ETH zürich

Material Shapes the Ages

Materials have such a profound impact on humanity that we name entire historical ages after them. Whether the Stone Age, Bronze Age, Iron Age or the Silicon or Plastic Age, the development and use of new materials has always led to technological progress and deep societal transformation. Today's materials are awakening a new age, transforming entire industries and the way we live our lives. Which material will define and leave its name to the next era?

A Modern Tree

Aerogels mainly consist of air and are amongst the lightest materials in the world. One gram of this highly porous material has the same surface as two tennis courts. The finely branched structure and the unique composition enable artificial photosynthesis. Like in a tree, CO_2 and water are converted into valuable energy carriers by using sunlight.

Titania aerogel in glass vial

Stone Age

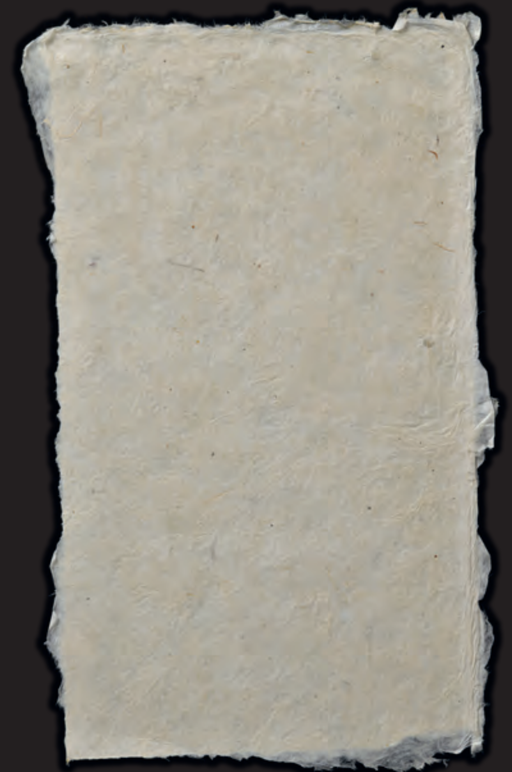
Gneiss "Bodio Nero" from Ticino, Switzerland

