Master of disguise: The ubiquitous nature of glass

Glass is one of the most versatile materials ever mastered by humankind. It continuously re-invents itself, to remain a critical component of our everyday lives. Ever since bronze-age craftsmen began melting sand in the presence of hydroxide salts, the production and use of glassy materials has permeated through our society. Rather than being limited to the aesthetic, in the modern world, glass has found a remarkable array of uses, including telecommunications, energy production, construction and healthcare, amongst others. In certain ways it is mystical, and science has been slowly unlocking its secrets for many years. This article will explore some of the most important applications of glass today, and what the future may hold for this wonderful substance.

Connecting our world

High definition video and audio on demand; the ability to see and communicate with people half-way around the world in real-time; studying and working online in a post-COVID society...These have all been enabled by something we never see, and most don't even know exist.

At the bottom of the worlds' oceans are thousands of kilometres of fibre-optic cables that transmit information from one country to another. In fact, subsea fibre-optic cables carry 99% of international internet traffic. Transmitting information using light has been one of the most important developments of the modern age, accelerating the Third- and giving rise to the Fourth Industrial Revolutions. Glass has been central to this technology. A fibre-optic cable is made up of thin strands of glass, each strand much thinner than a human hair. Information is transferred through each strand as a light signal, and scientists have cleverly used the refractive properties of different types of glass to keep the signal inside the cable. These days, scientists have also been able to add nanocrystals to the glass fibres, to further enhance its abilities and uses in communications and laser technologies.

Stronger than steel

Glass fibre materials have been around for a long time. If you have ever been near a marina, chances are you

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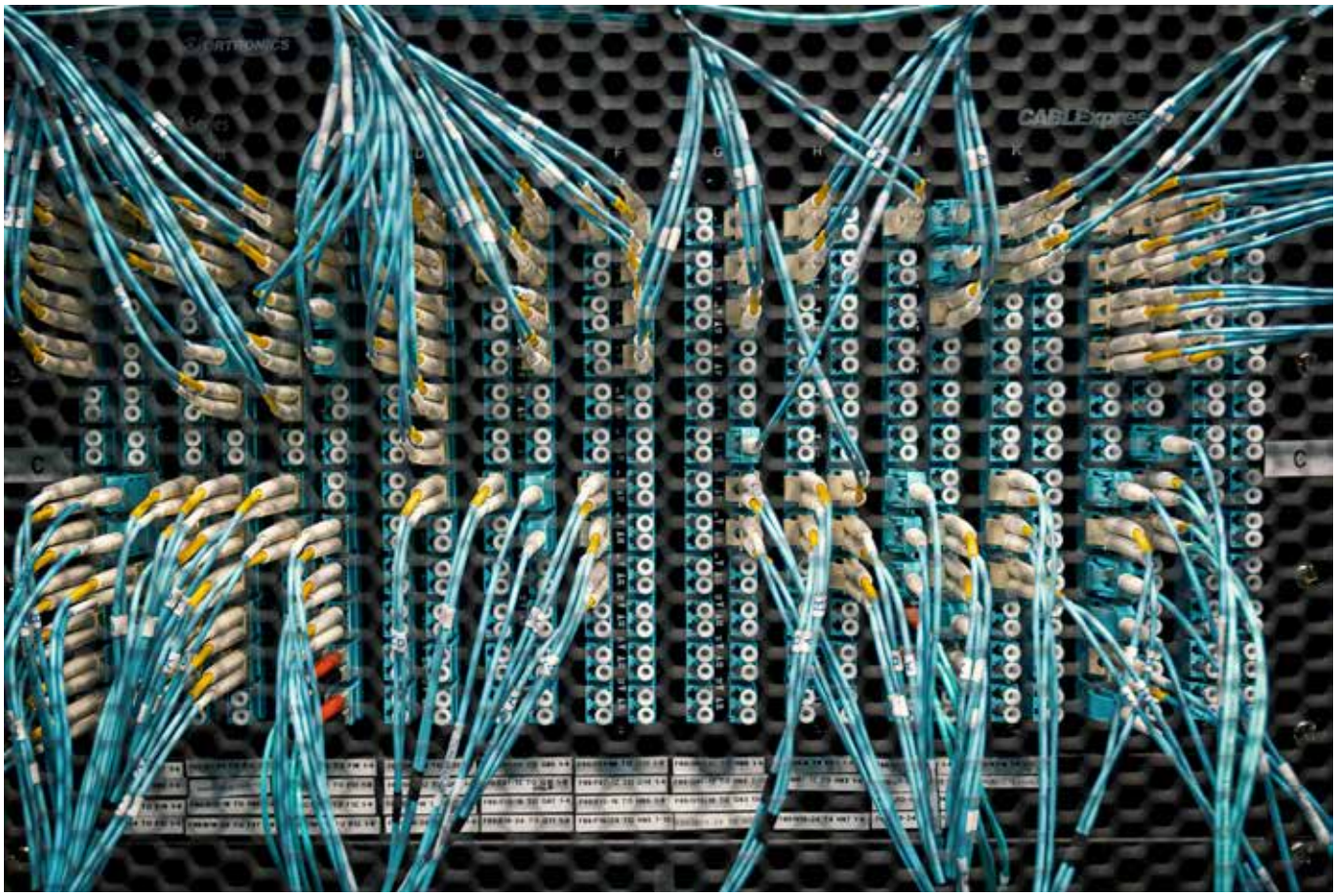
have seen a boat fabricated from fibreglass. Favoured for its strength to weight ratio and durability, this material has been used in numerous other applications, from automobiles and aircraft, to tanks and construction materials. It's not just glass however, typically fibreglass is a marriage of a polymer resin with glass fibres, the latter which gives the composite its characteristic strength. Since glass has very poor thermal properties, glass fibre materials are also very useful as insulation. Many chemical plants around the world use fibreglass insulating materials around their high-temperatures operations, to keep the heat in and protect their workers. Today, a lot of effort is being expended on the development of greener and more sustainable polymer resins, to improve the life-cycle of the fibreglass material and ensure that it has a place in the future of the construction and transportation industries.



