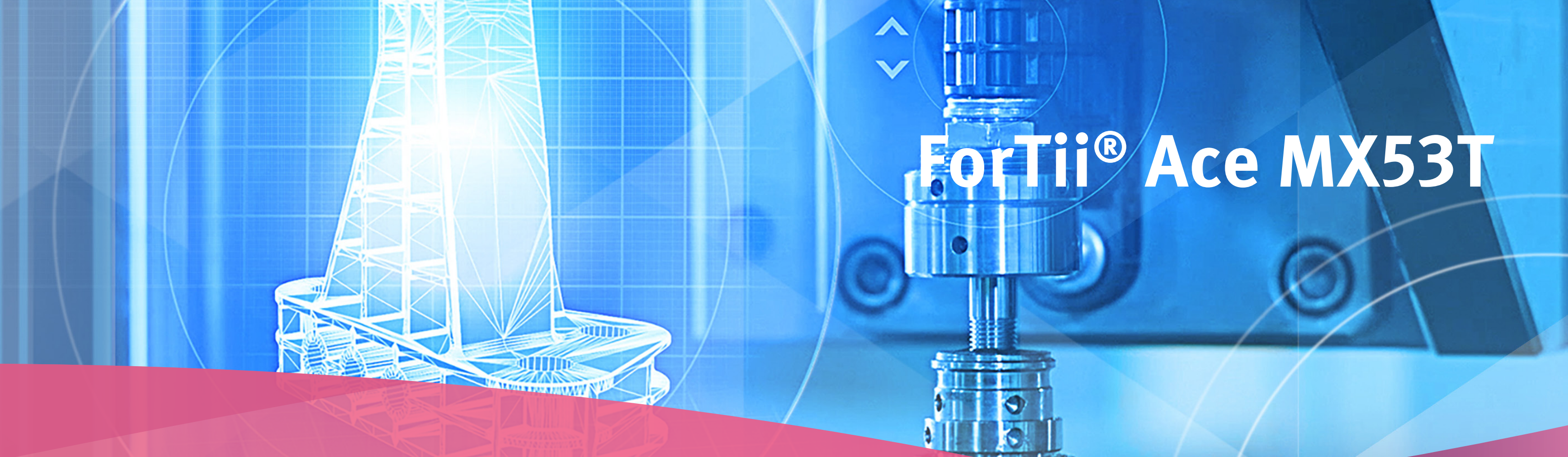

ForTii® Ace MX53T
reshapes the automotive industry – tested in the real world

Metals are replaced by engineering plastics for various reasons: light weighting, freedom of design, part integration, system cost reduction, NVH optimization and chemical resistance to various oils, fuels, road salt, coolants and battery acid. So far. Because the latest generation of engineering plastics is also as strong as metal. And even smarter.

At the same time component development requirements become more and more strict: shorter development cycles demand materials that are extensively tested in parts at relevant operating conditions, like a broad temperature range, high humidity and in aggressive environments. Materials need to come with extensive data packages to increase computer based predictability of part behavior and therefore reduce costly and timely iteration cycles during the design phase.

ForTii Ace MX53T a PPA (polyphthalamide) based on PA4T technology with a glass transition temperature (Tg) of 150°C. This enables an extreme robust part performance. ForTii Ace MX53T is the only PPA that can be used for metal replacement over a temperature range from -35°C up to 150°C and is tested in the real world.These facts distinguish ForTii Ace MX53T from conventional PPA. Component producers can design parts that have a wide temperature range or are in contact with relatively high humidity and require excellent chemical resistance. Extensive testing on parts prove that the intrinsic material properties can be transferred to the components under real conditions.

The result: **ForTii Ace MX53T** expands the use of PPA's in structural automotive parts to a broader operating temperature window, enabling the use of PPA's for load-bearing, structural parts in Automotive.

