaped steel parts, injected using granulate (metal powder and plastic binder), compressed in a sintering furnace at approx. 1300°C and ready for use with minimal machining.

Planet carriers are very complex and tolerance-critical gear parts. Most of them are assembled using several components, an intricate and therefore costly procedure.



It's much easier with MIM technology.



Well thought-out combinations of motors and assembly mechanics in MIM technology ensure high reliability in security technology.



Gear parts produced using MIM technology can be manufactured cost-effectively in large quantities.



**Sintered finished part M 1:1**

**Injection moulded part 22% larger than the finished part.**

Auto-tuner for automatic tuning of musical instruments. Six gear heads in the same housing illustrate the unit's compactness.

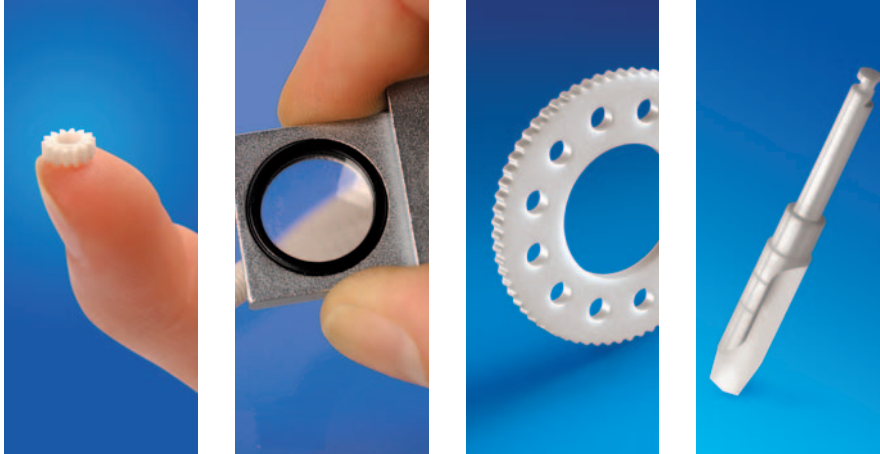
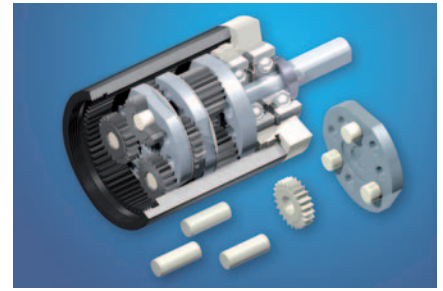


MIM for 1001 applications in cars, jewellery and watches, medical and dental technology, air and space travel, hand tools, mechanical engineering, microsystem technology, telecommunications.



# Versatile ceramic materials

High-tech ceramic materials have a wide range of uses. Their extremely high wear-resistance and excellent anti-friction properties significantly increase the service life of components, such as axes, shafts and their friction partners. The elasticity module and heat expansion coefficient are very similar to steel, so the combination of these two materials provides excellent results. Components made of hightech ceramic materials can also be used as insulators in electrotechnology and electronics. The human body accepts implants made of zirconium oxide with almost no side-effects and allergies. The aesthetics of these translucent materials are illustrated perfectly when they are used as dental implants for a natural effect.



**maxon ceramic – components for maxon motor**  
 maxon ceramic develops and produces components for maxon motor using high-performance ceramic materials. An in-house development and design department with state-of-the-art CAD technology and the facility for finite element calculation are pre-requisites for producing high-precision, top-quality components for drive systems.