Bronze Age

Tin bronze, cast

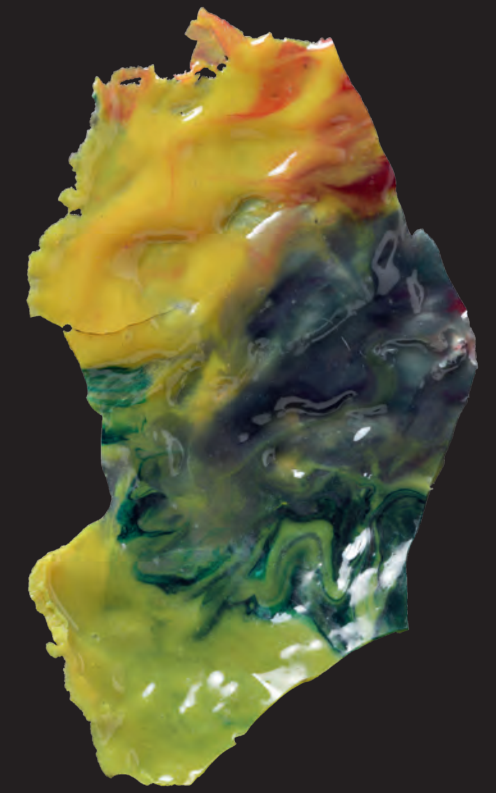
Iron Age

Roheisen



First Mass Storage

Hemp paper, handmade

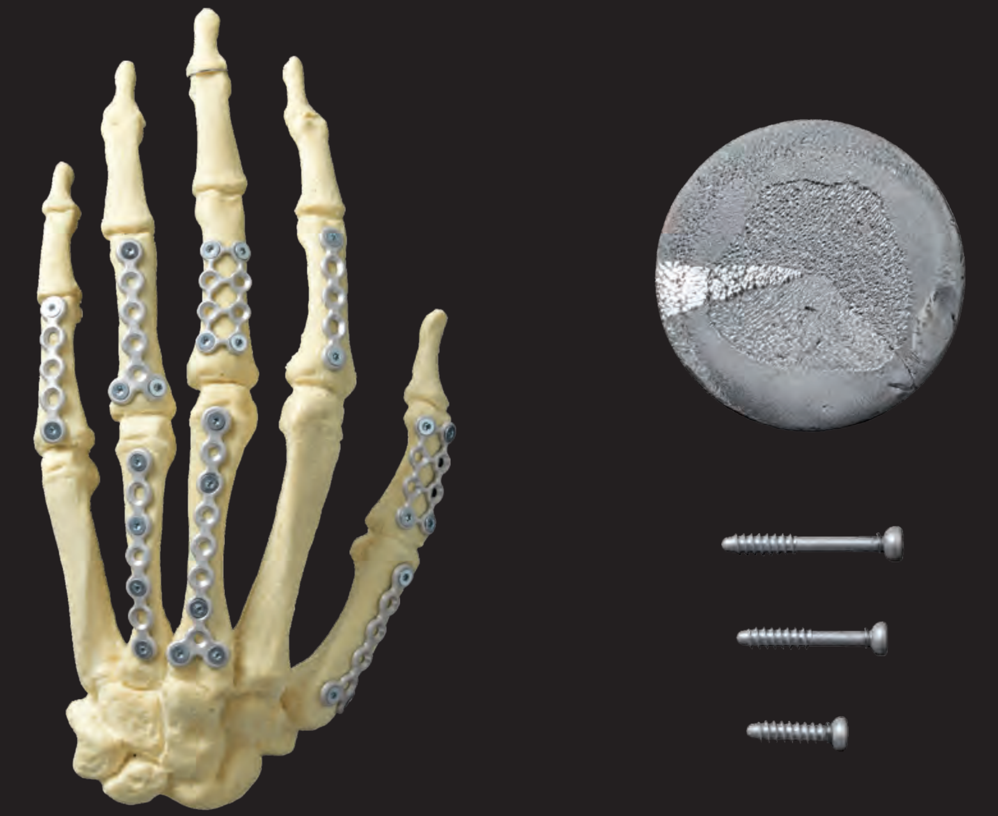


Polymer Age

Epoxy resins, dyed, produced by polyaddition of epichlorohdrin and bisphenol A

Silicon Age

Silicon



Implant and Forget

Bone implants, made of the world's purest magnesium, will degrade in the human body after fracture healing, rendering an implant removal surgery unnecessary. Additionally, magnesium stimulates bone growth. ETH Zurich's Laboratory of Metal Physics and Technology developed this material based on a magnesium distillation process and specific alloying with small quantities of the likewise biocompatible elements calcium and zinc.

Ultra-high-purified magnesium after distillation;
hand made of polyurethane with finger implants made of a biodegradable magnesium-zinc-calcium alloy –
bone screws made of a biodegradable magnesium-zinc-calcium alloy

Salt Template

3D printing has led to a paradigm shift in the world of design. But many high performance materials are incompatible with printing. Water-soluble, printed salt templates give these materials, like magnesium, access to complex lattice structures with the potential to heal bone, make lighter space shuttles and efficient cooling systems.

3D printed salt molds before and after infiltration
Silicone lattices after the salt has been washed away

White and Flexible Wood

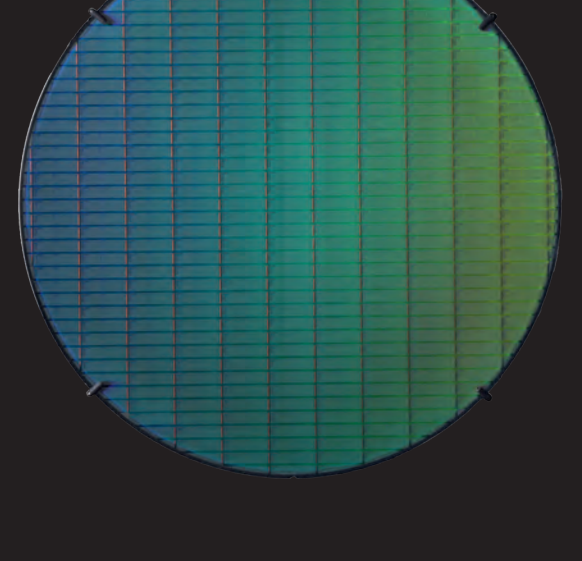
Lignin removal is a common procedure to produce paper. In a similar process, white, flexible wood can be produced, but the natural structure and beneficial fibre directionality are retained. The wet material can be easily deformed. Densification and resin impregnation result in natural high performance fiber composites.

Spruce wood (Picea abies)
Starch glue

Big Bang in a Multiferroic Crystal

Multiferroics are a new type of material combining magnetic and electric properties in a unique way. This can, for example, be useful for building novel electronic devices such as computers with ultra-low power consumption. But, multiferroics can do more: the pattern of electric charges in the picture above simulates processes that happened in the early universe - right after the Big Bang.

