FerroTec Ceramics Corporation: Materials Bringing Tomorrow's Products Today

FerroTec Ceramics is marketing Japanese advanced materials technology in Europe, the USA, Japan, China and Singapore, backed by locally based engineering and technical support capabilities.

As a world-class ceramic manufacturer, *FerroTec Ceramics* can draw on vertically integrated solutions as well as state-of-the art technologies and a high degree of process control. For the design of new products, rapid manufacturing capabilities and back-up from the R&D departments are available.

Background

FerroTec Ceramics Corporation was established in December 1989 and is headquartered in Tokyo. Today it has approx. 180 employees. In 2008, *FerroTec Group* took over *SUMIKIN Ceramics & Quartz Co. Ltd.* and in the same year integrated the *FerroTec Hangzhou Ceramics Division* to form FerroTec's global ceramics operation (Tab. 1).

The portfolio of FerroTec oxide and non-oxide ceramic materials comprises ultra-pure, super wear-resistant components with ultra-precision machinability and superior physical and chemical characteristics. The manufacturing sites are in Japan (Kansai for shaping, firing, machining and Ishikawa for machinable ceramics) and China (Hangzhou for machining).

Major shareholders of the company are *FerroTec Corporation* and *Sumitomo Metal Industries.*

FerroTec Corporation (JASDAQ listed) is a diversified technology company with over 4930 employees around the world and a worldwide presence in a broad array of end-products, manufacturing systems, and industries.

FerroTec has led the development of ferrofluid technology since 1968. In the core technology (Ferrofluid magnetic liquid and Ferrofluidic® sealing products for audio speakers, bio-medical particles, ferrofluidic feedthroughs and domains protection), the product portfolio has been continuously extended. The core businesses are: ferrofluids, ferrofluidic solutions, thermal solutions, fabricated quartz ware and vacuum coating solutions. A very import-

Tab. 1
Roots of FerroTec Ceramics Corporation (selected milestones)

1984	PHOTON CERAMICS CO., LTD. established in Kanazawa City, Ishikawa Prefecture; opening of Tokyo sales office.
1985	Start of sales promotion for "Photoveel" machinable ceramics.
1987	Sumitomo Metal Industries Ltd. financed capital to Photon Ceramics Co. Ltd.
1989	Sumikin Photon Ceramics Co. Ltd.; transferred sales right from Photon Ceramics Co. Ltd.
1998	Transferred Fine Ceramics business from Sumitomo Metal Industries Ltd, and changed corporate name to Sumikin Ceramics Co. Ltd. Opening of Kansai and Kyusyu sales offices.
2002	Merged Sumikin Quartz Co. Ltd. and renamed Sumikin Ceramics & Quartz Co. Ltd. Inclusion of Wakayama Plant (Quartz), substrate manufacturing section and opened Tohoku sales office.
2008	FerroTec Corp. financed capital, and divided Quartz Division. Renamed FerroTec Ceramics Corporation. Main plant renamed Ishikawa plant.

Keywords
high purity alumina (Al_2O_3), zirconia (ZrO_2), silicon aluminium oxynitride (SiAlON), aluminium nitride (AlN), silicon carbide (SiC), silicon nitride (Si_3N_4), machinable ceramics

FerroTec Ceramics Corporation
Nihonbashi Plaza Building
2-3-4 Nihonbashi
Chuo-ku, Tokyo 103-0027
Japan
www.ft-ceramics.co.jp

FerroTec GmbH
Seerosenstraße 1
72669 Unterensingen
Germany
www.ferrotec-europe.de
ceramics@de.ferrotec.com

ant user industry is the semi-conductor sector and others like the electronic device segment and photovoltaics. FerroTec is now a global enterprise spearheading substantial intercompany cooperation in research, manufacturing and marketing of products for high-end technical solutions.

Product range of FerroTec Ceramics

Advanced ceramic components

The product range comprises:

- alumina (99,5 %, 99,7 %, 99,9 % and 99,99 % Al_2O_3), 5N alumina targets
- silicon nitride Si_3N_4
- SiAlON
- aluminium nitride (AlN)
- silicon carbide (SiC)
- zirconia (ZrO_2)
- silicon-infiltrated silicon carbide (Si/SiC)
- sheet ceramics.

