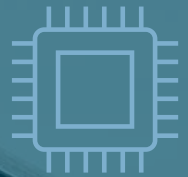
The Electronics Value Chain
and Its **Raw Materials**



Our critical dependence on electronics means we are equally dependent on the mineral raw materials needed to make them

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The Electronics Value-Chain

What's it all about

The roadmap for European electronics is about having stronger European involvement in the global electronics "value chain", benefiting our economic competitiveness and ability to innovate. So what is the electronics value chain?

A chip

...is the "brains" of every computing device. It is made up of active devices like transistors and diodes; passive devices like capacitors and resistors; and their interconnections.

Did you know?

A state-of-the-art chip today has about 800 million transistors, each measuring just 32 nanometres (about 1/3000th the thickness of a sheet of paper).

Applications

Chips are used in virtually all electronic equipment today: from computers smartphones and tablets, to domestic appliances, cars and factories.

Did you know?

Your car may soon be able to prevent accidents by "talking" to other cars – and to the road itself. v

Architecture

A chip's architecture depends on its purpose: what will it be used for? Its functions and behavioral features are based on that - iteratively until the "final" chip is designed.

Did you know?

Hundreds of people work to design, test, fine-tune and make a chip.

Systems

Electronic systems can be intelligent, miniaturised, and with advanced functionality – even integrating with biological systems.

Did you know?

You could soon be able to wear medical instruments 24/7: as bio-electronic systems take your vital signs for you.

Materials

Chips are built up on a thin "wafer" of semiconductor; usually silicon. The EU is investsing €1 bn over 10 years on research to substitute silicon with graphene - perhaps the thinnest, lightest and strongest material in the world.

Did you know?

Silicon is among the most common elements on Earth, and the key ingredient in sand.

Equipment

Making chips takes many complex precise steps, layering many different materials on top of each other. A typical "fabrication plant" needs many hundred costly items of equipment.

Did you know?

The rooms where microchips are made are 100,000 times cleaner than the cleanest hospital operating room.

Design tools

Computers are themselves used to design chips, from defining specifications, to testing and production.

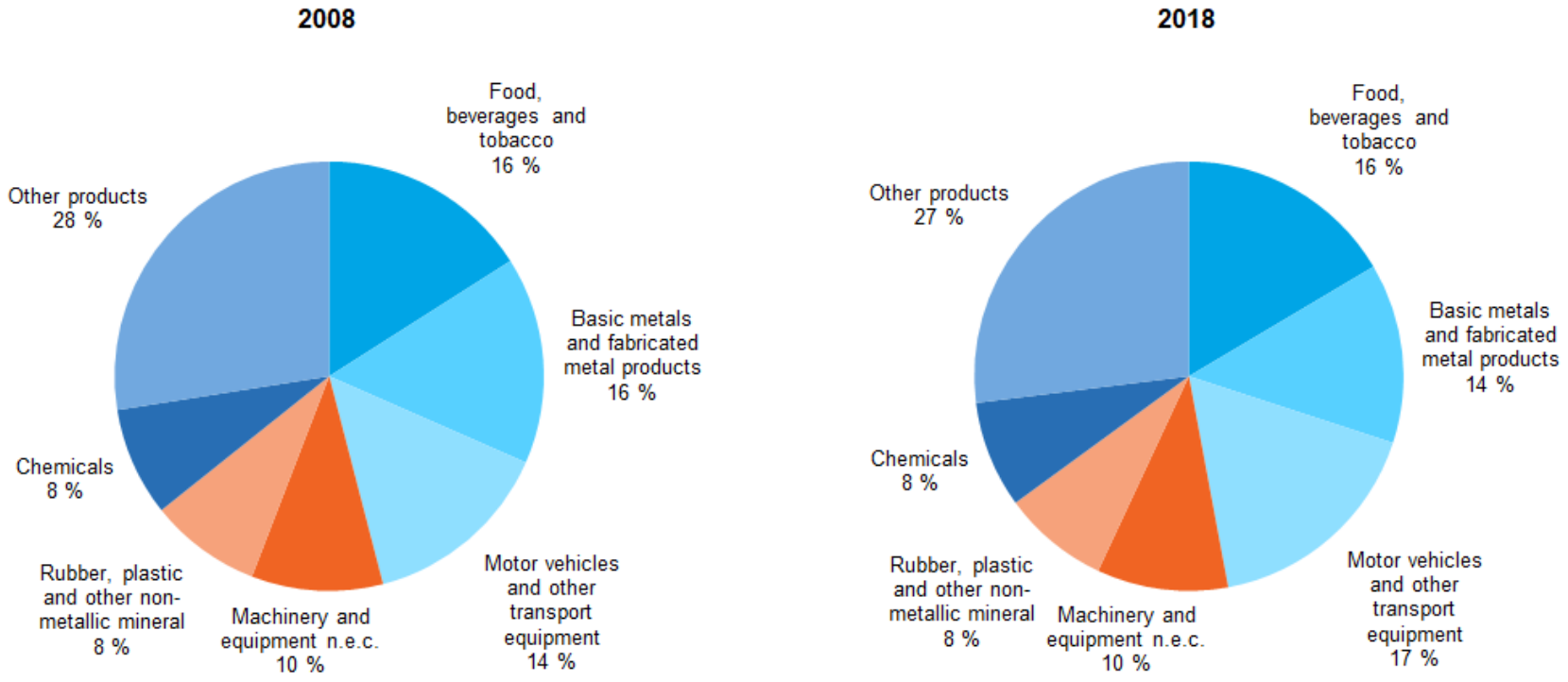
Did you know?

