Phonak Insight

High-tech Ceramic

Innovation in hearing aid housing technology

Introduction

Hearing aid technology has undergone significant progress over the past decades. Major milestones were the transition from analog to digital hearing aids in the mid-nineties, frequency compression algorithms and lately binaural directional features that build on real-time full audio transmission between hearing instruments. At the same time, the design of hearing aid housings has advanced by making hearing aids smaller, less visible and more ergonomic and by offering more color choices, hence supporting a variety of hearing aid user lifestyles.

Users have therefore been able to profit from better hearing performance as well as esthetics. Nevertheless, there was still room for improvement when it comes to the wearing comfort of hearing instruments and the long-lasting appeal of their housings (Kochkin, 2010).

With the introduction of high-tech ceramics for housings, Phonak leads the field in addressing the end-users' increasing demand for high-value, more durable, comfortable and cosmetically appealing hearing aids.

High-tech ceramic applications today

Advances in materials engineering and processing technologies have led to the use of high-tech ceramics in a variety of industries. Whereas in many applications high-tech ceramics are not necessarily visible nor particularly well-known to the consumer, today's exceedingly technological world clearly could not function without them anymore. Properties such as extreme hardness and high mechanical strength, outstanding biocompatibility and esthetic appeal, light weight as well as chemical inertness make high-tech ceramics indispensable for numerous applications. The fields of medical technology, luxury consumer goods and aerospace (to mention just a few) utilize the unique and manifold advantages of this branch of materials.

The watch industry for example uses high-tech ceramics due to their scratch-proof quality and high wearing comfort. Watches made from high-tech ceramics look as good as new even after an extended period of wearing time. Ceramic tooth restorations provide a beautifully natural look and are highly wear resistant. Chefs and amateur cooks use ceramic knives for their light weight, long-lasting sharpness and their resistance against bacteria, kitchen acids and salts. This resistance also ensures the material stays rust-proof. High-tech ceramics even protect space shuttles against extreme friction heat at their re-entry into the atmosphere after a mission.

Straumann® CARES® abutment, ceramic (on Straumann® Bone Level Implant)
© 2010 by Institut Straumann AG

Ceramic knives
© 2010 by Kyocera Corporation

High-tech ceramic hearing aids

Appealing cosmetics, high durability and utmost wearing comfort are the key user needs that high-tech ceramic hearing aids meet. High-tech ceramic housings have a high-value, high-tech and esthetic appeal due to the polished surface and their deep color. The slightly greater weight compared

PHONAK life is on

to polymer housings supports a high-value feel. The material's extreme hardness makes the housings scratch-resistant, and together with excellent chemical and biological inertness as well as UV resistance, high-tech ceramic allows this appeal to last for a long time. Lotions, sweat and other daily environmental influences will not alter it. The biological resistance also makes ceramic hearing instruments very hygienic.

Audéo S SMART High-tech Ceramic

The material's tactility, the extent of its thermal conductivity and excellent biocompatibility give ceramic hearing instruments high wearing comfort. Additionally, ceramic housings are smooth to the touch and quickly reach and maintain body temperature. This reduces perspiration behind the ear. Outstanding hypoallergenic properties make the material especially kind to skin. Overall, these qualities provide a natural and comfortable feel.

Ceramic housings can also be used in hearing instruments with wireless communication. The acoustic performance is equal to that of conventional hearing aids with polymer housings.

Materials used and processing technologies

Materials

Ceramics are non-metallic, inorganic materials. Today, we clearly distinguish high-tech ceramics used for the previously mentioned applications from porcelain, ceramic decorative objects or the pottery people made of clay already thousands of years ago. Widely used high-tech ceramics are Alumina (Al_2O_3; Aluminum oxide), Zirconia (ZrO_2; Zirconium dioxide), Silicium nitride (Si_3N_4) and Silicium carbide (SiC). Of course there are many more ceramic compounds as well as a diversity of ceramic composites, which make use of the combined properties of two or more different materials (e.g. ceramics and metals). The following section describes Zirconia, the high-tech ceramic used for Phonak's new ceramic hearing instrument housing, in more detail.

