KTW Technology
DRIVEN BY INNOVATION

SpaceTech4PlanetEarth

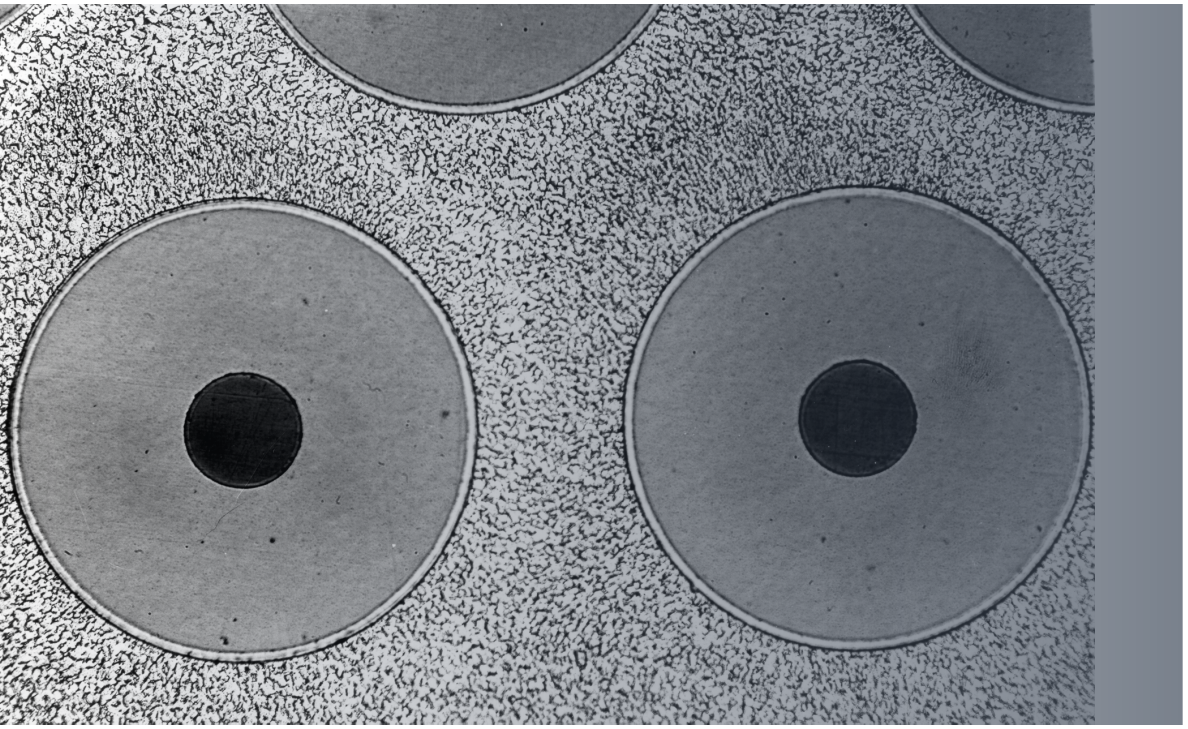
Titan Matrix Composites

SmartValve System

Vacuum Laser Welding

USP of KTW TMC Technology

In summary, more than **20-years research** and **development** in various organizations



Fiber reinforced Titanium alloy

Advantages (compared to regular/tempered steel)

- **Less weight**
- Higher stiffness
- Higher strength
- **Corrosion-free**, non-magnetic, **biocompatible**
- Temperature-resistant ~ 650°C

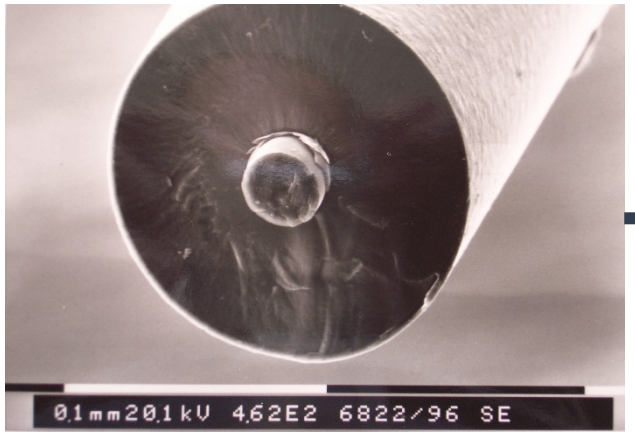
Reliable, high quality Manufacturing Process
for **all Titanium alloys**