While chips look flat, they are in fact three-dimensional, with as many as 30 layers of complex circuitry.

European Commission

Source: European Commission

Value of sold production by group of manufacturing activity, EU-28, 2008 and 2018 (% share of total sold production)



Note: EU-28 except Cyprus, Luxembourg, Malta
Other products: Wood and paper, and printing; Furniture, other manufacturing and installation of machinery and equipment; Electrical equipment; Computer, electronic and optical products; Textiles, wearing apparel and leather; Pharmaceutical products; Mining

Source: Eurostat (online data code: DS-066341)

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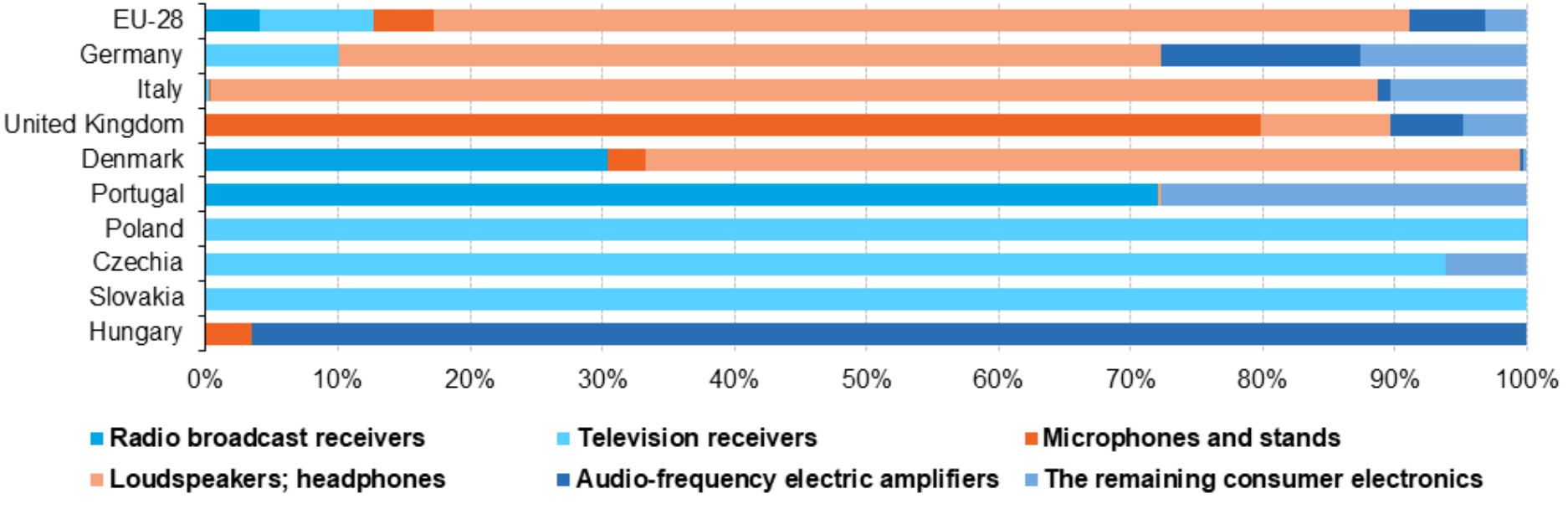
Production of consumer electronics in the EU-28 in 2018 (%)



Production of consumer electronics in the EU-28 in 2018 (%)
Note: Data are not available for Cyprus, Luxembourg and Malta and are therefore not included in the EU-28 total.
Data for other Member States not appearing in the figure are confidential.
Source: Eurostat (online data code:DS-066341)

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Semiconductors

- Today, semiconductors and their value chains underpin innovation and competitiveness in all major sectors of the economy.
- In Europe, the semiconductor ecosystem itself employs approximately 250,000 people directly.
- More than 800,000 people work on the integration of components into systems, applications and services across Europe, and more than 2.5 million are employed in the complete components value chain.
- For all the hardware components used in workstations, tablets, smartphones, PCs, laptops as well as supercomputers, the raw materials used to make them come from 50 of our 90 naturally occurring elements here on earth. And some, like **hafnium** are rapidly dwindling in supply.

