

BUSINESS SWEDEN

INSIGHT SERIES 2019

MATERIALS OF THE FUTURE

INTRODUCTION: TRENDS AND TRUTHS
IN THE MATERIALS RACE

Materials engineers are always on the lookout for the next big thing. But customers are increasingly playing an instrumental role in shaping the innovation paths and materials that transform everyday life. In collaboration with Swerea, Sweden's world-class research group, and trend analyst firm Kairos Future, Business Sweden presents a special report in nine parts about the race for stronger, lighter, more sustainable, absorbable – and fully connected materials.

INTRODUCTION: TRENDS AND TRUTHS IN THE MATERIALS RACE

TRUTH 1: DRIVEN BY CUSTOMERS FROM HEAVEN AND HELL

Demanding customers who want more and pay less are a strong incentive for rapidly developing, new and better materials. This will lead to a future with higher degrees of collaboration with customers in order to understand their needs, ideally before they are aware of them themselves.

TRUTH 2: ENVIRONMENTALLY FRIENDLY – SUBJECT TO RESERVATIONS?

The materials of the future are obviously designed in environmentally friendly ways with lightweight, energy saving and low-carbon emissions at top of mind, but how simple will it be to recycle them? Complex, tailor-made materials place high demands on future recycling facilities.

TRUTH 3: IN THE SHADE OF THE FOREST

The forest is a natural source of raw materials for much of what is made using oil today. Nations rich on forests have great potential for developing new, advanced materials industries based on raw materials.

TRUTH 4: HYPER-DESIGNED

There is no reason to believe that the trend towards more intensively designed and customised products will slow down, quite the opposite. In future, materials may even be designed all the way down to atomic level in order to meet increasingly high demands.

TRUTH 5: CONNECTED

Sensors can already be found on many products today, but in the future they will be embedded in materials to a far

greater extent as woven fibres, smart coatings, conductive nanotubes or in other forms. The materials will be able to report fractures, overheating and other issues via the Internet of Things.

TRUTH 6: BORN AT THE CROSSROADS

It is increasingly difficult for a single party to develop sophisticated and advanced materials. The materials of the future are therefore rarely born from a single company but in the interaction between several different parties, each with their own expertise, requirements and areas of strength.

TRUTH 7: CREATED BY NEW PIONEERS

New players from the IT and space industry, among others, are beginning to drive material developments to a larger extent. They can often afford to manage major collaborations or, if necessary, develop what they need themselves. Pioneers from other areas are entering the materials industry, both as partners and as competitors.

MATERIALS OUTLOOK 2020: WHERE ARE WE HEADING?

Join us as we explore the seven truths about the materials race in depth. Go to www.business-sweden.se/en/Invest/industries/new-materials

STEP INSIDE THE WONDROUS WORLD OF MATERIALS

Materials engineers are always on the lookout for the next big thing. But customers are increasingly playing an instrumental role in shaping the innovation paths and materials that transform everyday life. In collaboration with Swerea, Sweden's world-class research group, and trend analyst firm Kairos Future, Business Sweden presents a special report in nine parts about the race for stronger, lighter, more sustainable, absorbable – and fully connected materials. The journey begins here.

THE MATERIALS RACE

Materials are becoming smarter and infinitely more complex – pushing the boundaries of what's possible in every domain of daily life. As a mindset challenge grows in scope, mankind must adopt fresh thinking and pave the way for constructive change.

Lighter, stronger, connected and absorbable. From the microchips in our mobile devices to medical implants, jet engine components, insulation and steel girders in walls, new materials are reshaping the path of human progress. And they are increasingly being sourced from unusual places.

Viewed as a whole, the materials of the future are complex and challenging, not easy to manage even for experienced designers or manufacturers. They need to be studied from many different perspectives, several of which are new to industry. The future lies in close cooperation and willingness to change the perception of materials, from something static and simple to something vivid and complex. Materials are and will remain part of a greater ecosystem; both economically and ecologically; they permeate all human activity across society, industry and our everyday experiences.

