Watch and learn

There are few sectors where academia and industry work so effectively in unison – horology is one. **Ledetta Asfa-Wossen** caught up with innovation and development expert **Senad Hasanovic*** at Ceramaret, Switzerland, to talk about the changing face of watchmaking.

Ceramaret

Watchmaking is an intricate field, little known for its innovations, but manufacturers are now adopting increasingly sophisticated materials from the aerospace industry including advanced ceramics and some of the rarest metals on Earth.

Advanced ceramics have become an evermore critical part of watchmaking due to their high tolerance of extreme conditions such as severe changes in temperature, pressure, or corrosive environments. Particularly if these conditions present themselves at the same time, or over a prolonged period.

In 2017, engineers from the University of Manchester, UK, joined forces with Swiss watchmaker Richard Mille to develop a mechanical watch that is said to be the lightest in the world. Produced in collaboration with McLaren F1, the highly durable 40-gram watch features a case and strap made of a graphene-based composite called Graph TPT – that claims to be 200 times stronger than steel.

The university's involvement included evaluating the nanomaterial and helping with the fabrication of different components. Using X-ray computed tomography and Raman spectroscopy (read more on page 44) to study the material's mechanical properties, they found it had improved performance.

3D printing is another field where both academia and luxury watchmakers have worked closely to speed up the laborious prototyping process. The technique allows manufacturers to improve materials efficiency, design, and ergonomics by using direct metal laser sintering to build ultra-thin powdered metal forms layer-by-layer to create solid, complex metal parts.

Working with advanced ceramics

'The original use of ceramics in luxury products was for the hardness and scratch resistance. It was originally limited to a few brands – I would say watches with a price tag of under £5,341 and very high volumes,' explains Hasanovic.

'All these watches were previously made in black polished zirconia, with rounded edges and limited designs. The latest developments in ceramic manufacturing and machining has allowed designers to go a step further and achieve even sharper designs with various surface finishing techniques, such as sand blasting and polishing. These new possibilities have brought the ceramic up to a new level for products that cost over £89,025 because, besides the mechanical advantages, the material suddenly gained a very high perceived value after surface finishing, and started to compete with noble metallic alloys like gold and platinum,' he adds.

Then came another cycle of ceramics in the watch industry, based on colours, he explains. 'Several brands have put green, blue, brown, orange, and grey ceramic watch casings on the market but the difficulty here is to avoid the polymer-look of the ceramic. It's also very hard to maintain the stability in colour grade from batch-to-batch. In this branch of ceramics, you cannot have products with visible colour shade variations, especially if you have several components on the same watch. The fact that the colour is in the bulk material and not a coating is another important property of coloured ceramics. Coatings in luxury products are very dangerous, as soon as the coating starts to peel off or reveals the original colour under the coating, it immediately drops in value.'

Ceramaret are now working on manufacturing movement components in ceramics and Hasanovic sees silicon nitride as a strong candidate to enter into the micro-scale world of the watch engine.

'Silicon nitride is a very lightweight material with really interesting friction and wear properties, which can bring real value to the durability of a mechanical movement. So, why not increase power reserve by reducing the energy lost through friction? We look at ceramics for components where all other materials fail. Watchmakers understood the power of sapphire and ruby a long-time ago and are still using them because no better option exists currently. But watchmakers can now use ceramic components to directly replace metallic alloys that have reached their limits,' adds Hasanovic.

Engineering meets business

Originally a materials engineer from École Polytechnique Fédérale de Lausanne, Switzerland, having a business overview has given Hasanovic a distinct advantage in technology and materials development.

'Materials engineers are very often generalists with a broad spectrum of knowledge.

***Senad Hasanovic has worked in innovation and business development for ceramics specialists Ceramaret since 2015, following his role as Materials Engineer at Hublot Genève.**

Rare metals in watchmaking

Tantalum – A hard, corrosion resistant, greyish blue transition metal. Tantalum is more commonly found in electronic capacitators and high-stress applications and is mined in Australia, Central Africa, Brazil and Canada. Its immunity to body fluids also make it an ideal material for surgical devices.

Osmium – Known as the rarest and heaviest metal on Earth, osmium crystals have been used on the dials of luxury watches by Swiss watch manufacturer, Hublot. The precious metal is usually obtained from nickel refining waste. Powdered osmium gives off a pungent and distinct smell, hence its name from the Greek word meaning smell.

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When asked what the greatest materials development in watchmaking has been so far, Hasanovic adamantly says, "Magic Gold, of course."

I've worked with ceramics and concrete, studied the impact of sugar on cement, and worked on textiles for firefighters, to skin grafts, carbon-reinforced composites and super alloys for turbine blades. My role at Ceramaret now is to identify markets with strong growth potential and match that with the appropriate technology. The business side of the industry fills the need I have to see the bigger picture. For me, technology and market are inseparable.'

When asked what the greatest materials development in watchmaking has been so far, Hasanovic adamantly says, 'Magic Gold, of course'. A unique and proprietary material to Swiss watch manufacturer Hublot, the material is formed by fusing liquid gold with a porous ceramic substrate made of boron carbide – often used in military protection armour. Made of 750ppm pure gold, Magic Gold has a supreme scratch resistance of 1,000 Vickers compared to regular 18-carat gold at 400 Vickers. The material is cut into watchcases with diamonds because of its superior hardness.

Hasanovic was involved in the invention of the material, right through to the marketing of the product. The world's first 18-carat scratch proof gold alloy took two years to develop and is still the most significant materials development to come out of Hublot's experimental metallurgy department.

Challenging components

With Ceramaret, Hasanovic hopes to transfer the company's watchmaking competencies to even wider markets, beyond automotive and medical. The company currently manufactures ruby pallets and ellipses, producing custom ceramic jewel bearings made of alumina and zirconia and small precision ceramic parts.

'We have an innovative manufacturing process for ruby pallets. The surface roughness of our high-end components reaches a few nanometres and dimensions of about 200–300 micrometers. We have completely developed our technology, and even some of the equipment in-house, and use the expertise to manufacture other parts for different industries.'

But working with such small precision parts made of zirconia, ruby, alumina, and composites at this scale is not without its challenges.

'We mostly work with powder technology, shaping by dry pressing or injection moulding and then sintering the material to a polycrystalline bulk component. The difficulty is handling the sintering shrinkage, which can vary from 20–30 volume percent. The goal is to avoid any machining and stay in the near-net-shape process. You can imagine the immense challenge of manufacturing several hundred thousand watch components with dimensional tolerances of few tens-of-microns,' he concludes.