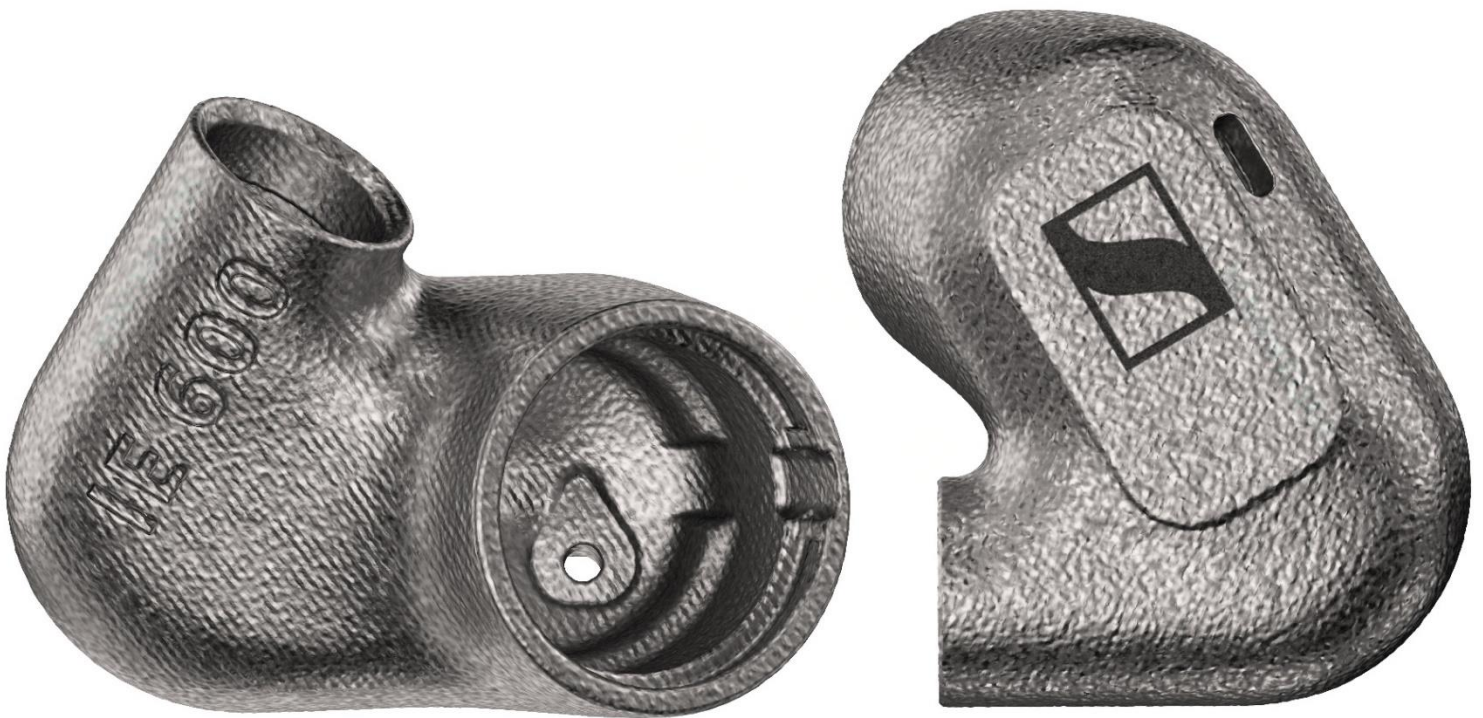


Case Study

SENNHEISER IE 600 – AMORPHOUS ALLOY HEADPHONE HOUSING FOR ETERNITY

INCREDIBLE AESTHETICS, UNIQUE ROBUSTNESS AND
METICULOUS CRAFTSMANSHIP



ABOUT SENNHEISER

We live and breathe audio. We are driven by the passion to create audio solutions that make a difference.

**SENNHEISER**

Building the future of audio and bringing remarkable sound experiences to our customers – this is what the Sennheiser brand has represented for more than 75 years.

While professional audio solutions such as microphones, meeting solutions, streaming technologies and monitoring systems are part of the business of Sennheiser electronic GmbH & Co. KG, the business with consumer devices such as headphones, soundbars and speech-enhanced hearables is operated by Sonova Holding AG under the license of Sennheiser.

www.sennheiser.com

www.sennheiser-hearing.com

CUSTOMER SPECIFIC APPLICATION CHALLENGES

Sennheiser stands for a world of audio that is second to none. The basis for these exceptional sounds and frequencies is, of course, the sophisticated high-end technology that makes this unique sound experience possible. Sennheiser products also impress with their unique standards of durability and quality. To meet this demand, the in-ear headphones from Sennheiser have been convincing for some time with exceptional materials, qualities and an appealing look.