In collaboration with Swerea, Sweden's research group for industrial renewal, and analyst firm Kairos Future, Business Sweden presents the eight-part special insight series, The Future of Materials, taking you on a journey into the fast-changing world of wonder materials.

The series aims to provide an overview of the materials that will dominate industry and society in the near future, as well as in 20 years' time. Each chapter uncovers insights driving greater understanding and awareness of today's materials bonanza, and the tremendous opportunities that lie ahead.

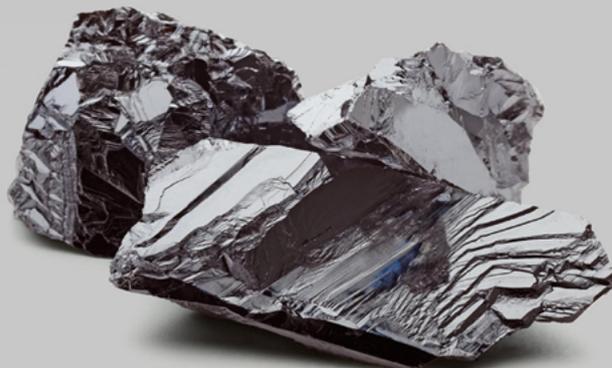
BACK TO THE ROOTS

From the ceramics that gave early man the ability to store and transport food and drink, to beautiful fabrics that for centuries have defined luxury, to bronze and steel weapons that forged the great empires of the small, warring kingdoms – materials have determined who is rich or poor, who owns the future and who is out of date.

Over millennia, materials sourced in nature have served mankind well. But today's materials challenges present opportunities as well as risks to society. Materials are not only our servants, but also impose limitations – steel, oil and rare earth metals are just some of the pillars on which society has been built. What do we do if and when they run out?

The Future of Materials dives into today's possibilities and needs – from customisation and 3D printing to circular thinking – exploring the elements at play that enable the wheel of innovation to turn faster. The series captures the perspectives and knowledge of 400 industry players and experts from a variety of disciplines including materials science, product development and recycling. All respondents were interviewed in a survey conducted by Swerea in 2016 for a first edition report.

“The Future of Materials dives into today's possibilities and needs – from customisation and 3D printing to circular thinking – exploring the elements at play that enable the wheel of innovation to turn faster.”



THREE FORCES SHAPING MATERIALS

Ever since the First Industrial Revolution and the arrival of assembly lines, countless new materials have been born in laboratories to meet the requirements of mass production. But the raw materials found in nature – in the ground, plants and animals – have never faded from view.

The materials of the future do not appear out of thin air. They are shaped by the outside world as much as they are formed by designers, engineers and researchers based on the demands placed on them and the usefulness they can provide. Today, we can control nearly all of the features we want a material to have, but what is the ultimate aim? What are the catalysts for development?

Three key drivers indicate what will guide the development of breakthrough materials in the future.

Endless demand: Ever-increasing and often unreasonable demands for better, lighter and stronger materials that must comply with the requirements set out for the products.

The spaceship paradigm: A shift towards a more holistic approach to sustainability in materials and an awareness that the raw materials on planet Earth are actually finite.

The hunt for efficiency: Gradual, often random, improvements on a small scale that become more frequent and faster in this interconnected age where new innovations can be shared instantly.

“Industrial use of materials is much more user-driven today. In the past, steel was made ”better”. Now customers say: We need to have it this way, either you provide us with the steel or we change our supplier.”

Eva Lindh Ulmgren, Head of Research, Swerea KIMAB

56%

...of respondents to our survey specified that “demanding customers” are a crucial strength for the Swedish materials industry.

FORCE 1: ENDLESS DEMAND

When Steve Jobs, the CO-founder and CEO of Apple, convened his team of designers and engineers little more than a month before the launch of the very first iPhone in 2007, he unleashed a series of criticisms with anger and frustration.