## Zirconium oxide $ZrO_2$ – for wear-resistant components

- Extremely wear-resistant and hard
- Excellent antifriction properties
- High mechanical solidity
- High temperature stability even when temperature changes
- Excellent insulation ability against heat and electricity
- High corrosion and chemical resistance, largely acid and alkali-proof
- Elasticity module and thermal expansion coefficient similar to steel
- Biocompatible and allergen-low
- Low specific weight

## Aluminium oxide $Al_2O_3$ – also resists high temperatures

- High temperature stability even when temperature changes
- Good thermal conductivity
- Average mechanical solidity
- Low coefficient of thermal expansion
- High corrosion and chemical resistance, largely acid and alkali-proof
- Very hard
- Low specific weight

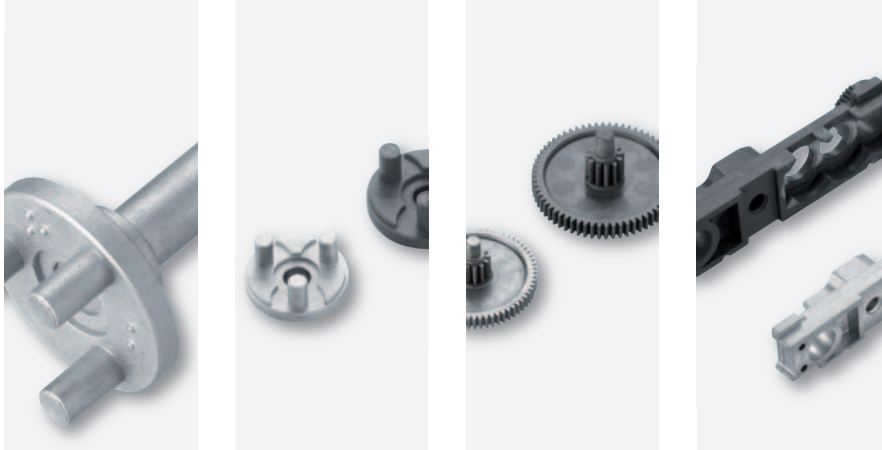
Material types		$ZrO_2$	$Al_2O_3$
Theoretical density	[g / cm <sup>3</sup> ]	6.08	3.98
Hardness	[HV]	~ 1200	~ 2000
Bending strength (4-point)	[N / mm <sup>2</sup> ]	800 - 1000	350 - 450
Elasticity module	[10 <sup>3</sup> N / mm <sup>2</sup> ]	approx. 200	approx. 350
Weibull module (m)		10	8 - 12
$K_{IC}$ value (critical voltage intensity factor)	[10 <sup>3</sup> N / mm <sup>2</sup> m <sup>1/2</sup> ]	8.2	3.5
Porosity	[%]	< 0.5	< 2
Maximum usage temperature	[°C]	≤ 1000 (dependent on humidity)	1400
Expansion coefficient	[10 <sup>-6</sup> / K]	approx. 10	approx. 5 - 7
Specific heat (20°C)	[J / kgK]	550	900
Thermal conductivity (100°C)	[W / mK]	approx. 1.5	approx. 25
Spec. resistance (20°C)	[Ohm cm]	10 <sup>10</sup>	10 <sup>15</sup>
Colour		white	white
Special features		very rigid, highly wear-resistant	high temperature applications

# Complex Shapes in One Step – Part for Part.

Complex components often have to be assembled from different parts and this is an intricate and expensive procedure. With CIM/MIM technology, the shape forming is predetermined using the injection mould. Tiny dimensions and intricate shape structures are unbeatable advantages of this process. Undercutting, cross holing, internal and external-screw threads and gear teeth can be produced.

## A wide range of materials covers all kinds of applications

Whether ceramic, stainless metallic or ferromagnetic materials, or materials of high tensile strength, the range of material properties is very broad and is defined by customer requirements.



## Cost-effective thanks to high quantities and efficient production processes

Production is cost-effective, as the quantities involved are large and almost no machining is required. Intensive utilisation of materials used also helps to keep costs down.

## Low tolerance levels and excellent surface quality

CIM/MIM technology yields high-precision components and excellent reproducibility. The surface quality means, in many instances, that no machining is required.

## Reliable mechanical and magnetic properties

We only use materials from recognised manufacturers known for their well-developed technology. High density materials are produced through the use of fine-grained powder and catalytic debinding. This high density level combined with an homogeneous material structure accounts for the excellent mechanical and magnetic properties.



## A well-kept secret: the tools

The injection moulds are designed in our own tool shop or in close cooperation with established, reliable and experienced partners.