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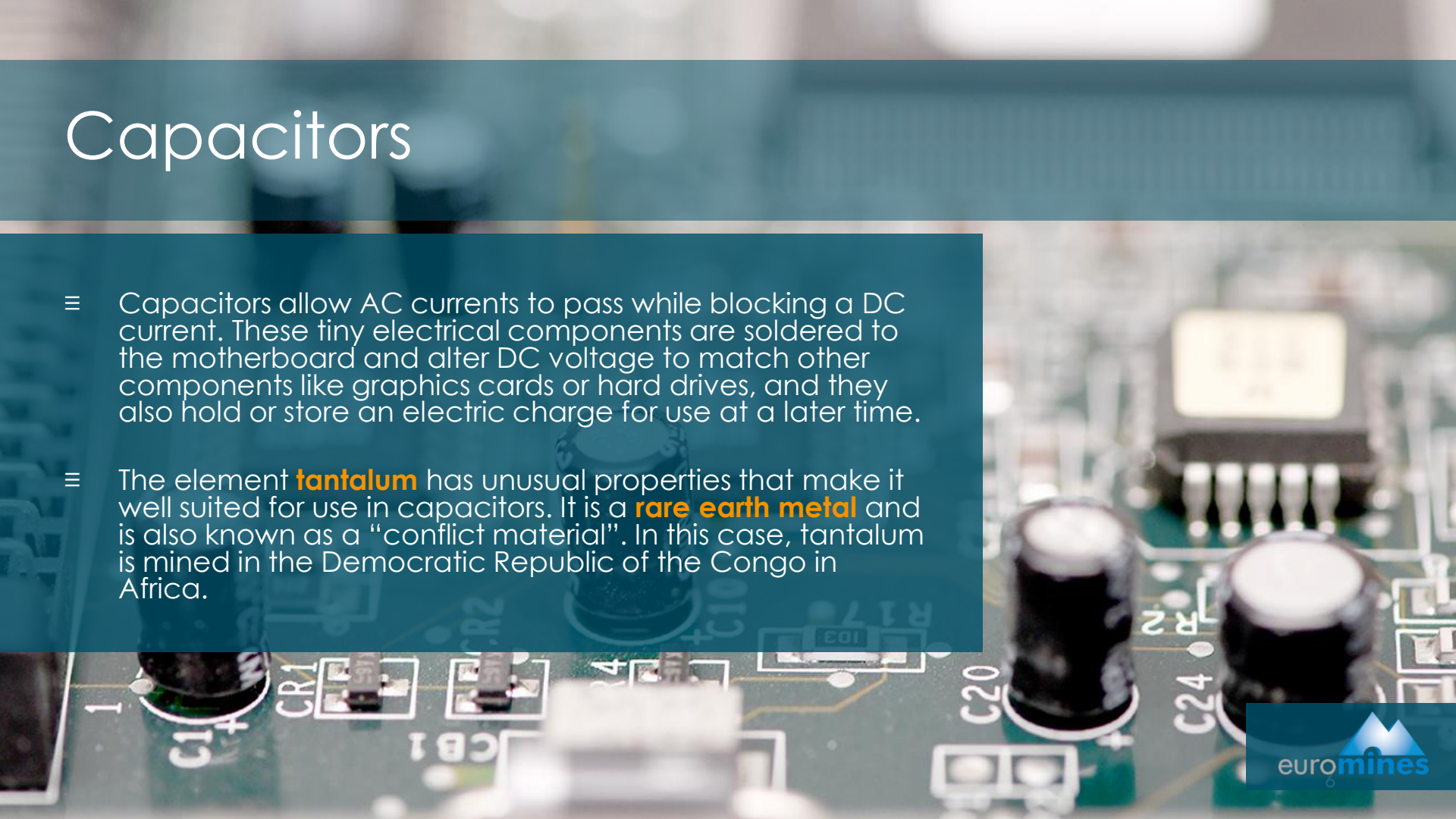
Capacitors

- Capacitors allow AC currents to pass while blocking a DC current. These tiny electrical components are soldered to the motherboard and alter DC voltage to match other components like graphics cards or hard drives, and they also hold or store an electric charge for use at a later time.

- The element **tantalum** has unusual properties that make it well suited for use in capacitors. It is a **rare earth metal** and is also known as a "conflict material". In this case, tantalum is mined in the Democratic Republic of the Congo in Africa.