Having carried a prototype iPhone in his pocket, Jobs was horrified to discover that the screen was badly scratched. Obviously, the product didn't measure up. “If the screen's plastic material scratches that easily,” he asked the development team, “how will anyone be able to carry it around in their pocket with keys, coins or other sharp items?”

“I want a glass screen,” Jobs then proclaimed. And so it was. But the glass screen eventually presented at the iPhone launch, called Gorilla Glass, had not been available on the market just six weeks earlier. It was rapidly developed



Photo: Patrik Svedberg

by the innovative glass company Corning, which first invented a chemically strengthened glass in the 1960s. In response to Apple's request, the company developed a new production method that could make 1.4 mm thick glass instead of the usual 4 mm thickness.

The story of Gorilla Glass, which became an instant product success and later gave rise to bendable Willow Glass, shows that often when you need a new material the solution already exists. Customer demand is the driving force for new applications and more efficient production methods. The price for Gorilla Glass will now continue to come down and, in the future, may be used in car windscreens where it can reduce scratches, stop cracks from stone chips and reduce weight.

In addition, the story illustrates the ever-intensifying race for innovation and how people with sufficient capital and willpower can drive endless demand. Environmentally friendly cars, noiseless engines, windows that let in just enough light are other typical examples where expectations can at times appear unreasonable. Yet these types of requests can often be met.

Last but not least, the customisation of materials (see Figure 2) to individual needs and tastes is not only possible but is arguably on track to becoming the norm. Customers are growing increasingly 'spoiled'; always looking for better, lighter, stronger and more beautiful materials that reshape the nature of demand.

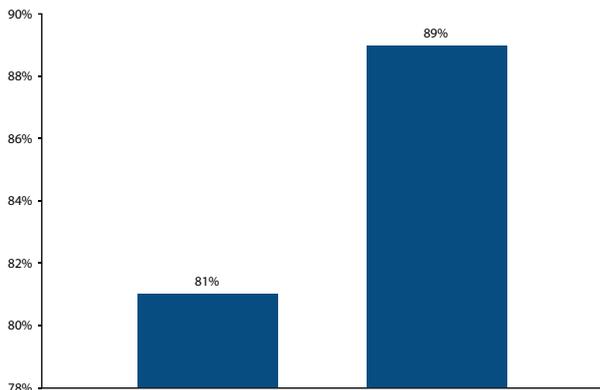


Figure 2: "Materials have become/are becoming more customised and intensively designed" - Percentage of respondents who agreed with this over the last 15 years and for the next 15 years.

FORCE 2: THE SPACESHIP PARADIGM

"Earth has become a spaceship without unlimited reserves of anything, whether to recover or to pollute." These words of the economist Kenneth Boulding were spoken as early as the mid-1960's but his vision has only now started to gain real momentum.

Today, more and more companies are recognising the need to adopt circular thinking and restructure operations. The paradigm shift is not just a talking point among environmentalists – it has transmuted to industry and society at large. And there is money to be made in sustainability. Using raw materials more efficiently, reducing extraction and investing in recycling means cost savings and huge competitive advantages.

3 BREAKTHROUGH MATERIALS:

- **Upsalite:** called the "impossible material", Upsalite is a form of magnesium carbonate that sets new records for surface area and moisture absorption.
- **NEXIMID:** A high temperature polymer used in aircraft engines to reduce weight and improve fuel efficiency.
- **Biodolomer:** is a fully degradable and compostable biomaterial with a wide range of application areas.

The world's nations are gradually becoming environmentally conscious. The focus is shifting from energy to materials, which are more difficult to innovate if they run out. Out of twelve alternatives presented in Innventia's International Consumer Survey, "creating more efficient systems for materials recycling" was the most frequently chosen environmental intervention – more popular than carbon taxation.

