Surface Improvement Products/Analytical technologies

At Toyo Tanso, we believe in the boundless possibilities of carbon, and our basic and applied research initiatives never stop.

Surface Improvement Products

- EVEREDKOTE™-B Products
- PYROGRAPH™ Products
- PERMA KOTE™ Products
- GLASTIX KOTE™ Products
- Toyo Siliconized Graphite

Analytical technologies

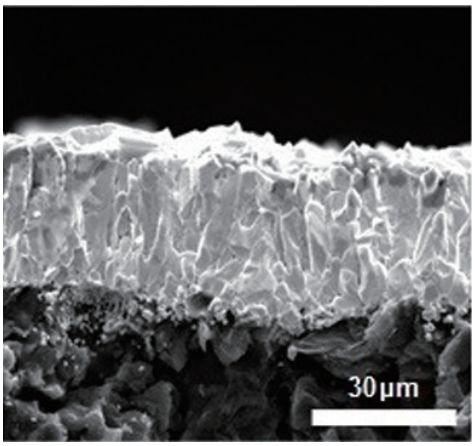
Surface Improvement Products

EVEREDKOTE™-B Products

EVEREDKOTE™-B is a material created by coating the surface of a highly purified graphite substrate with a fine layer of TaC (tantalum carbide) by means of a proprietary Toyo Tanso Chemical Vapor Deposition (CVD) process.

■ Features

- Excellent heat resistance.
- Prevents the separation and scattering of graphite powder, as well as the release of gases and impurities from the graphite substrate.
- Excellent resistance to reactions with etching gases.



Cross-sectional Photo of EVEREDKOTE™-B

■ Application

- Components for single crystal SiC growth
- Components for MOCVD
- High-temperature components

■ Properties/Test Data

Example EVEREDKOTE™-B Product

■ General Physical Properties

Item	Tantalum Carbide
Bulk Density	14.5 Mg/m³
Melting Point	3985°C
Hardness	1550 HK
Electrical Resistivity	0.15 μΩ·m
Thermal Conductivity	9 to 22 (W/m·K)
Coefficient of Thermal Expansion	7.1 (106/K)

* The above numerical values are those taken from the below source and are not guaranteed values.
Source: H. Holleck: Material selection for hard coatings, J. Vac. Sci. Technol. A, Vol.4, No.6, Nov/Dec 1986

■ Reactivity with Various Substances

Reactive Substance	1200°C × 5h	1600°C × 5h
Hydrogen Chloride	◎	◎
Ammonia	◎	◎
Hydrogen	◎	◎
Oxygen	× (600°C or more)	

* ◎: No reaction, ×: Significant reaction

Hydrogen chloride reaction test: 20 Torr, HCl/H_2 = 0.30/2.70 L/min (10%)
Ammonia reaction test: 20 Torr, NH_3/H_2 = 0.5/2.0 L/min (20%)
Hydrogen reaction test: 20 Torr, H_2 3.0 L/min
Oxygen: Cracking and embrittlement of coating in low concentration oxidized atmosphere.

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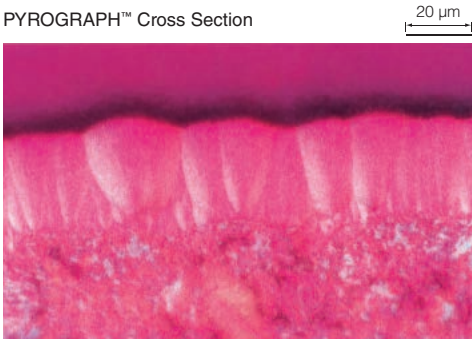
PYROGRAPH™ Products

PYROGRAPH™ is a product created by coating the surface of highly purified isotropic graphite with a fine layer of pyrolytic carbon by means of a proprietary Toyo Tanso Chemical Vapor Deposition (CVD) process.

■ PYROGRAPH™ Characteristics

- the pyrolytic carbon layer is extremely fine
- ultrapure
- the layer coating ensures extremely low gas permeability
- excellent corrosion resistance against gas
- excellent oxidation resistance at low temperatures
- excellent heat resistance
- prevents the parting and scattering of graphite particles, and the emission of gas and impurities from the graphite substrate

PYROGRAPH™ Cross Section



The column-shaped structure of the pyrolytic carbon layer means that the structure is extremely fine.