Crystal: multiferroic DyMnO3 single crystal
Image: 3D plaster-ceramics color print, enlarged view of the electric polarization pattern in a multiferroic hexagonal erbium manganite (ErMnO3) single crystal



Sprinting Magnetic Memories

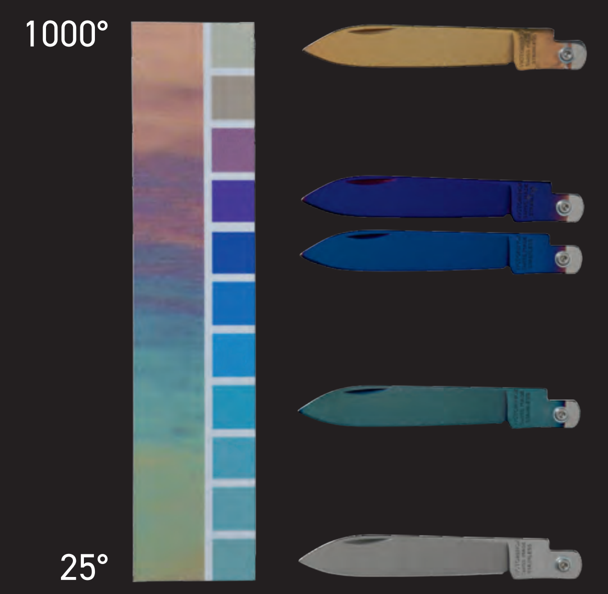
Nanometer-thin magnetic multilayers patterned on a silicon wafer combine the best of two worlds: nonvolatile data storage and electronic speed. Magnetic random access memories (MRAMs) will deliver instant on-off computing, nanosecond read and write times, and reduced power consumption.

Collaboration between imec Leuven and ETH Zurich
Gold on cobalt-iron-boron, magnesium oxide, cobalt-iron-boron, tungsten and silicon

Printed Strength

Nematic 3D Printing for Metal Replacement: novel liquid crystal polymers (LCPs) leverage polymer 3D printing to performance and precision levels required for industrial manufacturing. 3D printed LCP parts are lightweight and strong, show superior temperature stability and chemical resistance and survive in the harshest application environments.

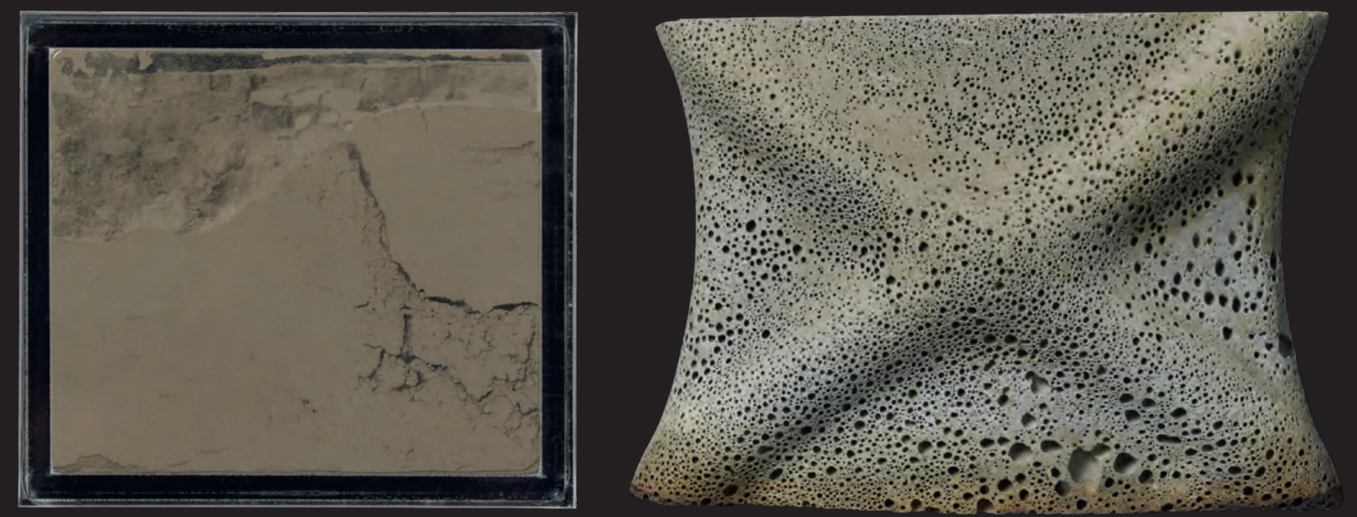
Printed LCP carabiner (right)
and commercial aluminum carabiner



Weakness Illuminated

These Swiss army knife blades are coated with a solid-state optical sensor that tracks even the smallest changes in the material by changing its colour. Simple visual inspection is sufficient to evaluate the condition of the material: has the material worn off? What temperature was it exposed to? A small-footprint colour sensor enables real-time tracking of devices, such as turbines in airplanes or offshore wind farms.