Alumina (Al_2O_3) is a popular material in engineering ceramics. Alumina exhibits high electrical insulation, abrasion and corrosion resistance as well as good cost effectiveness. FerroTec Ceramics provides a wide selection of alumina materials such as over 99,99 % high-purity grade alumina and high-plasma-resistance alumina, etc. Applications are: chamber parts for semiconductor equipment, wafer transfer parts, FPD manufacturing equipment parts, heat-resistant and electrical insulation components.

Zirconia (ZrO_2) from FerroTec Ceramics – known for high hardness and high toughness owing to stabilization of its crystalline phases – is used e.g. as edged tool material and in grinders on account of its superior wear resistance.

Silicon nitride (Si_3N_4) ceramics are high-hardness and high-toughness materials with high-temperature resistance and high heat-shock-resistance properties, which can be used in high-load and high-temperature environments. The FerroTec range is widely used in semiconductor equipment and general industrial machinery applications.

The strength of ***Aluminium nitride (AlN)*** ceramic is its high heat conductivity. The material also has other unique properties such as high florin plasma resistance and a similar expansion coefficient to silicon (Si). With these favourable properties, the FerroTec AlN ceramics are used in many different applications requiring high heat conductivity and/or high plasma resistance such as the parts used in semi-conductor equipment.

Silicon aluminium oxynitride (SiAlON) is an exceptional material for high-temperature applications subject to thermal shock. SiAlON ceramics are an excellent choice for extreme structural applications with high-temperature exposure.

Tab. 2
FerroTec oxide ceramic materials

Material	**Aluminia [Al_2O_3]**			**Low CTE Ceramics**	**Zirconia [ZrO_2]**
Material code	**AS999**	**AG999**	**AM997**	**LE101**	**Z403**
Main component purity [%]	**99,99**	**99,9**	**99,7**	–	94
Density [g/cm³]	3,95	3,95	3,93	2,5	5,98
Bending strength [MPa]	390	390	390	200	**880**
Young's modulus [GPa]	380	380	375	140	245
Vickers hardness [GPa]	18	17	18		16
Thermal expansion [~800 °C : × 10^{-6}/K]	7,7	8,1	7,6	**2,0**	10,4
Thermal conductivity [W/m · K]	33	30	33	5	3
Volume resistivity [Ω · cm] 25 °C	10^{15}	10^{15}	10^{16}	10^{14}	
Dielectric constant [10 GHz]	9,9	9,7	9,7		
Dielectric loss [× 10^{-4}]	0,5	6	1		
Q factor [× 10^4]	2	0,2	1		

Tab. 3
FerroTec non-oxide ceramic materials

Material	**Silicon Nitride [Si_3N_4]**	**Sialon [Si-Al-O-N]**	**Silicon Carbide [SiC]**	**Aluminium Nitride [AlN]**	
Material code	**SN606**	**SA201**	**SC902**	**ALN99**	**ALN94**
Main component purity [%]	90	90	97	99	94
Density [g/cm³]	3,16	3,20	3,10	3,24	3,31
Bending strength [MPa]	**750**	**880**	400	295	345
Young's modulus [GPa]	285	290	**400**	320	320
Vickers hardness [GPa]	16	12	**20**	11	11
Thermal expansion [~800 °C : × 10^{-6}/K]	4,2	**2,9**	4,3		
Thermal conductivity [W/m · K]	23	27	130	80	**150**
Volume resistivity [Ω · cm] 25 °C	10^{16}	10^{15}	3×10^6	10^{14}	10^{14}
Dielectric constant [10 GHz]	8,0	8,0	–	8,5	8,5
Dielectric loss [× 10^{-4}]	14	14	–	30	30
Q factor [× 10^4]	0,04	0,7	–	0,03	0,03

