

Lecture 1: Civilization and Evolution of Materials

FUNH 5000 L01

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2024-9-2



香港科技大学(广州)

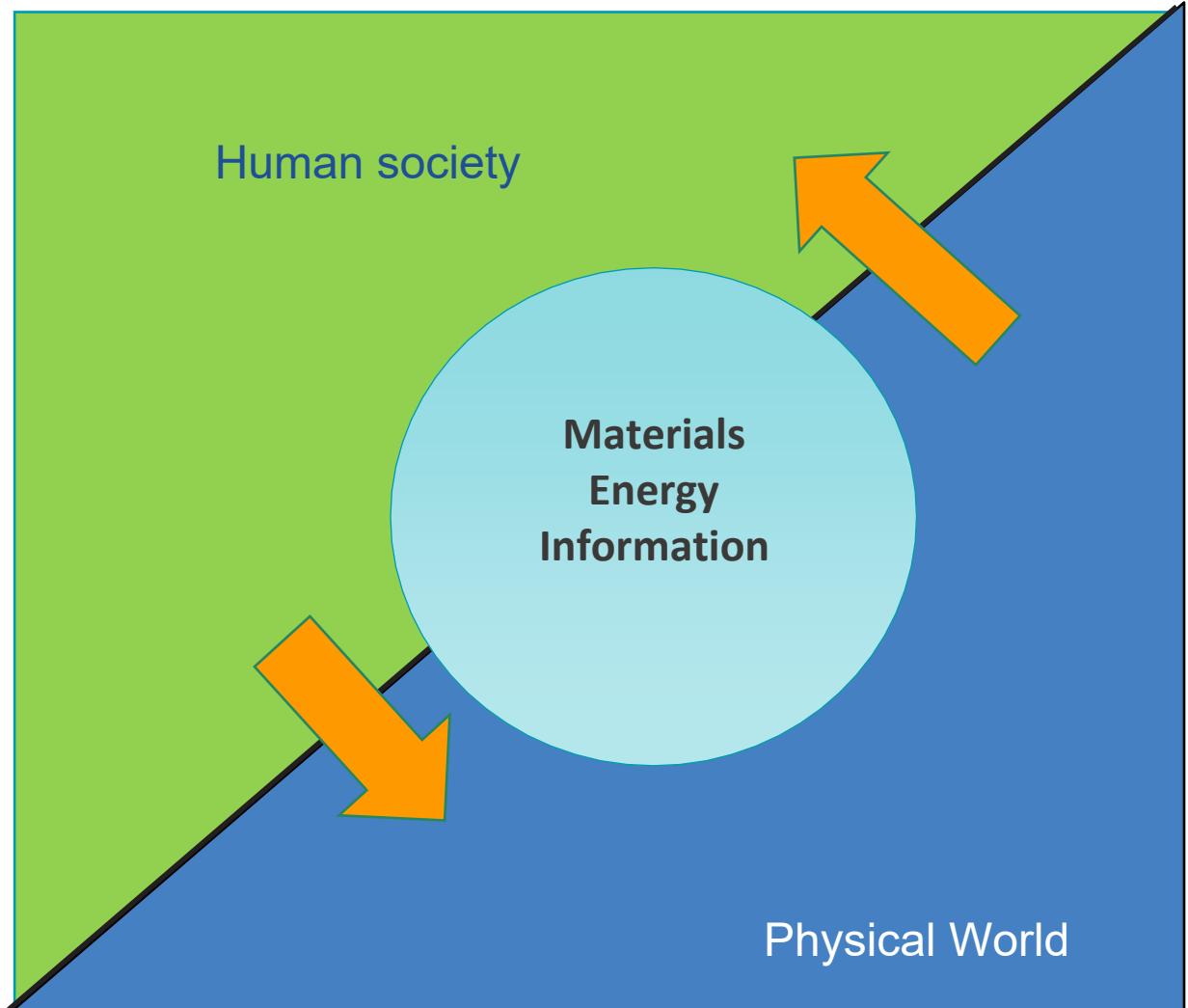
THE HONG KONG UNIVERSITY OF SCIENCE
AND TECHNOLOGY (GUANGZHOU)