ForTii Ace MX53T Facts:

- Semi-aromatic polyamide, PPA (polyphthalamide), based on PA4T technology
- Glass transition temperature, Tg of 150°C
- GF50
- MX: metal replacement, such as aluminum die-cast parts; engine covers, EPS housing, sensor housings, brackets, engine mounts, transmission components, etc.
- Stable processing
  - Standard high glass fiber polyamide hardware
  - Venting of weldline areas required
  - Tool preferably ≥140°C

ForTii Ace MX53T Key benefits:

- Robust part performance (static load, burst pressure) from -35°C up to 150°C
- Excellent chemical resistance (road salt, acid, mineral oil, transmission oil, etc.)
- Enhanced surface quality (for sliding and sealing functionality)
- Robust during assembly, EaB of 2.5% (Dry as Moulded @23°C)

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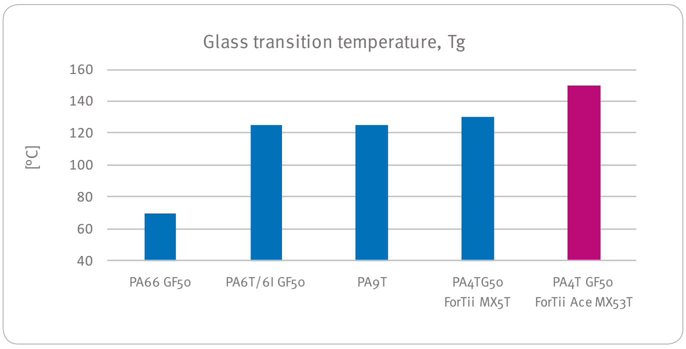
ForTii Ace MX53T – is outperforming existing solutions

Materials	Tg [°C]	Part strength -35 to 120°C	Part strength 120 to 150°C	Chemical resistance	Moisture absorption rate
PA66 GF50	70	+	0	0	0
PA66/6T GF50	75	+	0	0/+	0/+
6T/6I GF50	125	0/+	+	+	+
ForTii Ace MX53T	150	++	++	++	++

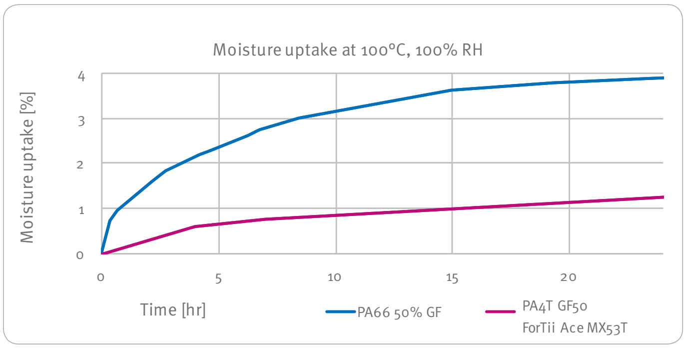
Vs. high performance PPA (PA6T/6I, Tg ~125°C):

- Up to 40% improved part performance (static strength until failure) at room temperature (RT) and at 120°C, resulting in a more robust solution, or the potential of further lightweighting (up to 30% less material)
- Improved chemical resistance, like: road salt, fuel, engine and transmission oil, water/glycol, etc.
- Enhanced surface quality (for sliding and sealing functionality)
- Higher glass transition temperature of 150°C vs 125°C for standard PPA's



Vs. PA66:

- Up to 40% improved part performance over the full temperature range 80-150°C
- Stable part performance up to 150°C
- Higher glass transition temperature of 150°C vs 70°C
- Increased HDT of 305°C@1,8MPa in comparison to 250°C@1,8MPa for PA66 GF50
- Enhanced chemical resistance vs road salt, oil, coolants, etc.
- Improved creep resistance at elevated temperatures, 4x lower creep at 120°C
- Reduced moisture absorption rate



ForTii Ace MX53T shows lower and slower moisture absorption vs PA66 GF50, when exposed to humid environments. At 100°C and 100% RH (Relative Humidity), PA66 GF50 shows a moisture absorption of 4,4% at equilibrium versus 2,7% for ForTii Ace MX53T.

The combination of higher Tg and slower moisture absorption qualifies ForTii Ace MX53T for structural parts that need a stable mechanical performance up to 150°C @DAM or up to 80°C @95%RH.