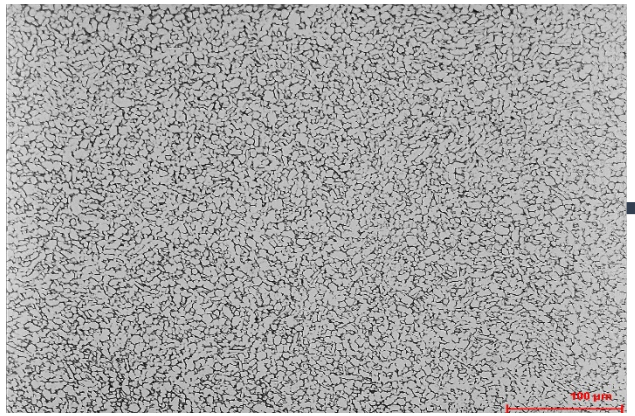
TMC Technology Principle

Challenge lies in **homogenic** and **seamless connection** of both materials

Si-C - Fiber

Diameter	140 µm
Density	2.9 g/cm³
Tensile Strength	4000 MPa
Stiffness/E-Mod.	380 GPa
Elongation	1.2 %

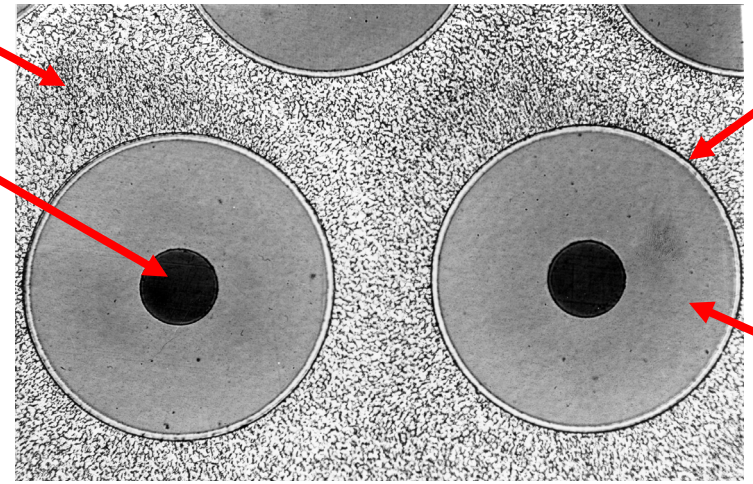




Ti-Alloy

Density	4.5 g/cm³
Tensile Strength	1200 MPa
Stiffness/E-Mod.	110 GPa
Elongation	10 - 20 %

TMC

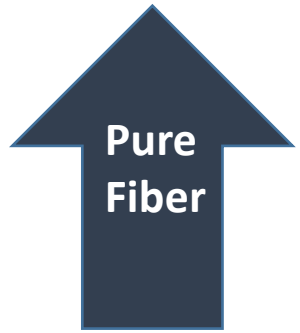


Characteristics	TMC	Tempered Steel	Ti Alloy
Density (in g/cm³)	4	7,8	4,5
Strength (in MPa)	2200	1700	1200
Strength at 600°C (in MPa)	1400	800	650
Stiffness (in GPa)	210	190	110
Elongation (in %)	1,3	6	15
Thermal Expansion (in K^{-1})	5 x 10-6	12 x 10-6	8,5 x 10-6

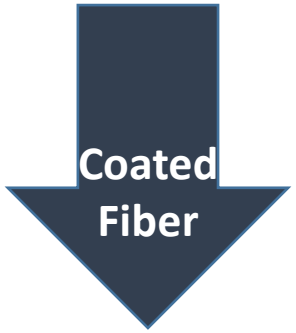
Alternative Manufacturing Processes

No real technological **alternative** available **beyond** the **Magnetron Sputter** Process

- **Foil – Fiber - Foil Technology**
- **Tape-Cast Process**
- **Plasma Flame Spraying**



- **Electrolytic Coating**



Mature Manufacturing Process

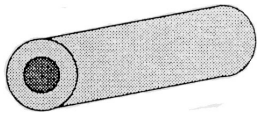
- **Electron Beam Deposition**
- **Cathodic Vaporization (Magnetron Sputter Process)**