So, it was also clear for the next generation that, in addition to the aforementioned longevity and durability, the continuation of the uniqueness of Sennheiser products had to be considered in every detail. This is exactly where the collaboration between Sennheiser and Heraeus AMLOY began, with the aim of bringing to market an outstanding product that fits into an outstanding product range using a new, exceptional class of material and a manufacturing process that is unparalleled in its precision and uniqueness.

**Durability****Longevity****Haptics****Optics****Uniqueness****Accuracy
& Quality**

SOLUTION: 3D PRINTING WITH NEXTGEN MATERIAL

The portfolio of requirements for the next generation of Sennheiser in-ear headphones was therefore, as described, more than demanding. Simultaneously producing long-lasting durability, preventing abrasion, wear and even corrosive phenomena, anchoring a uniqueness in material, product and manufacturing, and ultimately meeting the high-quality standards Sennheiser stands for, was the bar set for Heraeus AMLOY.

However, the iterative path to the final solution was not long in coming. The entire portfolio of requirements was covered by the exceptional material class of amorphous alloys. Through close coordination in the product development iterations with Sennheiser, the material and process know-how contributed by Heraeus AMLOY even enabled the range of requirements to be exceeded. The amorphous metallic structure offers all the qualitative advantages demanded by the so-called shock-frozen manufacturing process, in which the atoms have no chance to form a crystalline structure as in conventional metals. The result of the manufacturing process is a shiny, satin finish that is exceptionally resistant to corrosion and scratching and guarantees long-lasting enjoyment of the product. The material's high hardness and strength, as well as its high resistance to corrosion, leave no traces in the form of scratches or wear, even with daily use.



Figure 1: Powder bed fusion with amorphous metal powder



Figure 2: Automated series process in 3D printing via selective laser melting for the production of IE 600 housings

The housing of the IE 600 is manufactured using a 3D printing process based on metal powder, which allows any desired shape within tight tolerances. Chambers and channels are created without CNC post-processing as part of this additive manufacturing process. From the beginning of the collaboration, it was clear that Sennheiser's high quality requirements would shape the subsequent production process. The process includes both automated and manual steps, so that each headphone housing is unique in its depth of production. In the automated printing process, a computer-controlled laser melts one thin layer of AMLOY-ZR01 powder on top of the other, bonding the molten alloy to the already hardened material underneath. Layer by layer, the component thus builds up to its final shape. All residues from the manufacturing process are then removed, followed by thorough cleaning to achieve unparalleled surface cleanliness and quality. The surface is then blasted, polished, and after further surface treatment, the

housing is given its final, extremely durable aesthetic, which in turn ideally matches the high-performance requirements of the Sennheiser product range.

RESULT: ULTRA-HIGH PRECISION AND ROBUSTNESS

The handmade amorphous metal housing with the unique appearance fits ideally into the Sennheiser audiophile in-ear range and impresses in the sum of the application properties as manufactured. While the robustness and durability of the amorphous housing stands out due to its mechanical strength, absolute hardness, and chemical performance in the field of corrosion resistance, the high wearing comfort due to the low thermal conductivity as well as the optical and haptic surface qualities round off the result to a high-end product.

The specific value chain of the 3D printed series process has also proven that the material expertise of Heraeus AMLOY on the one hand and the innovative technology enthusiasm of Sennheiser on the other hand can lead to detailed shape perfection in scalable high output with reproducible quality, in a technological manufacturing process that was initially designed for prototyping or smaller product volumes. This is another milestone that shows that additive manufacturing will continue to play a central role in the manufacturing of amorphous components in the future, where limitations in terms of size, structure and, above all, performance will be redefined by the new commercially reliable class of materials.