■ Application

- Single crystal silicon manufacturing equipment
- Tube for atomic absorption spectroscopy
- OLED manufacturing equipment

■ PYROGRAPH™ Property Data

■ Impurity Analysis Example

Unit: mass ppm

Element	Content
B	<0.01
Na	0.03
Al	0.02
Cr	<0.10
Fe	<0.01
Ni	<0.01

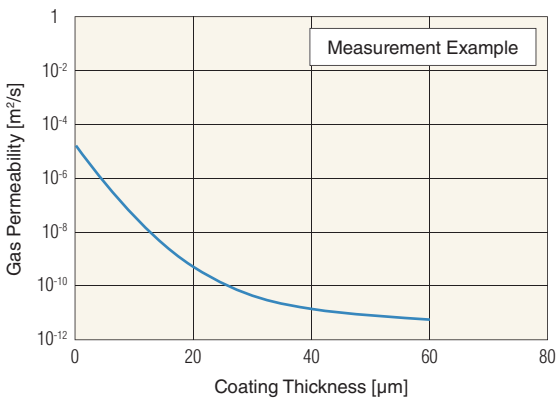
* Measurement method: Glow Discharge Mass Spectrometry
* The figures above are measurement examples, and are not to be guaranteed.

■ General Physical Properties

Item	Unit	Parallel to Coating Surface	Perpendicular to Coating Surface
Bulk Density	Mg/m^3	2.2	2.2
Hardness	HSD	100	—
Electrical Resistivity	μΩ·m	2.00 to 4.00	2 to 5 x 10^3
Coefficient of Thermal Expansion	10^{-6}/K	1.7	28
Tensile Strength	MPa	98 to 147	Extremely weak
Young's Modulus	GPa	29 to 39	—
Thermal Conductivity	W/(m·K)	170 to 420	2 to 4

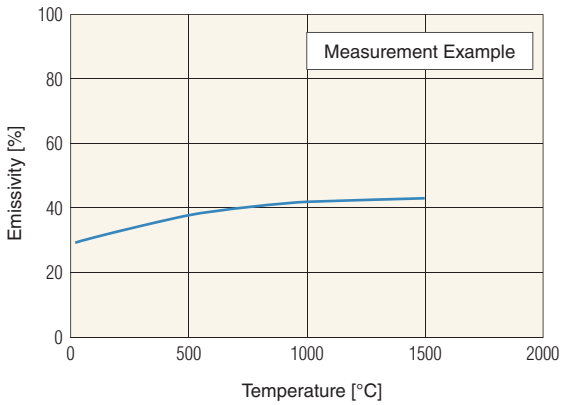
* The temperature range for the coefficient of thermal expansion is RT to 1,000°C.
* The figures above are extracted from other publications, and are not to be guaranteed.

■ Gas Permeability



Source: Pg. 137 of "Introduction to Carbon Materials" from the Carbon Society of Japan

■ Emissivity



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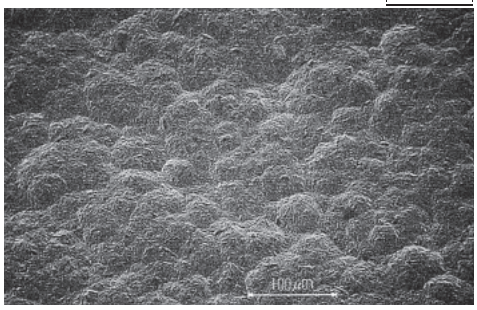
PERMA KOTE™ Products

PERMA KOTE™ is a product created by coating the surface of highly purified isotropic graphite with a fine layer of silicon carbide by means of a proprietary Toyo Tanso Chemical Vapor Deposition (CVD) process.

■ PERMA KOTE™ Characteristics

- The silicon carbide layer has excellent oxidation resistance, corrosion resistance and chemical resistance.
- The silicon carbide layer is stable at high temperatures and is extremely hard.
- Prevents the parting and scattering of graphite particles, and the emission of gas and impurities from the graphite substrate.
- Both the graphite substrate and silicon carbide layer are of high purity.
- Both the graphite substrate and silicon carbide layer have a high thermal conductivity, and excellent heat distribution properties.
- Material is designed so that cracks and delamination do not occur.