We can design a profitable tool concept for the customer. The specification of the tooling design is a very complex procedure that requires precise knowledge about the processing behaviour of raw granulate. The component's eventual application and the general commercial conditions must be considered.

## Advantages of metallic materials

- Almost the same excellent mechanical properties as cast or rolled steel
- Components have a 96% – 98% density
- Components have a closed structure and can be gastight and pressurised
- Excellent surface quality, almost no machining required
- Highly corrosion resistant
- Components can be heat-treated, polished, galvanized, welded, soldered and machined

Low alloyed steels for heat treatment			
Description	42CrMo4	FN02	FN08
Composition	42 CrMo4	Carbonyl iron with 2% nickel	Carbonyl iron with 8% nickel
DIN standard	1.7225	–	–
Properties	heat-treatable	case-hardened	treatable and case-hardened
Applications	Toothing parts, wear-resistant parts	simple components	
Yield strength $R_p$ 0.2 [MPa]	> 400	> 170	> 210
Tensile strength $R_m$ [MPa]	> 650	> 380	> 380
Ultimate strain A [%]	> 3	> 3	> 15
Stainless steels		Magnetically soft alloys	
Description	P.A.N.A.C.E.A.	17-4PH	FeSi3
Composition	X15 CrMnMoN 17 11 3	X5 CrNiCuNb 17 4	Carbonyl iron with 3% silicon
DIN standard	–	1.4542	1.0884
Properties	non-magnetic, nickel-free	can be hardened, ferromagnetic	–
Application	Medical technology, dental technology	corrosion resistant components	–
Yield strength $R_p$ 0.2 [MPa]	> 690	> 660	> 300
Tensile strength $R_m$ [MPa]	> 1090	> 950	> 500
Ultimate strain A [%]	> 35	> 6	> 20

# maxon ceramic – High vertical integration



Powder + binder = compound



Injection moulding



Debinding



Sintering



Machining



Control



The fine ceramic or metallic powder is mixed with a binder system and granulated to a material that can be injection moulded. This compound can be processed as freely as with injection moulding.



Under this modern process, the moulding is carried out by injecting the parts on specially equipped machines (green part production).



The process aims to eliminate the binder from the injection moulded part. This happens at a moderate 120°C in a protective gas atmosphere. The binder is continually removed from the outside inwards. The binder's gaseous products escape without any pressure build-up. Conversely, the gaseous catalyser easily moves inward into the interior of the component.

The part is finally sintered at around 1,500°C (CIM) or 1,300°C (MIM) in a sintering furnace where it is subject to a linear 22% shrinkage.



After sintering, the components can be ground to their final size if required and then polished.



Strict quality controls ensure that the manufactured part conforms to specifications.



# maxon CIM/MIM – Customised Products

In Sexau near Freiburg in Breisgau, Germany, over 200 specialist employees develop and produce components for the world-renowned maxon miniature drives. An in-house development and design department with state-of-the-art CAD technology and the facility for finite element calculation are pre-requisites for meeting future market needs. We also give our customers the benefit of our expertise, maintaining dialogue to develop customer specific solutions. In this way our customers benefit from our many years of expertise with a customised solution manufactured to maxon's high quality standards and our ability to provide prototype samples quickly.

## Construction and Development

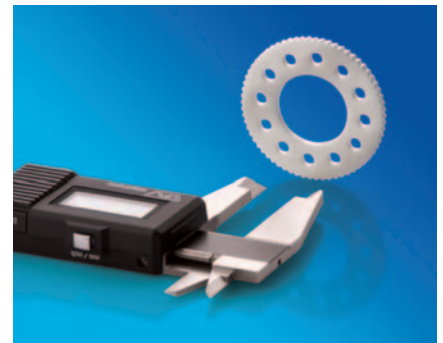
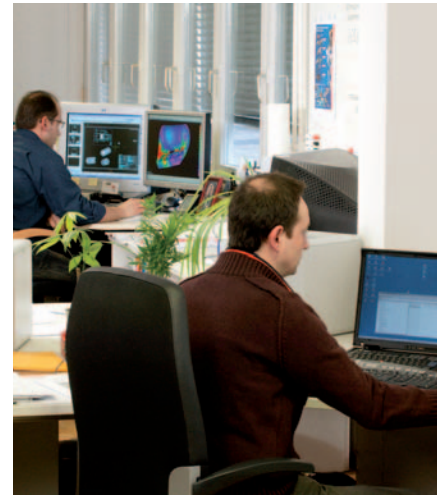
- Customised solutions according to the customer requirements
- Co-operative development with our partners
- Ultramodern CAD systems and finite element calculations
- Competent, experienced and customer-oriented team.