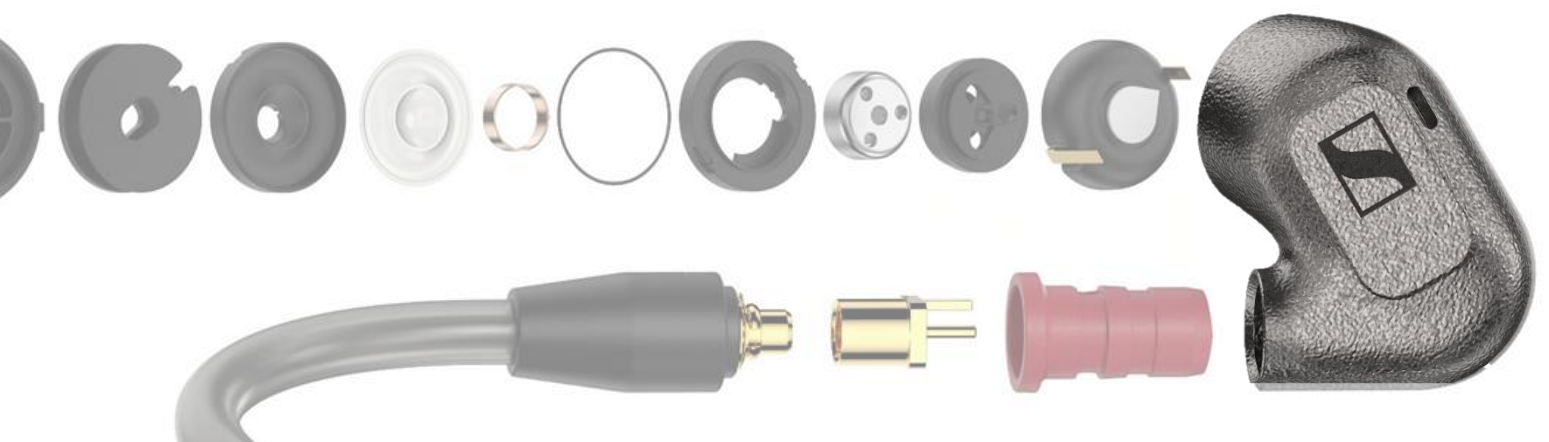
The proclaimed goal has therefore been achieved. Sennheiser's high-end sound technology is securely housed in a tough shell that resists all signs of corrosion and wear and allows the end customer to do the essential: **Enjoy the product for decades.**



Figure 3: Meticulous craftsmanship for the realization of high quality standards and to ensure lasting product performance

” **Amorphous alloys are an extraordinary new class of materials. Our high-tech AMLOY-ZR01 is used in components for aerospace and MedTech applications that require ultra-high precision and robustness. We are proud that Sennheiser evaluated our space-grade amorphous alloy and decided to use it for the IE 600.**

– Jürgen Wachter, Global Head of Heraeus AMLOY Technologies GmbH



OUTLOOK

The collaborative path from the first samples through quality standards and validation iterations to the final state-of-the-art manufacturing process in additive series production of the amorphous IE 600 metal housing marks an outstanding progress in enabling users and manufacturers to overcome limitations in component performance, to incorporate technology openness into value chains in a targeted manner and to realize products that even exceed market requirement portfolios. In the case study outlined, the use of amorphous alloys in 3D printing fulfilled all these conditions for a unique product and also established the field for further applications.

Due to the reproducible quality as well as the definable postprocessing of surfaces, it is also possible to map further segments and applications in the lifestyle sector with similar manufacturing depth. Considering the high requirements in the wearables industry for bracelets, hinges and housings, the use of amorphous alloys in 3D printing opens up many potential applications. Watchmaking with regard to bezels, bracelet pins, clasps, housings or shock-absorbing safety elements also opens up new possibilities in which amorphous alloys can become future components.

Now it's up to you to embrace this empowerment and join us in realizing the possibilities of amorphous alloy technologies.



Many thanks to the entire team at Heraeus AMLOY. Your dedication made it possible to create a unique product according to Sennheiser standards. It was a very pleasant and smooth development project, which excitingly appealed to the technical affinity of all involved due to the uniqueness of the material and variety of possible future applications.”

– Jermo Köhnke, Product Manager at Sennheiser

START YOUR AMORPHOUS JOURNEY NOW

About Heraeus

Heraeus, the technology group headquartered in Hanau, Germany, is a leading international family-owned portfolio company. The company's roots go back to a family pharmacy started in 1660. Today, the Heraeus group includes businesses in the environmental, electronics, health and industrial applications sectors. Customers benefit from innovative technologies and solutions based on broad materials expertise and technological leadership.

In the 2020 financial year, the FORTUNE Global 500 listed group generated revenues of €31.5 billion with approximately 14,800 employees in 40 countries. Heraeus is one of the top 10 family-owned companies in Germany and holds a leading position in its global markets.

About Heraeus AMLOY

Heraeus AMLOY specializes in the development of amorphous alloys and the production of amorphous components. These enable completely new high-tech applications due to their unique material properties such as high strength combined with high elasticity as well as corrosion resistance and biocompatibility.

Heraeus AMLOY's near-net-shape process solutions injection molding and 3D printing are ideally suited for industrial production

amloy@heraeus.com | +49 6181 35-9650 | www.heraeus-amloy.com