Solder

- Today solder is not made with lead in it, lead-free solder is made from a combination of these metals: **copper, silver, bismuth, indium, zinc, antimony**, and traces of other metals.

Microchips and Memory Cards: The Integrated Circuits of CPUs, GPUs, and RAM

It begins with Silica Sand

- Starting with **silicon dioxide**, which is mined from the earth as **silica sand** or **quartz** from locations at various purities. It is among the most plentiful elements on earth and is used in a massive array of products: it's one of three key ingredients for solar panels and for computer electronics.
- **Quartz** is melted and crystalized by seed crystals, pulled out into a long cylinder and cut by diamond saw into wafers, which are distributed to various "fabs" (factories) for making different computer components, including those for making SSD memory.
- Microprocessors are assembled and inspected in clean rooms that require a degree of sanitation one hundred thousand times greater than an operating room.
- The high purity **silicon** is bathed in hydrogen peroxide and sulfuric acid first to clean the wafers. Next, it is bathed in deionized water and sulfuric acid to remove any particulate matter. After the second bath, the oxide layer is removed with deionized water and hydrofluoric acid. The wafer is finally bathed one last time in hydrochloric acid, hydrogen peroxide and deionized water.

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Adding Other Minerals to Improve Speed

- Silicon's electrical properties are semi-conductive. However, when **silicon** is doped with a small number of certain elements, its conductivity skyrockets.

- To speed up the performance of their CPUs, some producers began using **hafnium**, a rare metal that is also used for control rods of nuclear reactors, which are used to control the fission rate of uranium and plutonium.

- Microchips (GPUs) are silicon-layered with **tantalum** and **palladium** transistors and capacitors for better storage on a smaller chip, which is perhaps the most interesting of the materials used for GPUs and RAM cards are made from a mind-boggling array of chemicals and **copper, boron, cobalt, tungsten**, for starters.

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Hard Drive Discs

- The HDD evolved from the DAT format from the 1980s, which both read and wrote data to magnetic media. Magnetic disks use magnetic tape which is an inexpensive plastic film filled with **iron oxide** filled with **chromium dioxide**, but the platter of a hard disk drive is a plain disk made from metal.
- Aluminium is lightweight and non-magnetic but lacks the necessary hardness to work correctly. Instead, an alloy of aluminium and **magnesium** is used along with elements like **silicon, copper and zinc**. There are five or more substances in the blank platter, which spins extremely fast. Since the read/write head will hover millionths of a millimetre above it, it has to be polished perfectly flat. **Aluminium** alloys for hard disk platters can't be polished to the degree necessary, so NiP, an alloy of nickel and phosphorous is used instead. **Nickel** is ferromagnetic, **phosphorous** in non-metallic, but NiP is largely inert with all the material properties of a metal.
- The "soft magnetic underlayer" of the HDD, as it's known, used to be made mostly of **nickel, cobalt and iron**. As demand for storage capacity increased over the years, these metals were increasingly replaced by the rarer and more expensive metals **platinum and ruthenium**.
- Ruthenium ranks 74th out of the 90 naturally occurring elements on this planet in terms of scarcity, but it is less expensive than platinum, which is more valuable as a catalytic agent in global chemical industry and its use as a catalytic converter in the automotive industry.

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Solid State Drives

- Solid State Drives (SSDs) start as wafers of silicon distributed to “fabs” (factories) built specifically for making SSD memory. After the cleaning process, the silicon wafer is ready for NAND flash memory (specific materials and processes for NAND flash memory production are well protected by intellectual property regimes at the companies who design, use and maintain them.)
- Hundreds of trillions of transistors in the circuit design are etched onto the circuit board using **potassium hydroxide** (also known as caustic potash), layered with a photoresist chemical and cured part-by-part.
- The caustic potash reacts with the silicon, forming an oxide layer of **silicon dioxide**, which forms a layer of non-conductive material which sets apart other layers of the circuit. The chip then receives more conductive layers of **copper and aluminium**.
- Though all of this work is done for the silicon chip of the SSD, the plastic printed circuit board – made of an epoxy polymer plate reinforced with glass and printing with **copper wiring –** is the more dominant material.
- Using **tin solder** and **gold wiring**, the NAND flash chips, which are covered in plastic casings for protection, are connected to the PCB board, which is then moved into an **aluminium casing**.