Magnetron Sputtering Processes

No limitations with respect to metal matrix used

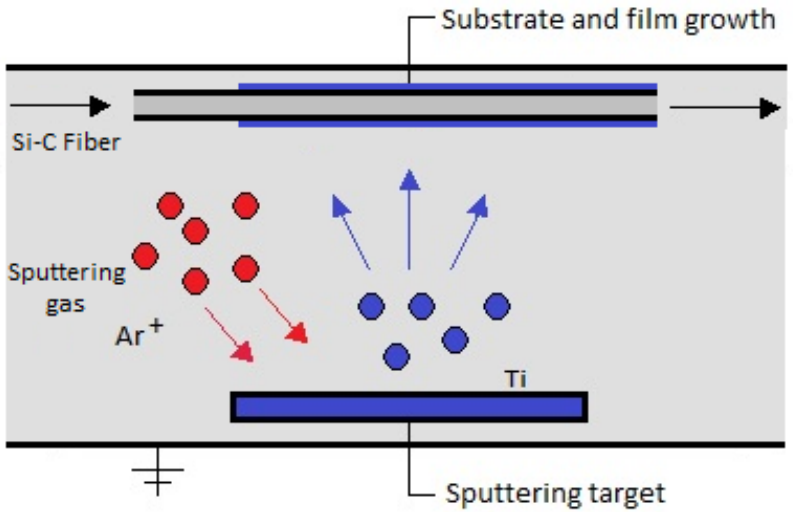
Magnetron Sputter Process

Sourcing

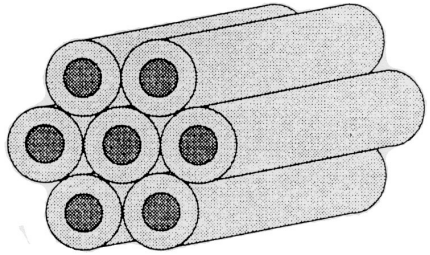


Endless Fiber

Fiber Coating

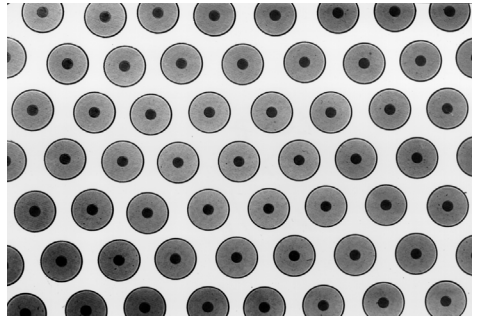


Trimming & Bundling



Cut to length / Coil

Hot Isostatic Pressing



Advantages:

+ Fiber distance distribution
+ Material properties
+ Reproducibility
+ Different metal matrix composites possible
+ Homogenity

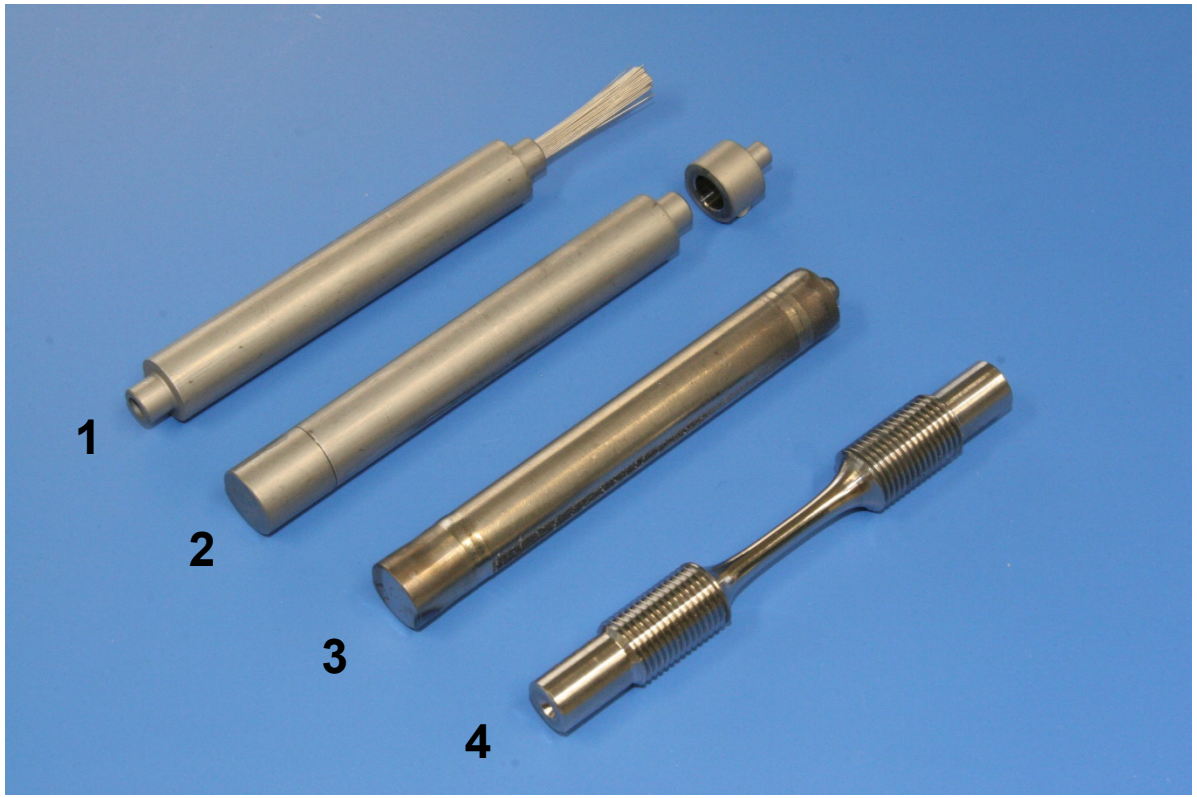
Disadvantages:

- Dimensional limitations
- Manufacturing Costs

Step-by-Step Process View

Fiber to be positioned in direction of loading

Example: Connecting Rod



1. Bundle of coated fibers to be filled into especially designed component (lengthwise / spooled depending on direction of load)
2. Closing of component with end caps and vacuum welding
3. Hot isostatic pressing to achieve seamless material connection
4. Machining of component to finalize shaping and address surface requirements

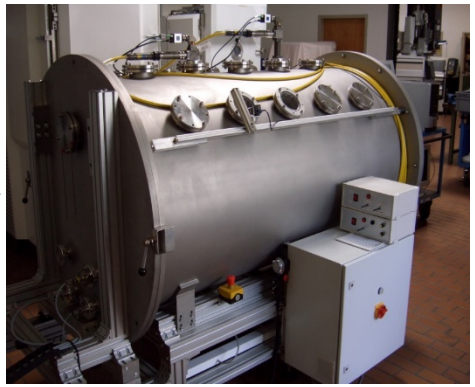
Technical Equipment required

3D Printing provides new design and application option

3D Metal Printing

Fiber Coating

Metal Machining



Vacuum Laser Weder

Hot Isostatic Press (HIP)

Final Machining

Markets

KTW Technology
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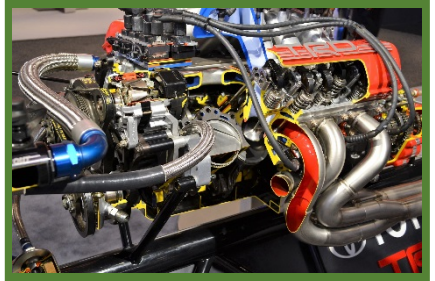
TMC is suitable for different markets