Part testing

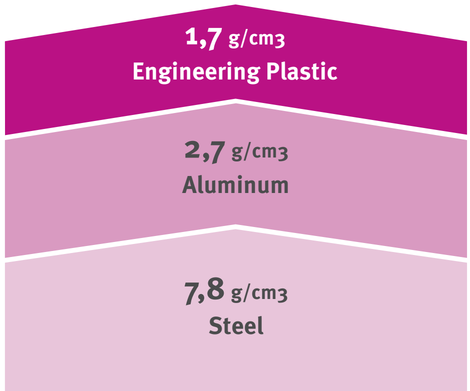
ForTii Ace MX53T retains part strength at higher temperatures. At lower temperatures, ForTii Ace MX53T outperforms other PPA’s. This effect is proven by extensive parts testing. **ForTii Ace MX53T comes with a comprehensive set of material data / support** needed by engineers to reliably construct plastic parts:

- Anisotropic stress-strain data taking into account fiber orientation effects
- Temperature dependence of mechanical properties
- Effect of humidity on mechanical properties
- Long-term material data (creep, fatigue, aging in different media)
- CAE-support
- Support of molding trials

ForTii Ace MX53T – is outperforming existing solutions

Pole position for engineering plastic vs. aluminum and steel

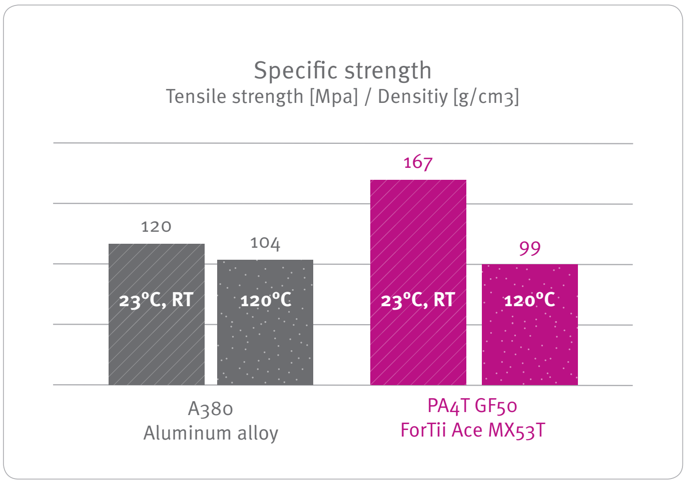
Over the past few decades car weight has been on the increase with the addition of safety and infotainment systems. The drive to further reduce CO_2 emissions and introduce new energy vehicles (alternative powertrains) calls for lightweighting solutions.
Shifting from steel to aluminum gives a relative weight advantage of a factor 1/3. Aluminum die-casting parts are nowadays an established solution in the automotive industry. **Further weight reduction of up to 50%**, compared to aluminum die-cast parts, can be achieved with engineering plastics. Many engineering plastics found their way into the automotive industry. Nowadays, up to 10,000 parts out of 30,000 parts are made from engineering plastics.



	Aluminum alloy A380 (die-casting)	Engineering Plastic (injection moulding)
Process	• Die casting • Relative high operating temperatures	• Injection moulding • High production efficiency, high volume mass production • Lower operating temperatures
Part	• Accurate dimensional tolerances • Casting close to net shape • Perceived higher quality part	• 50% weight reduction • 10-30% cost reduction • Design freedom, thinner ribs, more complex structures • Linear performance up to 120-150°C • High safety margin
Additional advantageous	• No metal inserts • Easy recycling • Thermal conductivity • Linear part performance up to 200°C	• Similar specific strength as alu die-cast @120°C • Linear part performance up to 150°C • High damping performance (NVH) • Corrosion resistant (road salt, coolants, battery acid, oil, etc.)

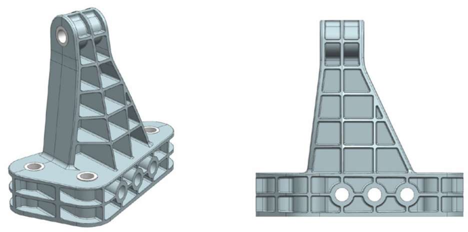
ForTii Ace MX53T is a high performance engineering plastic with a material profile that comes close to the linear performance of aluminum. It does not suffer from significant stiffness and strength reductions up to 150°C, nor does it suffer from aggressive environments (road salt, transmission oil, etc.).