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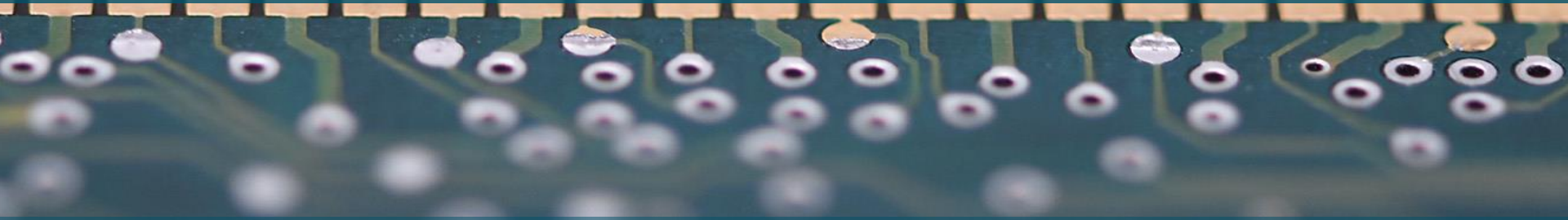
Printed Circuit Boards (PCB)



- The PCBs used in motherboards are made from an insulating sheet material layered with conducting **copper** tracks that also bookend either side. The copper tracks connect components, and the insulating sheet gives the PCB material strength and protects the layers from crossing paths.

- The components of GPUs are held in by **aluminium and copper, and tin, gold, silver and zinc** are used for switches and connections. ABS thermoplastic or a woven fiberglass material bonded by epoxy resin called FR-4 are the most common materials used in PCB boards, though ABS is more preferable because it is much more recyclable.

2019: Tender for 3 Supercomputers for the EU – How Many Raw Materials?

- the "Lumi" EuroHPC supercomputer, which will be hosted by CSC, the Finnish IT Center for Science, and to be installed in its data center in Kajaani (Finland). This lot foresees the procurement and maintenance of a leadership-class pre-exascale accelerated supercomputer, which enables the convergence of HPC, artificial intelligence (AI), and high-performance data analytics (HPDA).

- the "MareNostrum 5" EuroHPC supercomputer, which will be hosted in and by Barcelona Supercomputer Center – Centro National de Supercomputacion in Spain. This lot foresees the procurement and maintenance of a world-class supercomputer, which will, inter alia, be fully powered with green energy, including heat reuse.

- "Leonardo" EuroHPC supercomputer, which will be hosted in Bologna (Italy), in the premises of the new data centre of CINECA, a non-profit consortium, made up of 70 Italian universities, four national research centres and the Ministry of Universities and Research (MIUR).