PERMA KOTE™ Surface SEM

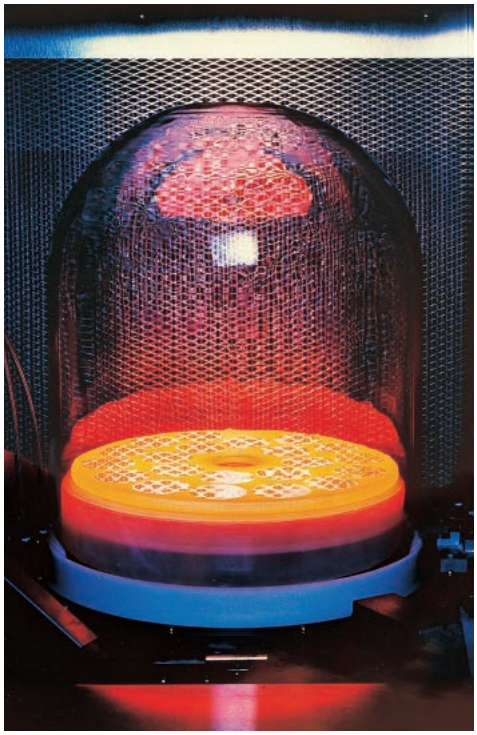


■ Coating Thickness

The standard thickness is 120 μm; however this can be modified within a range of 40 to 500 μm.

■ Application

- Susceptors for silicon epitaxial growth
- Single crystal silicon manufacturing equipment
- MOCVD susceptors
- Heaters
- Heat spreaders
- Oxidation resistance components



Silicon Epitaxial Growth System

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■ PERMA KOTE™ Property Data

■ Corrosion Resistance

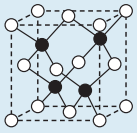
Name	Chemical Formula	Concentration (%)	Temperature (°C)	Time (h)	Change in Mass (g/m²)
Hydrofluoric acid	HF	47	80	144	-1.0
Hydrochloric acid	HCl	36	Boiling point	144	0
Sulfuric acid	H_2SO_4	97	110	144	0
Nitric acid	HNO_3	61	Boiling point	144	0
Hydrofluoric acid + nitric acid	HF + HNO_3 (1:1)	100	80	288	-1.0
Nitric acid + sulfuric acid	HNO_3 + H_2SO_4 (1:1)	100	25	288	-1.0
Sodium hydroxide	NaOH	20	80	288	0
Phosphoric acid	H_3PO_4	100	100	192	-1.0
Nitrohydrochloric acid	HCl + HNO_3 (3:1)	100	80	192	0

■ Reactivity with Various Substances (In a Vacuum)

Reactant	Chemical Formula	1200°C x 3h	1600°C x 3h
Aluminum	Al	○	△
Boron	B	◎	◎
Cobalt	Co	△	×
Chromium	Cr	△	×
Copper	Cu	○	△
Iron	Fe	×	×
Molybdenum	Mo	◎	○
Nickel	Ni	◎	×
Lead	Pb	△	×
Silicon	Si	◎	○
Tin	Sn	◎	△
Tantalum	Ta	◎	◎
Titanium	Ti	◎	○
Vanadium	V	◎	×
Tungsten	W	◎	○
Alumina	Al_2O_3	◎	×
Boron oxide	B_2O_3	◎	◎
Chromium oxide (III)	Cr_2O_3	◎	×
Iron oxide (III)	Fe_2O_3	×	×
Magnesium oxide	MgO	◎	△
Manganese oxide (IV)	MnO_2	◎	×
Lead oxide (II)	PbO	○	△
Silicon dioxide	SiO_2	◎	△
Titanium oxide (IV)	TiO_2	◎	○
Vanadium oxide (V)	V_2O_5	◎	△
Zirconium oxide (IV)	ZrO_2	◎	○

* ◎···No reaction ○···Slight reaction
△···Reaction ×···Significant reaction

■ Layer Properties

Crystal Structure	ß-SiC (Cubic System) Structure  ○ : Si ● : C
Bulk Density	3.2 Mg/m³
Hardness	2800HK
Electrical Resistivity	0.2 Ω·m (through the fall-of-potential method)
Flexural Strength	170 MPa (through 3-point bending)
Young's Modulus	320 GPa (through the deflection method)

* The figures above are extracted from other publications or are measurement examples, and are not guaranteed.

■ Impurity Analysis Example

Unit: mass ppm

Element	Content
B	0.15
Na	0.02
Al	0.01
Cr	<0.1
Fe	0.02
Ni	<0.01

* Measurement method: Glow Discharge Mass Spectrometry
* The figures above are measurement examples and are not to be guaranteed.