The glass transition temperature, Tg, indicates the reversible transition from a hard, glassy state into a more soft, rubbery state, and is used as indicative parameter to illustrate the point where a significant reduction of strength and stiffness of the polymer can be observed. The high Tg of ForTii Ace MX53T allows for a more 'metal-like' design approach up to 150°C.

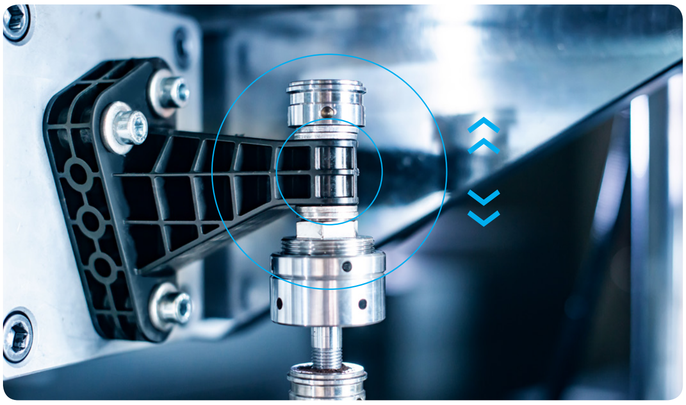


Enhanced part performance of ForTii Ace MX53T: illustrated on the load bracket demonstrator

Illustrated on a load bracket demonstrator (maximum load until failure): The enhanced part performance of ForTii Ace MX53T, up to 150°C. The load bracket demonstrator includes multiple ribs and weldlines.



ForTii Ace MX53T Load bracket demonstrator



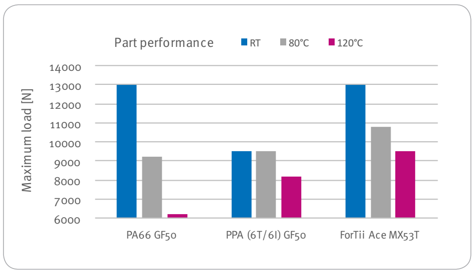
Besides the mechanical performance and resistance vs environmental influences, Noise Vibration and Harshness (NVH) has become an important Critical To Quality (CTQ) of structural parts in the automotive industry. The Noise Vibration and Harshness (NVH) performance is influenced, among other things, by the design and material properties, like damping and stiffness. These include damping and stiffness. The combination of high damping and high partial stiffness determines the NVH performance.

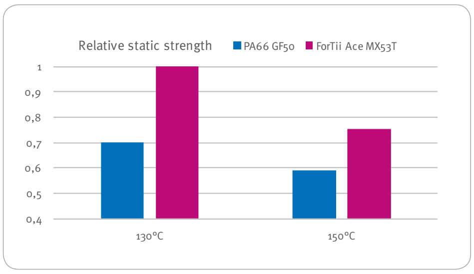
Vs. aluminum:

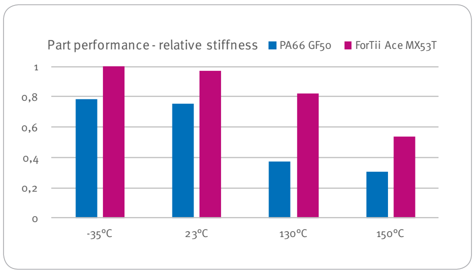
The intrinsic damping characteristic of an engineering plastic can be of a magnitude higher vs aluminum, yet the material stiffness is lower.

Vs. PA66:

The component stiffness can increase by a factor of 2-3x, with ForTii PA4T, vs PA66 over a temperature range from -35°C up to 150°C







About the technology

ForTii Ace MX53T is part of the DSM ForTii metal replacement portfolio (MX) and allows you to design and realize parts without loss of performance from -35°C up to 150°C @DAM or 80°C @95% RH. The Tg of 150°C provides additional safety margin. This technology is perfectly tailored to automotive applications, such as enclosures (EPS, actuators, sensors), brackets, covers, fuel pumps, and connectors.

Concentric slave cylinder

Sensor housing

ForTii Ace MX53T examples automotive components

ForTii Ace MX53T – innovative solution for load-bearing constructions

If you would like to know how ForTii Ace MX53T could help you innovatively realize load-bearing constructions – in terms of performance, cost and sustainability – contact us today: **dsm.com/contactdep**

www.fortii.com