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Powering the future

Photovoltaic cells consist of semiconductor materials that are able to convert incident light into electrical energy. These exotic materials are good at harnessing the power in solar radiation, but are not very durable, so they have to be protected when placed out in the open. However, they still need to access the maximum amount of light so can't be placed under an opaque material. Practically no material other than glass can offer high solar radiance transmittance, together with strength and durability. Therefore, in most solar panels, the photovoltaic cells are sandwiched between sheets of tempered glass.

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The incident light is able to pass through with ease, but the cell is protected from the other environmental conditions. As scientists work on developing higher efficiency photovoltaic materials, glass remains a critical supporting act for this renewable energy technology. An interesting development in this area has been solar glass, a new construction material that is able to absorb a portion of the incident light, and allow the rest to pass through. It can be used in the place of windows and glass panels in buildings, directly converting the incident light into electrical energy, without the need for a separate photovoltaic cell. Perhaps one day, the very buildings we occupy will be able to generate all the energy we need.

Medical miracles

The human skeleton provides the framework for one of the most intricate biological machines in nature. However, it is somewhat more than just scaffolding for organs, nerves and skin. It integrates with the organic parts of the body, serves as a storage for calcium and carries an extensive network of blood vessels. Bone regeneration is therefore a very complex and challenging task in medicine.
Amazingly, some fifty years ago, a glass material that could bond to living tissue without rejection by the body's immune system and undergo dissolution in the presence of blood, was developed. It revolutionised orthopaedic surgery, by providing damaged bones with sufficient support and the opportunity to regenerate in a natural way. Bioactive glass has since become an integral part of the orthopaedic field, to treat damaged bones and bone defects.

An even more ubiquitous use of bioactive glass is in toothpaste to treat sensitive teeth. Here the bioactive glass promotes the regrowth of calcium at the base of the tooth, and protects the nerves from exposure to hot and cold foods and drinks.

Glass, climate change and the circular economy

When one thinks about glass, one imagines a clean, clear material that epitomises something natural and sustainable. Glass is indeed made out of relatively abundant, natural materials, and can be recycled and reused many times without significant loss of quality. Nevertheless, it takes a large amount of energy to produce glass products, due to the melting temperature of the glass. This temperature can be lowered by adding salts that are high in sodium and potassium, but only to a certain extent. There is still the need to heat up the glass precursor to almost 1700 °C. To do this, glass manufacturers rely on furnaces powered by both fossil fuels and electricity (the latter also often produced from fossil fuels).

There are efforts underway to develop new furnaces that can run on green hydrogen, produced through electrolysis of water, and to use electricity derived from renewable sources, such as solar, wind and hydro. Engineers are also making the furnaces more energy efficient, to ensure that most of the energy input goes towards maintaining the glass melt. Decarbonization of the glass industry is a significant step towards ensuring the future sustainability of the industry and to mitigate against the current and future effects of climate change.

In South Africa, approximately 44% of glass packaging is recycled (according to The Glass Recycling Company, 2020). This is well below most of the countries in Europe, where the value is on average 78%. Nevertheless, as a manufactured material, glass is amongst the top ten, keeping company with steel, aluminium and paper products. Glass recycling is a critical part of the circular economy concept, reducing waste and improving usage of materials through the complete life-cycle. If you haven't already participated, find out the location of a glass bank in your area, separate out your glass packaging waste, and become part of the glass recycling initiative.

Through the looking-glass

What does the future of glass look like? We can only offer some educated guesses.

Currently, scientists are working on combining glass with new materials to provide convenient properties, e.g. the ability to change colour with changes in temperature, which could improve the storage and supply of beverages and medicines.

Flexible glass products are allowing electronic devices to do amazing things, effectively bending our reality. Advances in photovoltaic technology will perhaps allow such materials to be applied like glass coatings to buildings and infrastructure. Glass may actually form the basis for such infrastructure in the future, as steel and brick did in the 19th and 20th centuries.

Glass has and will continue to be used in space exploration, as integral parts of space-craft and instruments that are charting our past and future. The world's wonder material is playing an increasingly important role in our everyday lives, and as we enter the second half of this century we can expect it to continue to assist in meeting the greatest challenges we face.

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Ingilazi ingenye yezinto ezingakhiqiza izinto ezahlukahlukene eyaziwa ngabantu abaphila la emhlabeni. Iyaqhubeka nokuziqamba kabusha futhi isiyinxenye yezimpilo zethu ebalulekile. Kulesiskhathi samanje ingilazi ingasetshenziselwa izinto eziningi. Singasho sithi, inemfihlakalo engaqondakali, kodwa ubuchwepheshe buyasiza ukuba siqonde lemfihlakalo kancane kancane.

Translated by Zamantimande Kunene

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