## Manufacturing

- Flexible production and assembly installations
- High-efficient state of the art technology
- Profound know-how in powder injection moulding
- Precise manufacturing with equally high quality standards
- Short delivery times
- Production samples and small series from 1 pc upwards
- High expertise in the design of injection moulding tools
- Reliable quality controls

### Your benefits are

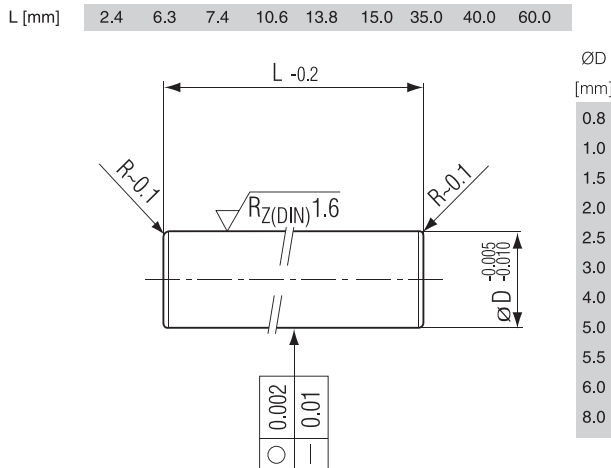
- All-in-one: Customer designed advisory service, development and manufacturing under one roof
- Convincing cost-performance ratio: Optimal solutions at attractive prices
- Service at a high level by competent and solution-orientated partners
- Flexibility with samples -, single and small-batch manufacturing
- Security through high quality standards and quality assurance systems
- Ceramic components increase the efficiency and quality of your products



Customised solutions using appropriate materials such as steel and ceramics.

# maxon ceramic standard components

maxon ceramic offers ceramic shafts within the standard stock program. Ceramic shafts with the dimensions given below are available at short notice.



Precise management of the shrinkage process requires the expert knowledge.



The strengths of the powder injection moulding process stand out in particular in the miniature and micro domain.

# maxon motor at a glance.



**maxon DC motor**  
DC motors with moving coil rotor and strong permanent magnets:  
Ø6 - 75 mm,  
0.3 - 250 watts.

**maxon A-max**  
DC motors with moving coil rotor and AlNiCo magnets,  
Ø12 - 32 mm,  
0.5 - 20 watts.

**maxon HZ-max**  
DC motors with moving coil rotor and Neodymium magnets:  
Ø13 - 29 mm,  
0.75 - 22 watts.

**maxon EC motor**  
Brushless servomotors, autoclavable versions available:  
Ø6 - 60 mm,  
1.2 - 400 watts.

**maxon FC-max**  
Brushless servomotors with modular design:  
Ø16 - 40 mm,  
5 - 120 watts.

**maxon LC-powermax**  
4-pole brushless servomotors with maximum performance:  
Ø22 and 30 mm,  
120 and 200 watts.



**maxon flat motor**  
Brushless DC external rotor motors in flat design:  
Ø6 - 90 mm,  
0.03 - 90 watts.

**maxon micro drive**  
DC and EC drives with diameters smaller than < 10 mm:  
Ø6 - 8 mm,  
0.03 - 1.2 watts.

**maxon gear**  
Standard spur and planetary gearheads as well as customer specific gearheads

**maxon tachometer**  
Encoders, DC tachos, resolvers.

**maxon motor control**  
Control electronics for DC and EC motors, servoamplifiers and positioning control units.

**maxon ceramic**  
High-tech ceramic components (MIM/CIM technology), mainly customer specific solutions.

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