Zirconia, the oxide of the metal Zirconium, is well known for its outstanding biocompatibility, resistance against corrosion, extremely high mechanical strength and very good tribological properties (such as wear resistance). Its hardness is much higher than steel and titanium. For various applications, so-called Yttria-stablized Zirconia (YSZ) is used, which offers enhanced fracture toughness compared to pure Zirconia. The stabilization of the material is achieved by a mechanism that is based on a stress-induced change of its crystalline structure: when a component made of YSZ is hit (e.g. when dropped), micro cracks may form in the material. Triggered by the mechanical stress that is caused by the shock, crystals in the area of the cracks' tips will change their structure, thereby extending their volume. This results in the compression of the cracks, which will prevent or at least halt the advancement of micro cracks in the material. Accordingly, significantly enhanced lifetime and reliability of the component can be achieved with YSZ compared to regular Zirconia.

Processing

a) Preparation of raw material and forming process

The fabrication of any high-tech ceramic component starts with the raw material: by means of mixing, milling and filtering, a homogenous mass of the desired particle size, chemistry and color (pure Zirconia is white) is produced. Various additives serve as auxiliary materials for the further processing.

Ceramic powder

The raw material "feedstock" then undergoes the forming process in which the shape of the technical component is defined. Among the common forming methods, injection-molding allows for comparatively complex geometries. This is used with the Phonak Audéo S SMART ceramic hearing aid housing. For this purpose, the feedstock is fed into an injection molding machine where it is heated. The applied heat turns the feedstock into a viscous mass that can be injected into the mold under high pressure. Injection pressure, the recipe and share of weight of the additives, heat

distribution in the mold and several other parameters play a crucial role in achieving the defined dimensions and mechanical properties of the product.

b) Sintering and polishing

During the subsequent sintering (firing) at temperatures beyond 1000°C/1832°F, a controlled process that lasts from several hours up to days, the ceramic particles grow together and a high theoretical density (i.e. low porosity) is achieved. The component accordingly undergoes a shrinkage of 20-30% during the sintering process. This shrinkage must be taken into consideration in advance when designing the injection mold and poses major challenges when it comes to avoiding cracks in and surface defects on the component. Above all, sintering is the essential step allowing for the ceramic component's material properties like high mechanical strength, wear resistance and chemical resistance. After sintering, a grinding or polishing process might be required to make the surface smooth and glossy, depending on the application. Meticulous inspection of the component is crucial to ensure that the final product meets the requirements in terms of dimensions, functionality, physical properties and cosmetic appearance.

c) Coating

Ceramics are naturally hydrophilic, meaning that they quickly distribute any water drops or moisture on their surface. Audéo S SMART's high-tech ceramic housing is therefore coated with a special invisible, hydrophobic (water-repellent), wear-resistant coating that was developed specifically to combat this. The coating makes the finished product highly resistant against moisture.

Summary

Significant improvements in hearing instrument technology have revolutionized the world for hearing aid wearers in the past decades. Innovations have been made in numerous performance areas, for example for better speech understanding in noise and intelligent user control options. Hearing instruments have also become smaller, more ergonomic and more stylish.

High-tech ceramics are used in a wide range of industries for their excellent physical and chemical properties. The combination of high hardness, chemical and biological resistance with high-value, esthetic appeal makes them also highly suitable for the use in hearing instrument housings. High-tech ceramic hearing aids provide a long-lasting scratch-free shine and a high wearing comfort to the user.

With the use of high-tech ceramic materials, Phonak introduces a significant innovation in hearing instrument housing technology by bringing together the world of high-end consumer goods and the technological world of materials science.

Reference

Kochkin Sergei (2010) MarkeTrak VIII: Consumer satisfaction with hearing aids is slowly increasing. The Hearing Journal Vol. 63, No. 1: 19-27.