Vocabulary of this lecture

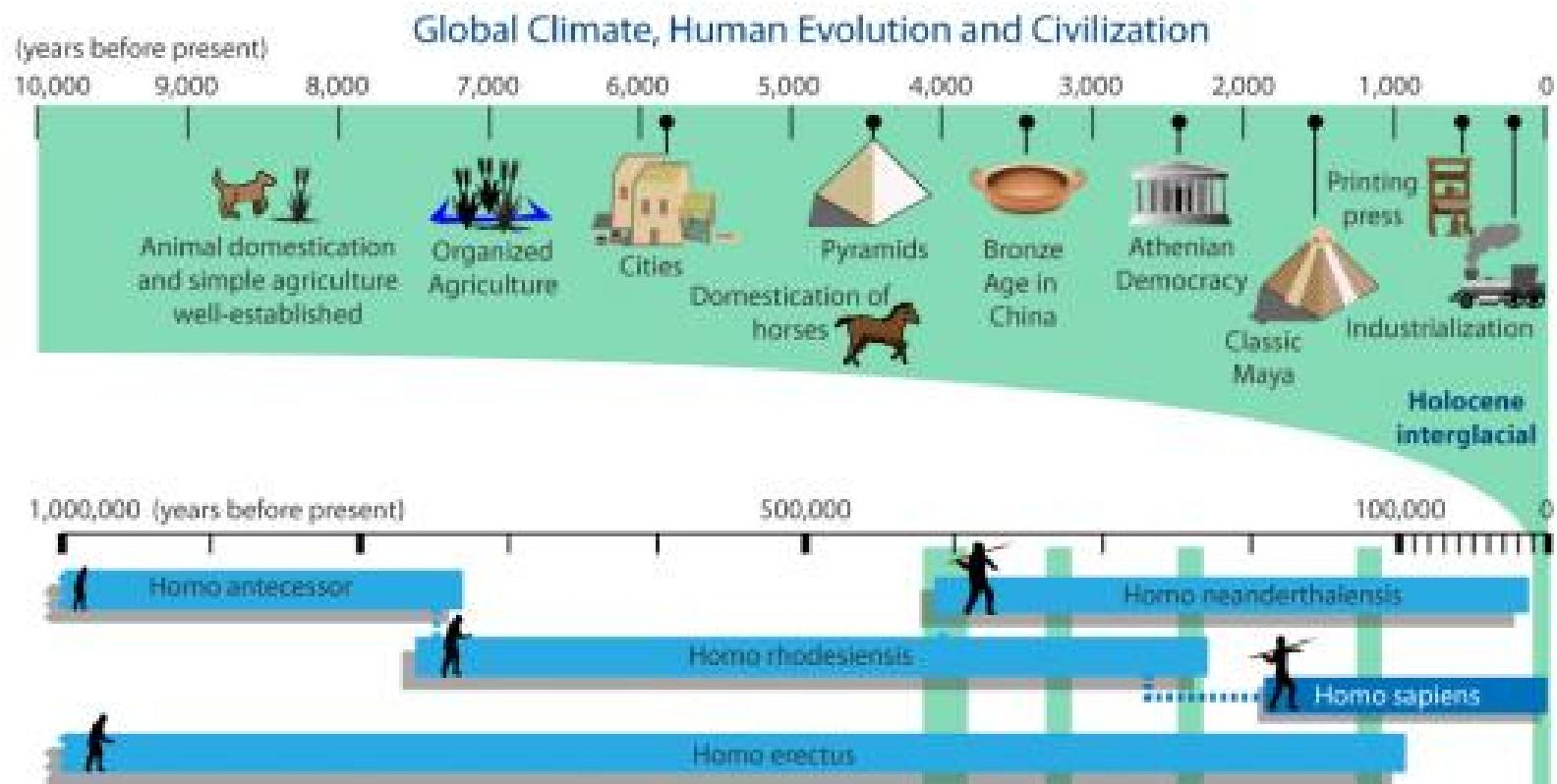
- Clay: 粘土
- Porcelain: 瓷器
- Brittle: 易碎的
- Charcoal: 木炭
- Ceramic: 陶瓷器
- Kaolinite: 高岭土
- Crystalline structure: 晶体结构
- Meteorite: 陨石
- Vulcanization: 硫化
- Insulative: 绝缘的
- Incandescent: 发白热光的

Human Civilization

- The development of new capacities in science, engineering, politics, arts, etc.
- Civilization develops through exploration of the physical world.
- More advanced civilization is often characterized by better productivity and capability in meeting the needs of human beings.