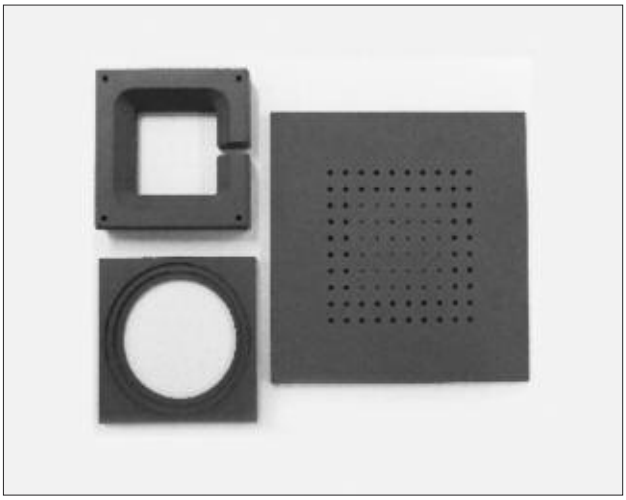

Fig. 1
Machined Photoveel II-S Black parts

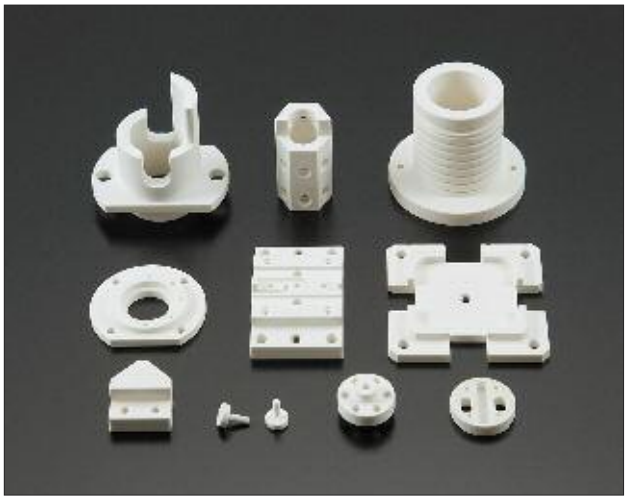

Fig. 2
Machined Photoveel parts

Yttria (Y_2O_3) of high purity (99,9 %) and a flexural strength of 180 MPa are a FerroTec speciality for applications that call for excellent plasma resistance.

Silicon carbide (SiC) is a light, extremely hard, and corrosion-resistant material that make it a strong candidate for wear applications in the harshest environments. Silicon carbide also offers other desirable properties such as excellent thermal conductivity and a high Young's modulus.

Low CTE ceramics exhibit zero expansion at room temperature. These lightweight ceramic products are a good choice for applications like e-chucks and high-precision instruments in which dimensional stability is critical (semi-conductor process equipment and precision machinery parts)

FerroTec ceramic components are manufactured in-house from the raw material mixing to finishing of sintered components. For sintering, gas-fired kilns (alumina), vacuum furnaces (silicon nitride, SiAlON, silicon carbide, aluminium nitride), electrical furnaces (yttria, zirconia) and hot presses (alumina, aluminium nitride) are installed. Grinding centres for green machining and finishing of sintered parts are available as well as lapping machines and CVD and PVD systems for surface coating (e.g. TiN, TiC, SiC, Al_2O_3).

Tab. 4
Machinable ceramics

		Photoveel		Photoveel II Series					
Material	**Glass ceramics**	**Photoveel**	**Photoveel (New)**	**II**	**α 3,4**	**II-S**	**α 5**	**Al_2O_3 (Typ)**	**HP-Si_3N_4 (Typ)**
Coefficient of thermal expansion [× 10^{-6}/°C]	9,4	8,3	8,5	1,2	3,4	4,7	5,2	7,0	3,3
Density [g/cm³]	2,52	2,59	2,60	2,56	3,30	3,50	3,70	3,93	3,3
Bending strength [MPa]	98	167	170	440	370	320	325	390	840
Young's modulus [GPa]	64	65	65	157	140	130	130	375	290
Volume resistivity [Ω · cm]	10^{15}	10^{15}	10^{15}	10^{14}	10^{14}	10^{14}	10^{14}	10^{16}	10^{14}
Coefficient of thermal conductivity [W/m · K]	1,7	1,7	1,7	50	30	23	20	33	25