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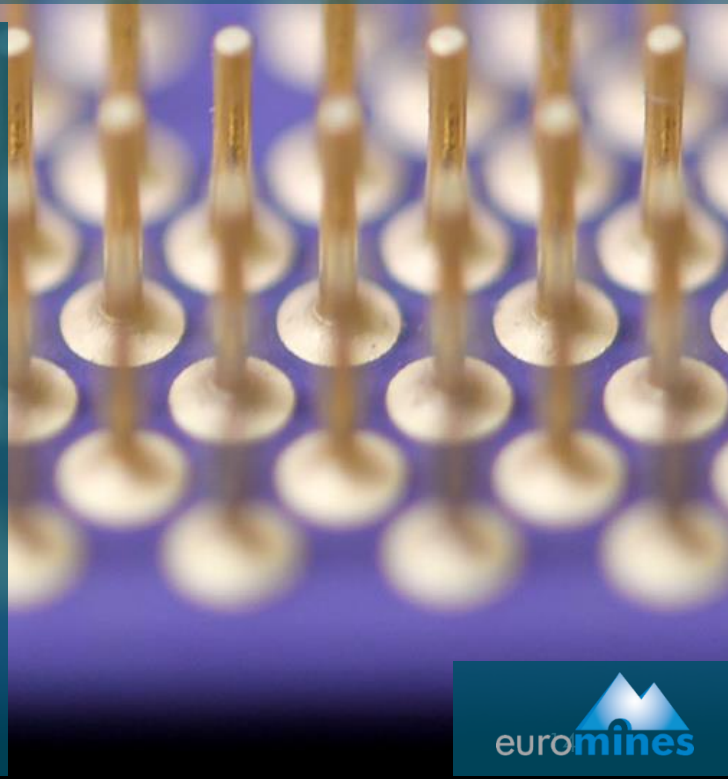
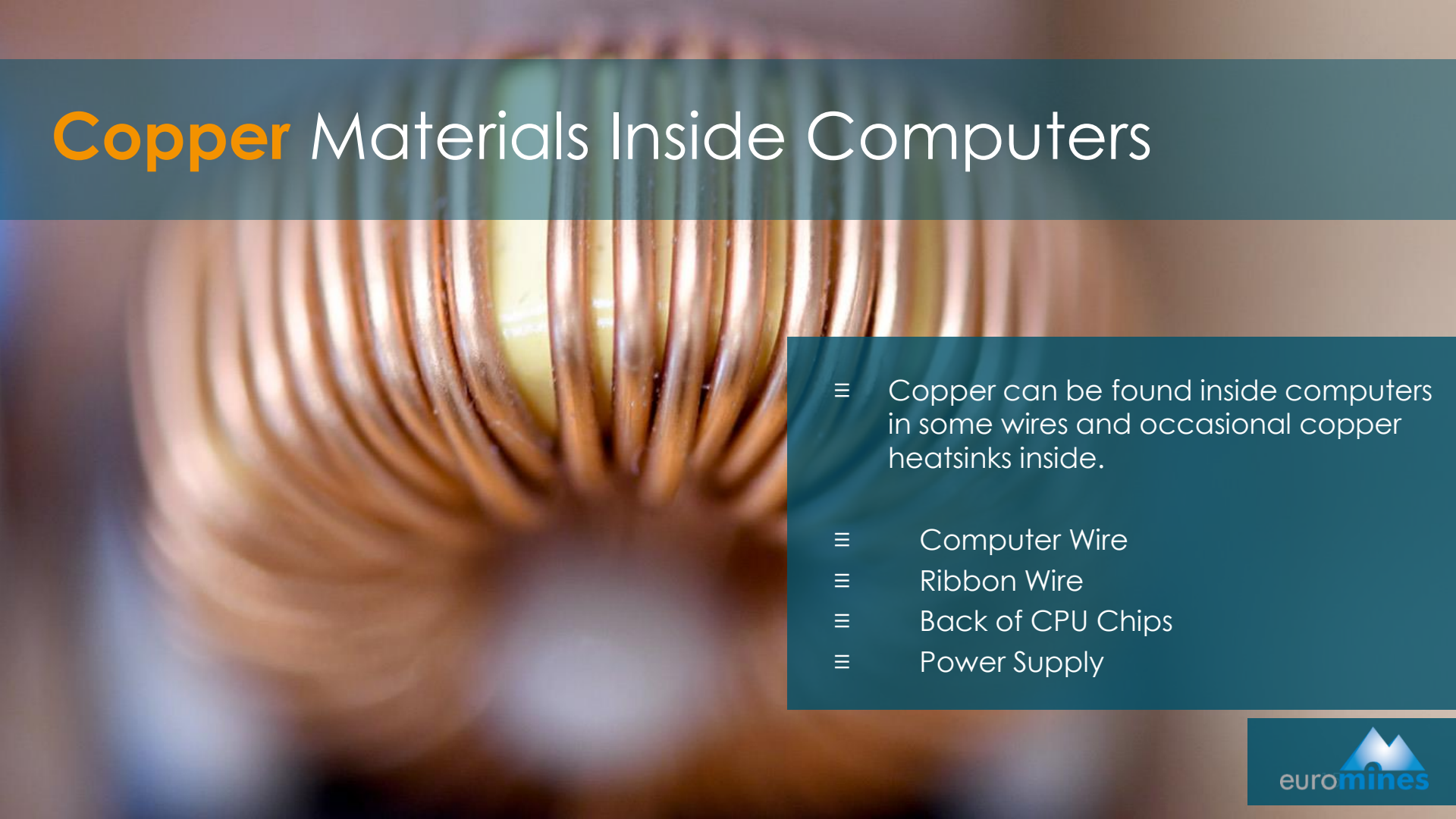
Gold Materials Inside Computers

- This is the obvious metal that is desired when scrapping computers. Whether it's from the RAM boards, CPU chips, or the motherboard, gold is all over the inside of a computer. Many older computers will have more gold content inside of them compared to the more modern computers. Gold is such a high-valued commodity that manufacturers have tried to find more ways to avoid using such an expensive metal.

- CPU Chips
- RAM Boards
- Motherboards
- Hard drive Boards



Copper Materials Inside Computers



- Copper can be found inside computers in some wires and occasional copper heatsinks inside.

- Computer Wire
- Ribbon Wire
- Back of CPU Chips
- Power Supply

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Copper Facts

- In the most powerful computer chips, copper's superior electrical conductivity enables conductor channel lengths and widths to be significantly reduced. The result is much faster operating speeds and greater circuit integration - 400 million transistors can be packed onto a single chip. Power requirements are now reduced to less than 1.8 volts, and the chips run cooler than ever before.

- The use of copper conductors in the chip is the last link in a now unbroken copper chain comprising the electronic data path between user and computer. From external cables and connectors to bus ways to printed circuit boards, sockets and leadframes, it's all copper.

- Since their invention early in this century, electron tubes have depended on copper and copper alloys for their internal components. They include the cathode ray tubes used in TVs and computer monitors, voltage rectifiers, audio and video amplification and broadcast applications, and the magnetrons in microwave ovens.