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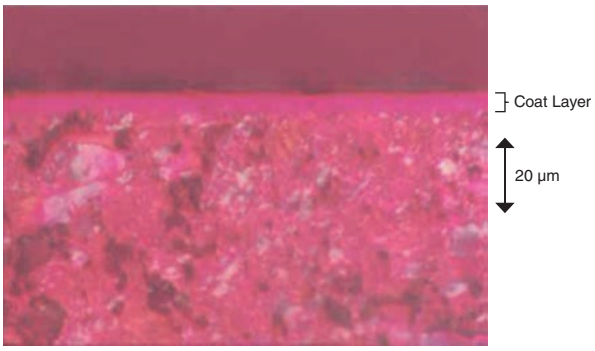
Glass-like Carbon Coated GLASTIX KOTE™

GLASTIX KOTE™ is a material impregnated or coated with glass-like carbon on a graphite or neighboring surface.
It enables use of various Toyo Tanso graphite materials as a substrate, and it does not lose its substrate properties. Not only does this material offer enhanced durability against scratching and other friction, it also reduces the generation of dust.

■ Features

- Able to use various Toyo Tanso graphite materials as a substrate.
- Does not lose graphite substrate properties.
- Able to reduce the generation of graphite powder.
- Enhanced durability against scratching and other friction.

"GP2B" Cross-section



■ Application

- Parts for silicon single crystal pulling devices
- Parts for epitaxial growth
- Dies for continuous casting
- Glass sealing jigs

■ Properties/Test Data

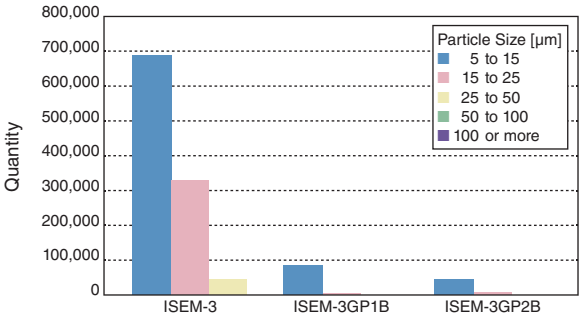
■ General Physical Properties

Grade	Bulk Density	Hardness	Electrical Resistivity	Flexural Strength	Compressive Strength
ISEM-3	0	0	0	0	0
GP1B	0	+3%	0	+8%	+3%
GP2Z	0	+3%	–	+7%	+4%
GP2B	0	+3%	0	+13%	+3%

* Example of physical properties when using ISEM-3 as a graphite substrate and applying GLASTIX KOTE™ GP series processing.
(Rate of change with measured value of ISEM-3 substrate as the standard)

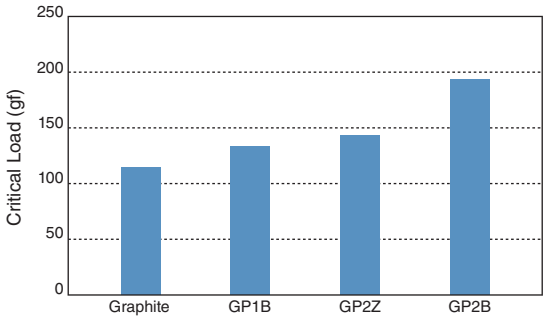
Test piece dimensions:
10 × 10 × 60 mm: Bulk density, hardness, electrical resistivity, flexural strength
10 × 10 × 10 mm: Compressive strength

■ Dust Reduction Effect



GLASTIX KOTE™ processing can greatly reduce the amount of carbon dust generated.
* This is the result of measuring the number of fine particles in the cleaning solution.

■ Scratch Strength Comparison



The durability against scratching with GLASTIX KOTE™ processing nearly doubled, and a similar improvement in wear resistance can be expected.
* Critical load indicates the vertical load when the surface begins to show damage.

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Toyo Siliconized Graphite SiC/C Composites

Toyo Siliconized graphite is a material with a composite layer of silicon carbide (SiC) and graphite (C).
The material has excellent properties of both silicon carbide and graphite, and not only are they ideal for sliding material applications, the surface layer of the graphite substrate is covered with a fine SiC layer, making it ideal for high-temperature atmosphere applications as well.