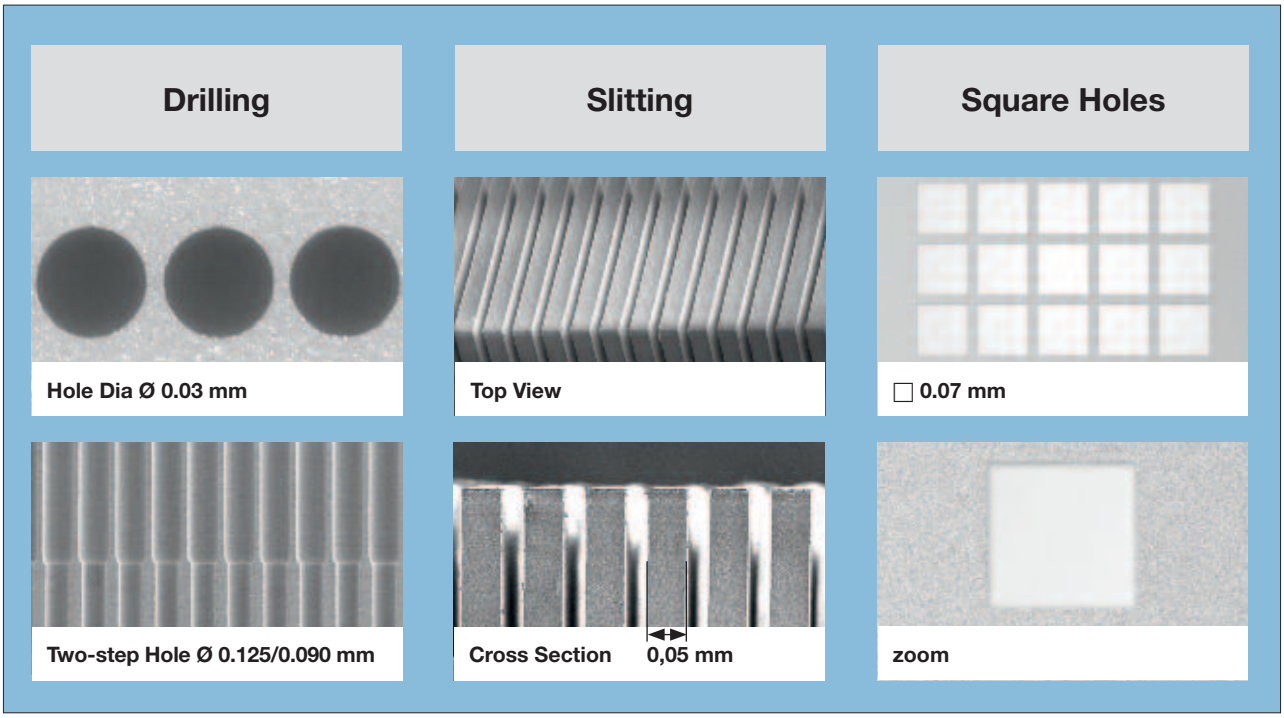

Fig. 3
Examples of machining on microscopic scale

Additionally special manufacturing know-how is available for joining ceramic components.

Machinable ceramics (Photoveel series)
Outstanding properties of FerroTec Photoveel products are:
- high strength
- fine grain structure
- wide range of CTE options
- high thermal conductivity
- colour variations
- supports microscopic hole drilling.

Ferrotec's machinable ceramics (Fig. 1–2) offer superior machinability as they can be processed with standard machining tools. Features of these ceramic materials are precision machinability, electrical insulation, heat insulation and resistance. FerroTec offers wide ultra-high precision machining in-house, to meet specific customer needs and ensure short lead times and quick delivery. Grinding equipment available: rotary grinder, machining and grinding centre, cutting machine, plain grinder, dicing saw, lapping machine, etc.

Inspection equipment used: e.g. 3D coordinate measuring machine, surface roughness measuring machine, non-contact shape measuring machine.
Photoveel II and Photoveel II-S nitride ceramics are the enabling materials for the next generation probe cards. Holes with diameters as small as 40 µm and 60 µm pitch can be drilled into Photoveel II and II-S (applications are e.g.: inspection parts, insulation parts for micro-machining with a diameter tolerance of ±5 µm.

KS