- Radio and television signals are carried to transmission antennas by hollow conduits called wave-guides. Wave-guides made of oxygen-free, high-conductivity copper are 30% to 40% more efficient than their aluminium counterparts.

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Copper Facts

- On a smaller scale, copper strip is used to shroud electron tubes, transistors, integrated circuits and even complete electronic chasses to prevent radio frequency (RF) interference.

- Most electronic components generate heat which can cause them to age and fail prematurely. This is especially true for today's highly integrated microprocessors (computer chips).

- Copper is used to enhance new radio frequency identification (RFID) technology used for security, tracking and purchasing systems in retail, manufacturing, transportation and distribution.

- Most printed circuit boards for electronic products are made by laminating a sheet of copper onto a flexible film and then etching away much of the copper to leave thin lines of solid copper that carry current. A new method uses inkjet technology to deposit only thin copper lines onto the circuit, eliminating waste and making circuits less expensive to produce.

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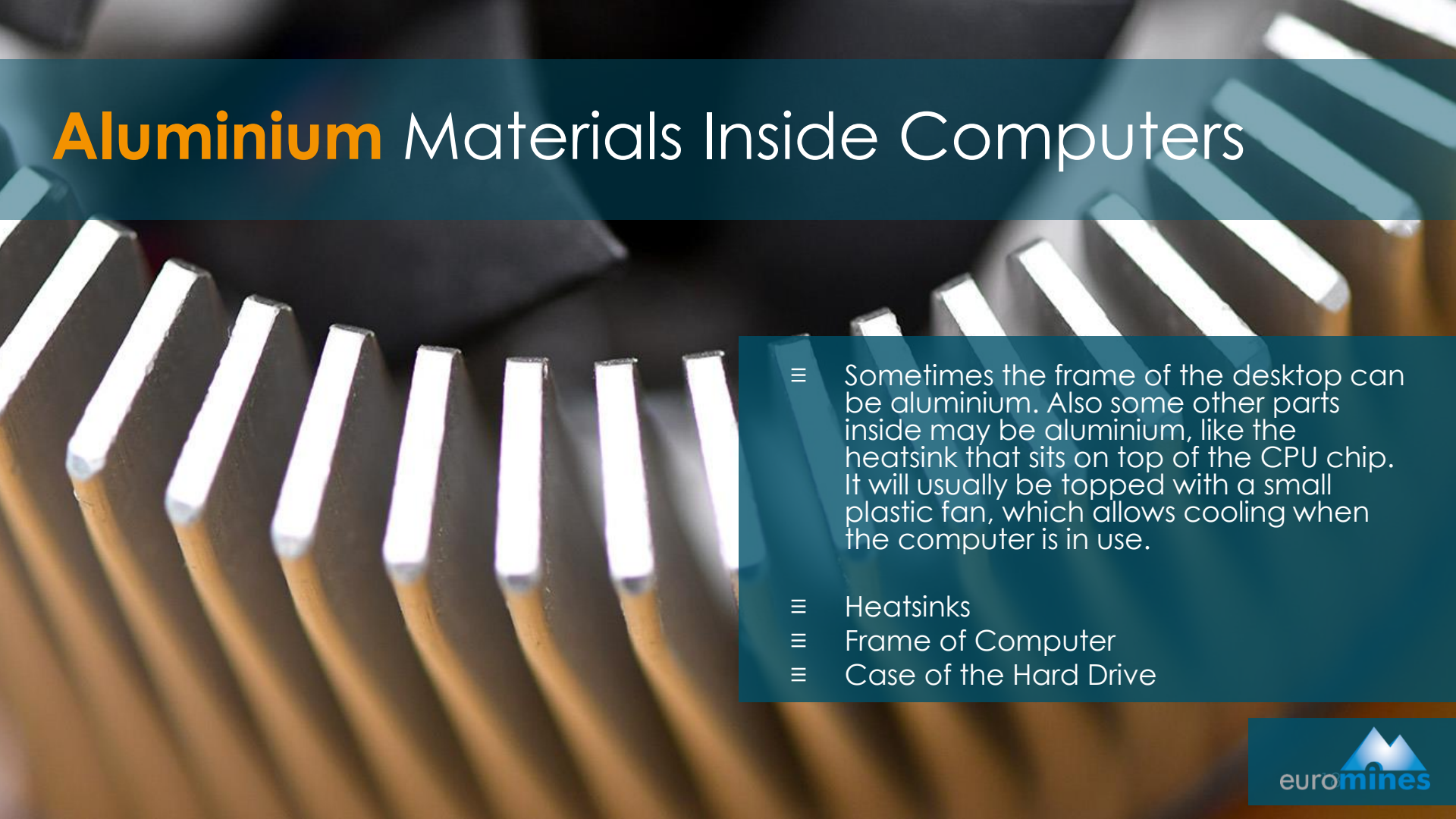
Aluminium Materials Inside Computers



- Sometimes the frame of the desktop can be aluminium. Also some other parts inside may be aluminium, like the heatsink that sits on top of the CPU chip. It will usually be topped with a small plastic fan, which allows cooling when the computer is in use.