Development of civilizations

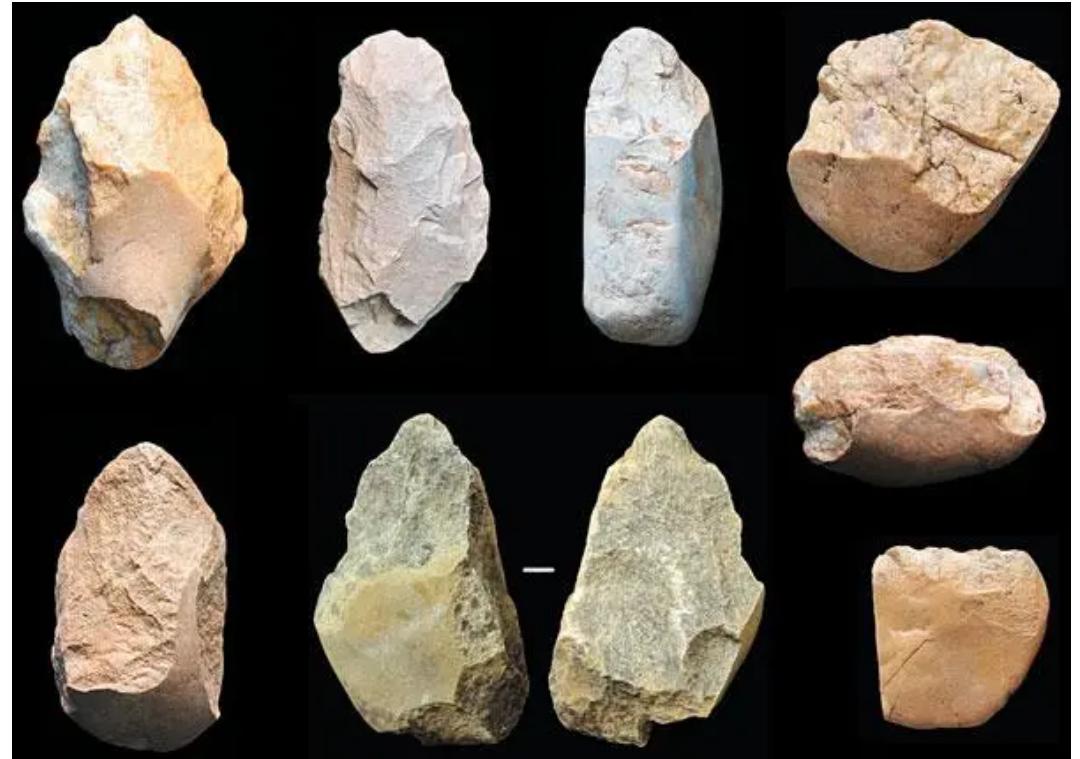


Stone Age
↓
Pottery Age
↓
Bronze Age
↓
Iron Age
↓
Steel Age
↓
Polymer Age
↓
Silicon Age
.....

- Materials play a critical role in the development of civilization
- Different civilization stages are closely connected with the development and use of new materials

Stone Age

- 100 million years to ~10000 years.
- Hunting and gathering are the key activities of human beings in the Stone Age.



Stone Age

- Cutting and cracking were the primary needs for tools.
- Stone tools improve over time



New Stone Age to Pottery Age

- **The use of fire accelerated the evolution of civilization in many ways.**
- **In early years, firing temperature drives the development of materials.**



<https://evolutionoftheprogress.com/invention-of-fire/>

Pottery Age

- Started at around 18000 BC.
- Clay is the raw material for pottery.
- Pottery was developed to meet the need for storing food or water.
- Sun-drying pottery is only suitable for storing dry materials.



<https://www.soulceramics.com/pages/how-to-dry-pottery>

Pottery Age

- A chemical reaction occurs under the fire of clay near 500-800 °C, and the clay hardens and can hold water.
- Wood burning was often used for pottery