Stainless steel (knife blades) with sensor made of titanium aluminum nitride and titanium nitride



Reborn from Ashes

Industrial waste, such as fly ash, is often abandoned. But, it can be recycled to produce a type of foam that combines excellent insulation performance with sustainability. This foam is intrinsically nonflammable and fully recyclable. This invention embraces the circular economy and advanced manufacturing technologies. It envisions or "rethinks" a future resource-effective building culture.

Fly ash, cast wall element made out of ashes

Swimming Steel

3D printed steel foams are lighter than water. Their vast network of pores gives them sponge-like absorption properties that can be tuned to soak up oil, water, or both. When they are made oil absorbent - hydrophobic - they float on the water surface and could be used to clean up crude-oil spills in the ocean.

3D printed steel foams swimming on water

ETH zürich

How Material Shapes the Ages

Since ancient times, materials have influenced the scientific, technical and societal development of humankind.
In the Stone Age, stone weapons and tools changed the way we hunted and how we fed and clothed ourselves. In the Bronze Age, the production of bronze led to the development of new weapons and advanced civilizations with fortified cities and wide-ranging trade routes. In the Iron Age, the iron plough allowed humans to produce food surpluses that enabled them to apply themselves to new trades. In this sense, new materials are so important to the development of our societies that we name our historical ages after them. A world without steel, plastic or semiconductors is unimaginable nowadays, and new materials continue to have a considerable impact on our quality of life. Without them, there would be no smartphones or tablets, no energy-efficient houses, no lithium-ion batteries, no dental implants and no artificial skin: materials science touches every part of our lives.

Designing a New Material Age

The 21st century presents major technological challenges that we will be able to overcome only by developing sustainable materials. For example, plastics are used to such excess that they have now become a global environmental problem. This presents a challenge for materials science and has led to a worldwide change in thinking, making sustainability a key aspect of research. How can we develop new materials and processes that use fewer resources and are easier to recycle or – even better – are biodegradable? Our technology is only as smart as the materials on which it is based. It's time for an upgrade.

The Vast Land of Properties

Imagine a material so light that a tablespoon of it weighs less than a redwood ant (approx. 3 mg or 0.0001 oz.) and yet has the surface area of three basketball courts (more than 1,200 m^2 or 12,916 ft^2).
Or imagine a material that repairs itself when torn. Scratch-proof screens, longer-lasting batteries, extremely light bicycles or breathable contact lenses – almost all modern everyday products rely on materials with special properties. Which properties would you change in the materials around you?

Materials Science at ETH Zurich

ETH Zurich's Department of Materials (D-MATL) brings together students and leading scientists in a lively and interdisciplinary environment, focusing on high-level scientific and engineering education and technological challenges relevant to the future of our society. Materials science is an independent discipline at the interface of science and engineering. Merging the philosophies of scientists and engineers advances not only basic materials research into new realms but also solves technological challenges in a sustainable manner. Ongoing research in the department includes hybrid and actively engineered materials, soft matter and polymers, nanostructured metals and magnetoelectronic materials.

ETH Zurich

ETH Zurich, the Swiss university for science and technology, features regularly in international rankings as one of the best universities in the world and the leading university in continental Europe. Situated in the heart of Europe, forging connections worldwide, ETH Zurich offers an ideal environment for independent thinking and a climate that inspires top performance. Its 520 professors and more than 23,000 students from 121 countries generate innovation in areas ranging from data science to robotics and from nanoscience to cutting-edge medical technology. Switzerland's advanced economy benefits from the nearly 160 patents and licensed technologies, nearly 200 inventions, and more than 25 spin-off companies emerging from the university every year. ETH Zurich also holds a commendable track record of scientific excellence with 21 Nobel laureates, including Albert Einstein.

antistatic / breathable / bending / bendable / biomimetic / bioresorbable / brittle / crystalline / stretchy / elastic / fatigue-resistant / coloured /
moisture repellent / fluorescent / liquid / dimensionally stable / true to form / castable / skin-friendly / hexagonal / heat sensitive /
high strength / insulating / easy / light weight / light / lightfast / magnetic / miniaturizable / renewable raw material / reflective / tearproof /
recyclable / fusible / quick-drying / heavy / fissile / stable / strong / highly absorbent / superconductive / temperature and humidity regulating /
temperature resistant / transparent / impermeable / inelastic / universal / heat-insulating / warming / soft / resistant / reusable