■ Features

- SiC/C composite layer can be applied to an entire product or just the areas required.
- Composite layer can be formed from the surface to deep within the material.

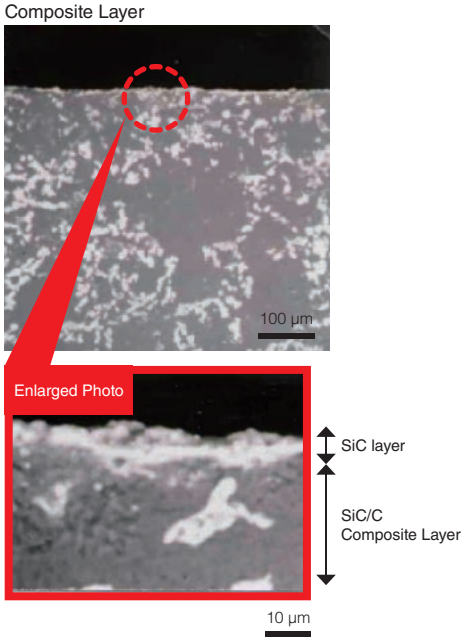
[Sliding Material Applications]

- Excellent blister resistance and enhanced wear and oxidation resistance.
- Graphite substrate does not lose workability.

[High-temperature Atmosphere Applications]

- A SiC layer forms on the processing surface, enhancing oxidation resistance and reducing scattering from the graphite substrate.

Cross-sectional Photo of SiC/C Composite Layer

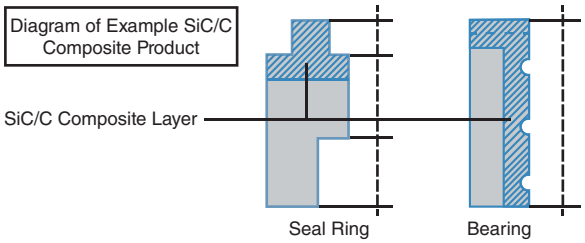


■ Application

- Metallurgic members
- Mechanical seals
- Bearings

■ Properties/Test Data

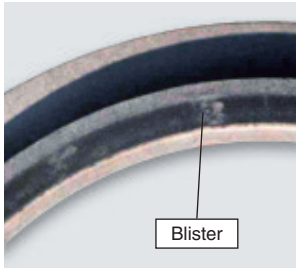
■ Diagram of Example SiC/C Composite Product



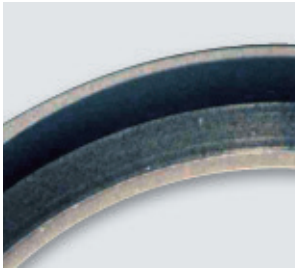
SiC/C composite layer can be applied to an entire product or just the areas required.
The inner diameter of the bearing can be processed after becoming a composite, thereby falling within the tolerance.

■ Sliding Application (Blister Test)

Example of Blister Formation

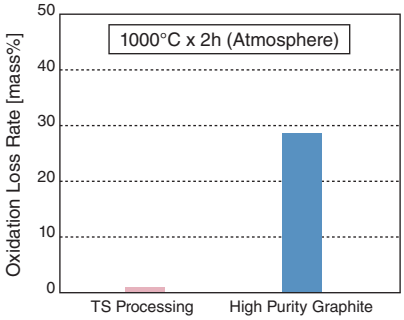


Example of Blister Improvement Using TS-004



Because the material retains a high mechanical strength and the sliding surface has a moderate surface roughness, it is easy to form a lubricating layer on the sliding surface, and it is difficult for blisters to form when using liquid oil.

■ High-temperature Atmosphere Application (Oxidation Loss Test)



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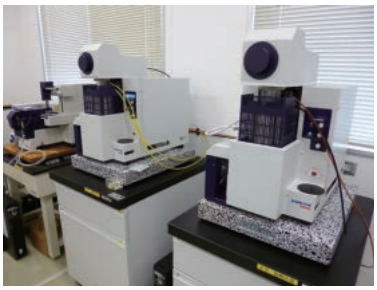
Analytical technologies

Toyo Tanso employs analytical technologies using a diverse range of analysis equipment to develop new materials and pursue research and development into material design and new applications. We also respond to a wide range of customer requests such as manufacturing process improvement, and also contribute to identifying and problem solving. In this way, we continually strive to provide better products and more sophisticated technologies and services through analytical technologies.