In the circular economy of the future, material waste is not an option. For industrial companies that means viewing everything as resources and minimising materials loss, whether newly acquired raw materials or waste residue in industrial plants. For consumers, it means being part of something larger than oneself as materials go from linear use to a system of circular reuse and extended lifecycles.

Upsalite





FORCE 3: THE HUNT FOR EFFICIENCY

Hardened steel in precisely weighted layers was the secret behind Japanese warfare for centuries – the famous swords that would become a symbol of the country's history. Gradual improvements made the steel stronger. But this incremental development is in no way unique to Japan and is reflected in all material research across the globe.

We are constantly on the search for better, more efficient solutions that make things like steel unbreakable. The hunt for efficiency is perhaps the most fundamental force underpinning the new materials drive. And it occurs in a Poisson point process: small, random discoveries are made from countless experiments. While not always revolutionary, material structures are made a few grams lighter, a millimetre thinner or slightly more durable.

In a globalised world and thriving knowledge economy, these discoveries occur more frequently than ever. Unlike in the past, scientific discoveries are not kept as state secrets. Researchers worldwide can instantly share their discoveries in networks and build on the work of experts on the other side of the planet. Material developers are colleagues as well as rivals, and are unlikely to reach a final destination as new goals will emerge on the horizon, just beyond their reach.

More often than not, the materials industry is shaped by a marathon of gradual changes rather than individual disruptive technologies. Anyone who doesn't carry on the race will slowly but surely fall by the wayside as competitors outrun them with better, more cost-efficient solutions that are likely to set new industry standards.

SWEDEN – A NATION RICH IN FORESTS AND MINERAL RESOURCES

Sweden is Europe's leading mining nation and a global forest industry giant. These natural resources formed the bedrock for Sweden's industrialisation. And they remain important today. But times are changing. Digitalisation is eroding demand for newsprint and new technology is driving innovative applications for traditional metals and high-tech metals. Sweden hosts mineral deposits like graphite, lithium, rare earth metals.

The shift towards sustainable development and renewable materials is transforming the forest industry from a bulk orientation to high value added biobased materials. Innovative companies are using Swedish wood to develop new bio-based materials such as barrier films, chemicals, carbon fibre, textile fibers and other applications with industry-changing potential.



Photo: Melker Dahlstrand

ABOUT THE AUTHORS

Swerea: Swerea is the Swedish research group for industrial renewal and sustainable growth. Our mission is to create, refine, and convey scientific results in the areas of materials development, production and product development. We work in applied science, with extensive industrial knowledge and experience of how research results are translated into practical use. Our five research institutes exist at roughly a dozen towns in Sweden and France, and we have a network of over 700 member companies and 3,000 corporate clients. We create greater competitive power for Swedish industry.

From October 1st 2018 two thirds of Swerea is acquired by RISE Research Institutes of Sweden, and one third will form a new research institute, Swerim.

Kairos Future: Kairos Future is an international consulting and analysis firm that helps companies take leaps towards the future. Through trend and scenario analysis and support in innovation and strategy, we help customers with the big picture and the direction for the future. Kairos Future was formed in 1993, our head office is situated in Stockholm and we have partners worldwide.

Business Sweden: Business Sweden helps Swedish companies grow global sales and international companies invest and expand in Sweden. We ensure that international companies can rely on our knowledge, experience and extensive network to identify new business opportunities and achieve an accelerated return on investment. Business Sweden is present in 50 of the world's most promising markets and owned by the Swedish Government and the industry, a partnership that provides access to contacts and networks at all levels.



We help Swedish companies grow global sales and international companies invest and expand in Sweden.

BUSINESS SWEDEN Box 240, SE-101 24 Stockholm, Sweden
World Trade Center, Klarabergsviadukten 70
T +46 8 588 660 00 F +46 8 588 661 90
invest@business-sweden.se www.business-sweden.com