- Heatsinks
- Frame of Computer
- Case of the Hard Drive

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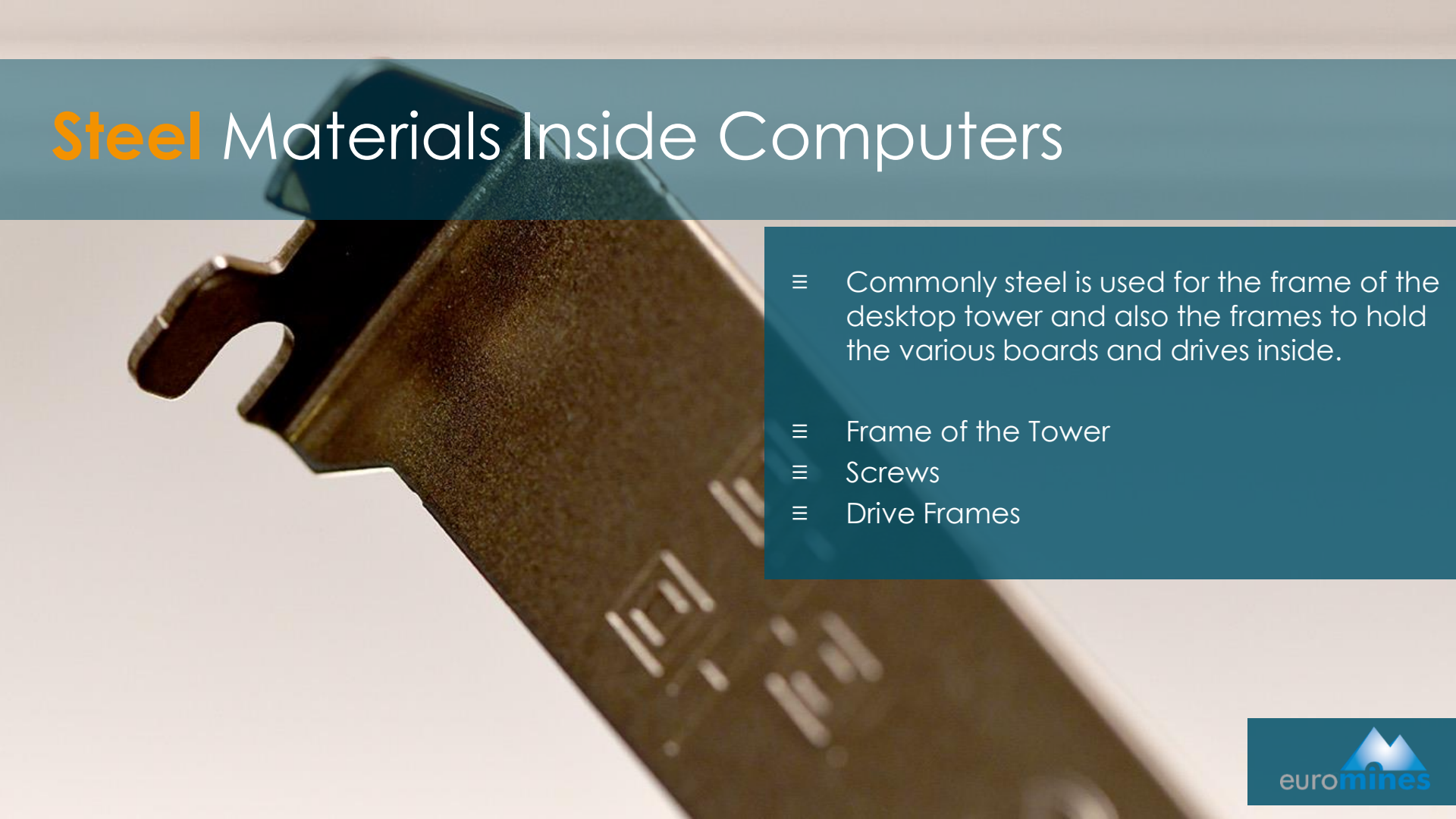
Steel Materials Inside Computers



- Commonly steel is used for the frame of the desktop tower and also the frames to hold the various boards and drives inside.

- Frame of the Tower
- Screws
- Drive Frames

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