AVIATION

SPACE TRAVEL

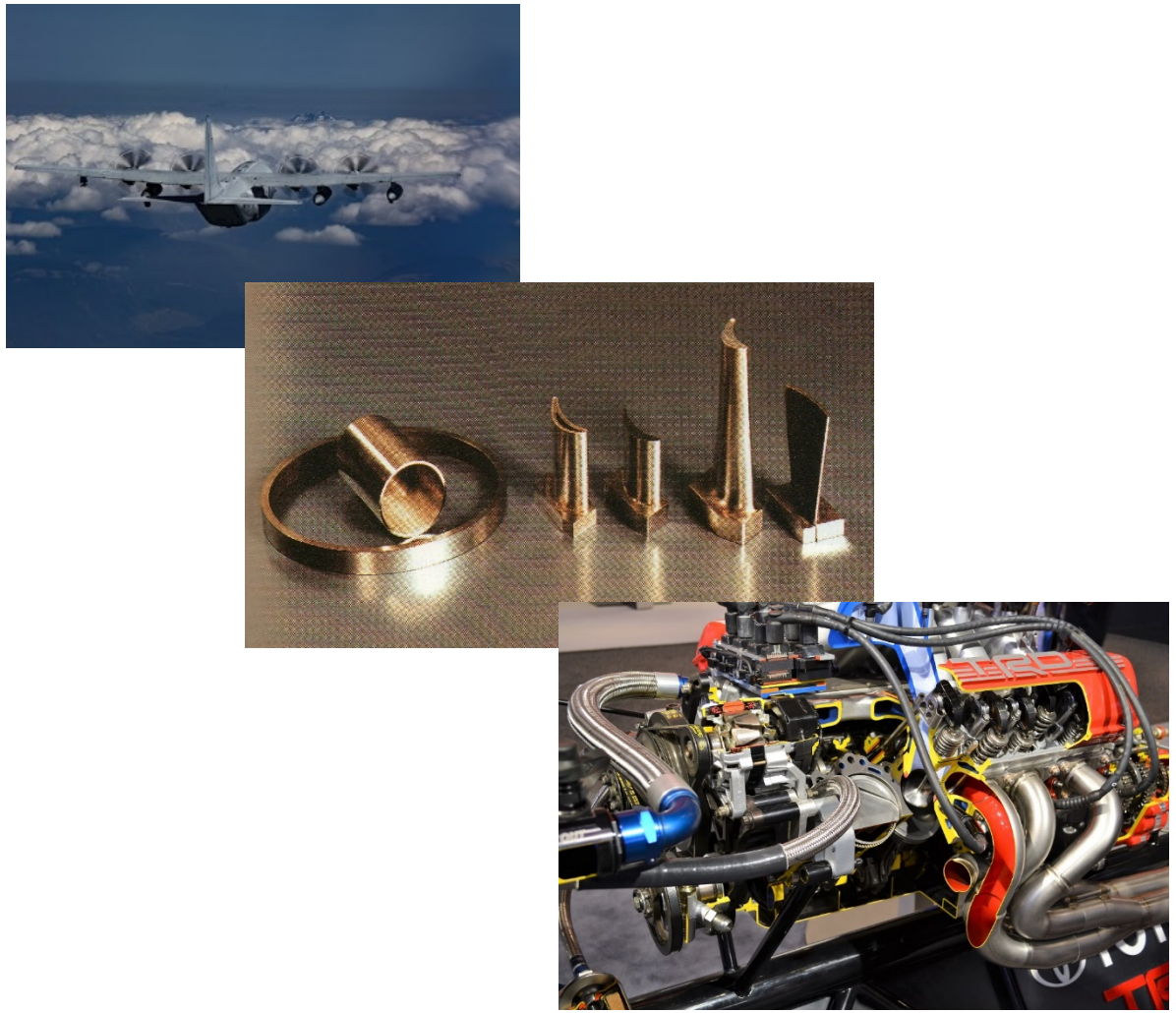


RACING

MED TECH

High-performance Engine Parts

Typical applications - highly stressed engine components



TMC adopted mainly in Engine Technology (Aviation / Motor racing)

Performance more important then costs

Application examples:

- Turbine / Fan Blades (weight reduction -30%)
- Impeller Blade Wheel (weight red. -30%)
- Inlet/Outlet Valves (weight red. -15%)
- Connecting Rod (weight red. -10%)
- Stud Bolt (weight red. -40%)
- Piston Pin (weight red. -40%)
- Drive Shaft (weight red. -50%)

Built basis for success of TOYOTA Formula 1 engines (2002-2006), until F1 changed regulations

Medical Tech

The TMC advantages promises to be the perfect material for hip implants

Per anno 400.000 hip implant operations in Germany,
Worlwide Turnover of hip implants is approx. $20bn

Problem: the dwell time is limited to ~15 years inside the body

Solution: hip implants of TMC shall have a significant longer lifetime (we are in the research phase)

Idea: prostheses made of TMC under use of Ti-Alloy with medical approval

Advantage: further operative procedures are extremly reduced and relief of the health system

Orthopedic Implants

TMC based implants improve quality of life for patients

Materials used
- Titanium alloys (TiAl6V4, TiAl6Nb7 - forging alloy)
- CoCrMo forging alloys

Todays limitations
- risk of fatique fractures (titanium implants)
- Pure biocompatibility of steel
- Limited number of implant operations per joint

Implants typically replaced after 15 years

Costs per surgery in Germany (EUR 10.000 excl. material)

Advantages of TMC-based implants:
- Lifecycle extension of implant
- Replacement of steel implants
- Reduction of medical surgeries
- Improved quality of life

Hip Implants Market

STRIKER CORP.

Sell 650,000 hip implants and knee joints every year worldwide
Sales: $ 9.946 billion

DEPUY SYNTHES

Total revenue in 2015:
$ 9.3 billion

SMITH&NEPHEW

Total revenue in 2016:
$ 4.7 billion

ZIMMER BIOMET

Hip products sales in 2016: $ 1.868 billion

E-Drives for Regional Air Mobility

Expand use of E-Drives into Aerospace by increasing power density

- Worldwide more than 100 aerotaxi projects ongoing
- Piloted or autonomous
- Different principles: jet or helipcopter
- Weight, payload, drive power are critical

Today's limitations due to power density of available E-Drives (<10 kw/kg), doubling required as target performance

Use of innovative techniques and materials
- 3D prints, carbon fiber to reduce weight of components
- Limited esp. regarding high temperature applications

Advantages of TMC-based components:
- Reduced weight of heavy iron parts, esp. rotor / stator
- Increased performance (increased RPM)
- Reduced weight of safety shields etc.

Thank You & Get in Touch

KTW Technology GmbH
Gleeser Str. 14, 56653 Wehr
info@ktwsystems.de
+49 160 411 1100