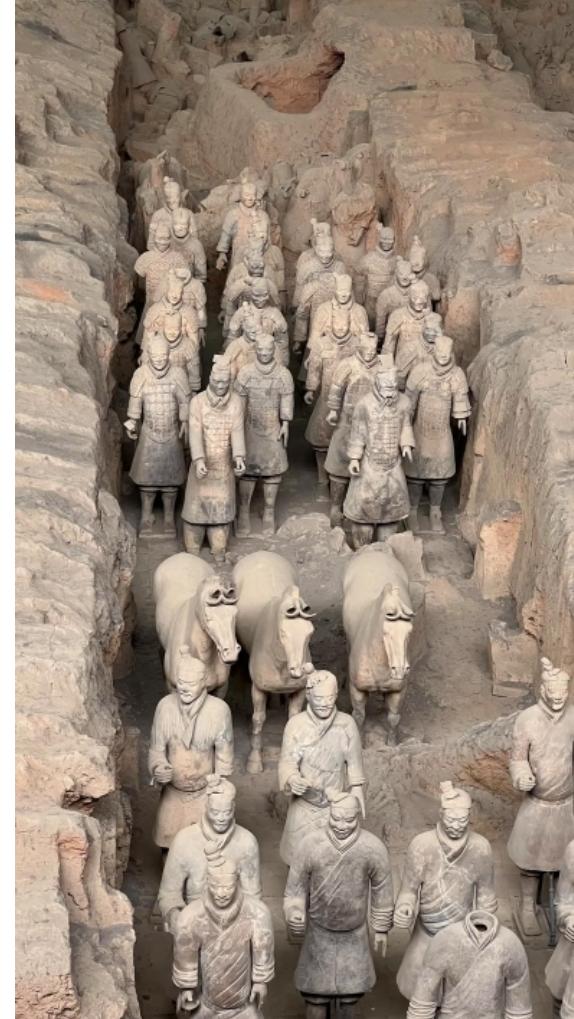
夏代陶鬲

<https://www.huatu.com/photo/show/20230828/123210687200.html>
<http://www.zhongguociwang.com/show.aspx?id=16567&cid=139>



仰韶文化 (5000-3000BC)

Pottery Age



Terracotta of Qin Dynasty

<https://www.douyin.com/note/7203369125379444025>

Pottery Age



唐三彩



<https://www.mct.gov.cn/>

Pottery Age

- Porcelain
- Raw material is Kaolinite
- Burned at temperatures between 1200 and 1400°C
- Stronger, better water resistance than earthenware



Pottery Age

- Heat treatments trigger reactions in raw materials and substantially improve the properties of materials.
- Ceramics are the **first** man-made material.
- Forming **crystalline structures** in potteries by firing was an important technological advance for human beings.



Bronze Age

Farming further developed. Conflicts between different tribes became frequent.

Stronger and more powerful tools are needed

Charcoal was used, increasing firing temperatures

Bronze was then invented, starting the Bronze Age (~4000 BC)



Bronze Age

Bronze: alloy of copper and Tin. Pure copper is too soft; adding other metals increases the hardness.

Cu-Zn alloy (bronze) requires temperatures of $\sim 800^{\circ}\text{C}$, lower than the melting point of pure Cu (1084°C).