■ Thermal analysis

Graphite material has excellent thermal durability, and as it is often used in high-temperature environments, it is important to understand the way it behaves when heat is applied to a material. Toyo Tanso has a wide variety of thermal analysis equipment (TMA, TG-DTA, etc.), and can provide data to meet your usage conditions. Based on this data, we provide a range of services that can help with material selection including: heat stress calculation and FEM analysis, etc., for component design; analysis of chemical reactions and state changes due to heat; and analysis of material wear in oxidizing atmospheres.



■ Structural and surface analysis

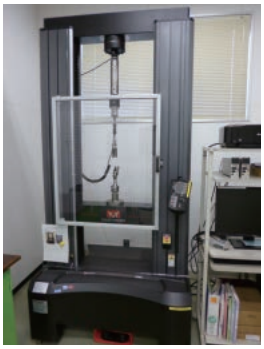
Graphite material is polycrystalline and porous in nature, and differs greatly in terms of surface shape and internal structure due to differences in raw materials and manufacturing methods. To select and develop materials suited to your application, it is therefore important to have an understanding of a variety of structures. Toyo Tanso uses all sorts of measurement equipment suited to these analyses (XRD, FE-SEM, polarizing microscopes, etc.,) depending on the purpose, and conducts a range of analysis from the macro to the nanoscale level.

■ Element analysis

As graphite materials can be made with a high degree of purity, they are frequently used in applications where it is necessary to avoid contaminants such as semiconductor fabrication equipment. In applications where a high degree of purity is required, analysis of trace contaminants is an important analysis tool. Toyo Tanso has a variety of element analysis equipment (ICP-OES, XRF, etc.,) and is ready to respond to your requests.

■ Physical properties

We provide data on basic physical properties such as tensile, compression, and flexural strength as well as modulus of elasticity, all of which are essential for component/material design.



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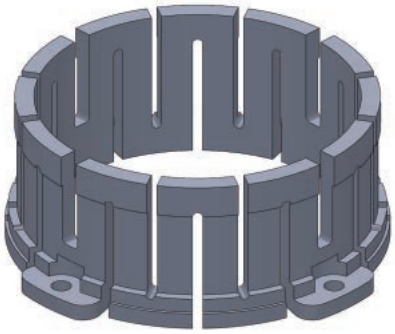
■ 3D CAD drawings

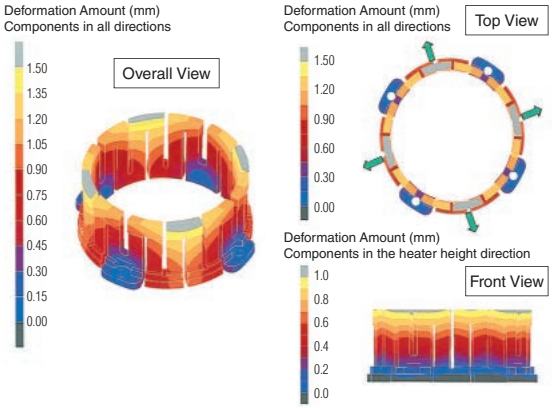
Toyo Tanso recreates three-dimensional images of products on a computer via 3D CAD, and improves the quality of the finished product by checking shape details before product processing. We also offer design support via 3D CAD based on your schematic diagrams and design information.



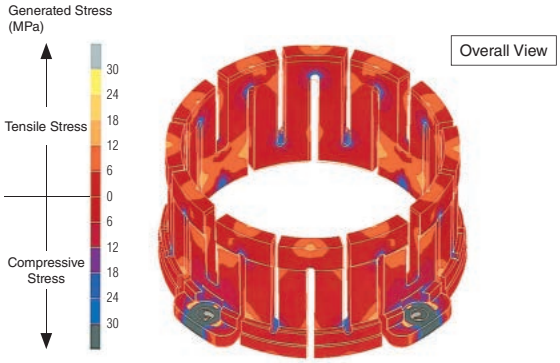
■ Finite element method (FEM analysis examples)

By analyzing heat deformation, heat stress, current density distribution, and other factors in complex product shapes using FEM computer simulations depending on your environment, Toyo Tanso offers comprehensive support of design processes for improving product performance, reducing costs, improving product development speed, etc.

■ Thermal Deformation Analysis Results



■ Thermal Stress Analysis Results



■ Current Density Distribution Results

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