From High-End Watch Components to Surgical Implants: a Continuous Passion for Efficiency

With over 100 years of experience, Ceramaret has built a solid reputation for the reliability and quality of both its ceramic parts manufacturing and the service it provides. Their customers can rely on a solid engineering team to support and guide their designers at the very earliest stages of new ceramic projects. The time to market can be significantly reduced if the first prototypes are functional and do not require multiple iterations before the final design is reached.

Fig. 1
Complex-shaped dental implant abutments

One of the broadest definitions classifies ceramic materials as all solids that are neither metallic nor organic. Advanced structural ceramic components are manufactured using powder technology. The raw material is a nanopowder, which can be formed through methods such as dry pressing, extrusion or injection moulding. Shaping is followed by a standard heat treatment phase which transforms the part from a pressed powder compact to a solid bulk material. The heat treatment will sinter the part so that the particles grow into grains, thereby creating a bulk material.

The ultimate objective is to complete as much as of the design as possible at the forming stage and thus avoid or reduce post firing machining operations. Ceramaret has extensive experience in dry pressing of zirconia, alumina and silicon carbide components. This know-how is based on tool design and a deep understanding of pressing parameters. The ability to predict anisotropic shrinkage and crack formation, and porosity control, requires a combination of skills that Ceramaret has been developing for many years, and which now form a solid basis for its ceramic manufacture.

Keywords
high-precision advanced ceramic parts, injection moulding, nanopowders, zirconia, alumina, silicon carbide, silicon nitride

Injection moulding

Uniaxial pressing is probably the most cost efficient manufacturing process in the ceramic industry. Some component designs require several post-processing operations if manufactured from pressed blanks. Injection moulding is different in that complicated designs can be manufactured in near net shape. Long and expensive machining operations can be avoided, as the design is

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Fig. 2
Precision watch parts with high surface finish and esthetic requirements

Fig. 3
State-of-the-art metrology equipment, a high accuracy multisensor measurement system

moulded directly. Due to the high costs of mould manufacturing, injection moulding is a profitable option for large production runs. Injection moulding at Ceramaret has undergone significant developments in the last three years. Major milestones were achieved last year with the reinforcement of the injection moulding department and an increase in production through the use of this particular manufacturing process.
Alumina, zirconia and silicon nitride are the materials that can be offered on a standard manufacturing basis. Composites such as ATZ, as well as other non-oxide ceramics, could be considered depending on the application and quantities. Ceramaret is capable of developing custom feedstock for injection moulding for cutting-edge applications.

Dental Implants

Research suggests that about 98 % of dental implants are made from titanium. The remaining 2 % are ceramic, more precisely zirconium oxide stabilized with yttrium oxide. Back in the 60's, some alumina implants were produced, but their use was discontinued mainly because of the poor mechanical resistance offered by this material.
In the last ten years, several companies have launched research programs to develop implants made from zirconium oxide. Zirconium oxide is known to offer great stability and biocompatibility. The surface can be functionalised to facilitate osteointegration and its mechanical properties are not critical to this application. Indeed, if the implant design respects the fundamental rules of ceramic requirements and manufacturing is performed diligently, the mechanical resistance of the implant exceeds the requirements for dental applications.
Most patients will choose zirconium oxide for aesthetic reasons if they are offered a choice. There is a new group of patients who are obliged to remove their metal implant and replace it with a ceramic one. Some metal implants release elements into the bone structure which can damage the bone and affect the stability of the implant.
Ceramaret has the required skills to manufacture reliable and cost effective zirconia dental implants. The challenges here are the capacity to manufacture an accurate design with a very specific surface roughness without damaging the phase structure of the material or creating microcracks which can significantly weaken the implant.

High-end watches

It is no secret that precision and aesthetics are key factors for manufacturers of mechanical high end watches. Ceramaret is proud to manufacture components that can be found in the world's most prestigious watches. This success is the result of tremendous efforts to ensure quality and precision on an industrial level. It requires discipline, rigor and passion to manufacture tens of thousands of components with tolerances of a few microns, and functional surfaces finished up to 5 nm of roughness.
The experience gained while serving the watch industry for decades has an influence on global manufacturing, in that every component produced receives the same level of rigor and care.
Other markets, such as implants or components for medical instruments, have different specifications but require equal diligence to manufacture.

Beyond oxide ceramics

After developing a manufacturing route for silicon carbide pistons a few years ago, Ceramaret launched a project to manufacture silicon nitride components. For specific applications where zirconium oxide is too heavy or aluminium oxide is too fragile, non-oxide ceramics such as silicon nitride or silicon carbide appear to be the most appropriate alternative. Silicon nitride is a very lightweight material with mechanical properties similar to zirconium oxide, and is very reliable at very high temperatures (1600 °C in an inert atmosphere). It is a perfect candidate for high temperature applications, particularly because silicon nitride has a very low thermal expansion coefficient, and is therefore highly resistant to thermal shocks.

Silicon nitride shows exceptional tribological behaviour, in terms of friction and wear resistance. This, along with its low density, makes silicon nitride perfect for sliding parts used in the automotive industry.

Silicon carbide is an exceptionally hard yet lightweight material. One of its key properties is high thermal conductivity. This makes it perfect for parts which need to withstand high levels of wear whilst simultaneously evacuating the heat generated by friction.

Lean manufacturing

All processes at Ceramaret are lean oriented, favouring fluidity, flexibility and agility in both manufacturing and management. Review of the quotation reduces the time-to-response to an average of five days. A visual and dynamic overview of the global manufacturing process guarantees a daily performance rate and leads to continuous improvement. The teams communicate on a daily basis to share and discuss the indicators and other topics related to their work. Irregularities are efficiently tracked and teams can anticipate and take actions in good time. Employees are encouraged to share their ideas and take ownership of the innovation and development process at Ceramaret. Through short actions, several improvements have been implemented with a major effect on the consolidation of the production process.

Ceramaret's lean manufacturing and management is another success in the quest to best meet customers' needs and requirements, working in tandem with the ISO-9001, ISO-14001, ISO 13485 and OHSAS-18001 certifications.

Fig. 4
Extraction of an injection-moulded part