Bronze Age



Bronze Age



央视
新闻



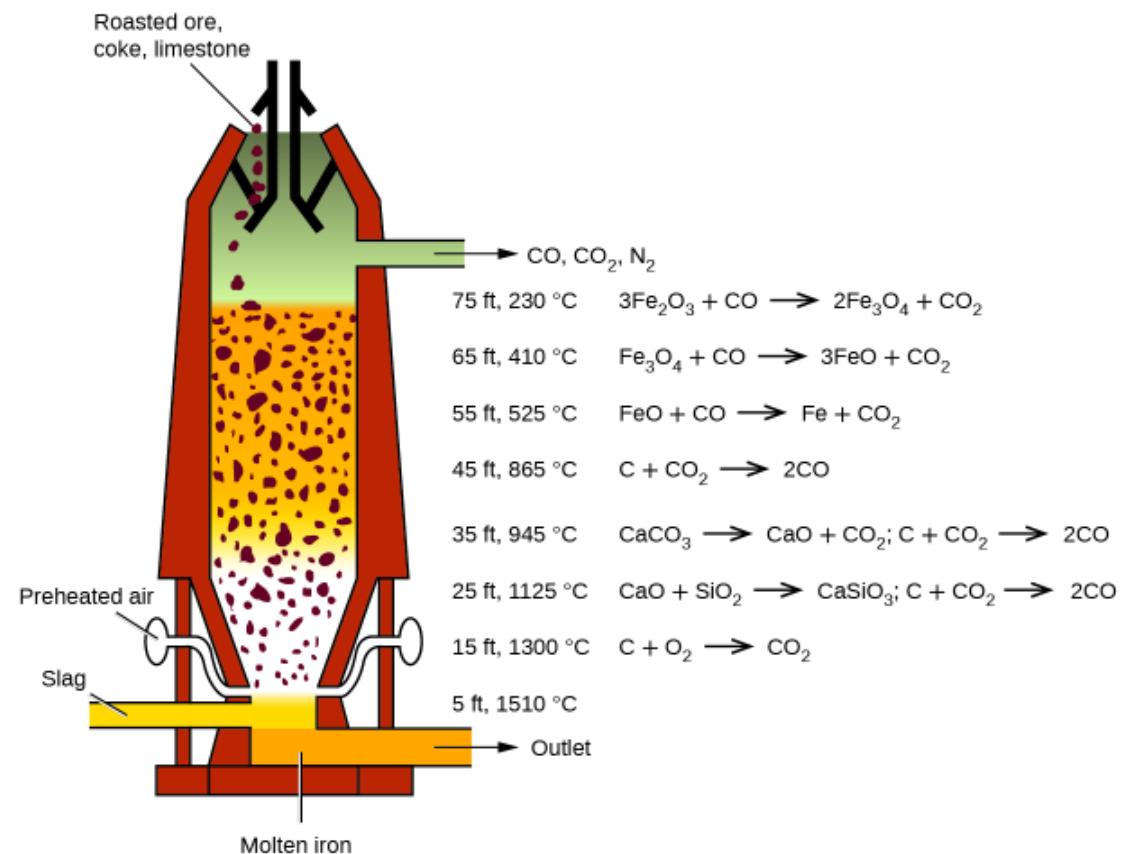
Iron Age

- Started as early as 4000 BC.
- The word “iron” means “metal from the sky”, from meteoric iron.
- learned to smelt iron ores and transform them into cast iron (1538°C).
- Compared with bronze, iron is more abundant, and more broadly used in agriculture



Steel Age

- Iron is soft, easy to rust
- Iron alloys, such as steel, demonstrate superior properties
- Steel is an alloy of iron and carbon
- Large-scale steel production started during the Industrial Revolution

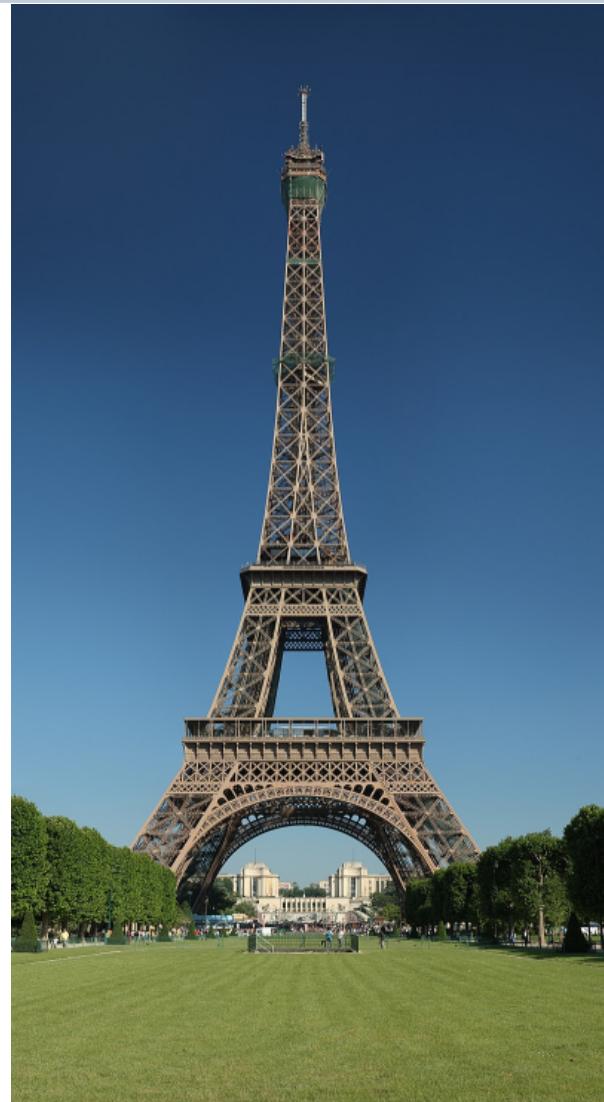


Steel Age



<http://www.railway-fasteners.com/news/Quality-steel-rail-for-sale.html>

Steel Age



<https://zh.wikipedia.org/zh-cn;>

https://www.gov.cn/jrzq/2008-06/20/content_1022397.htm

Steel Age



<https://www.itipack.com/steel-strapping-machines-for-metal-industry/>
<https://www.meet-in-shanghai.net/cn/attraction/>

Steel Age

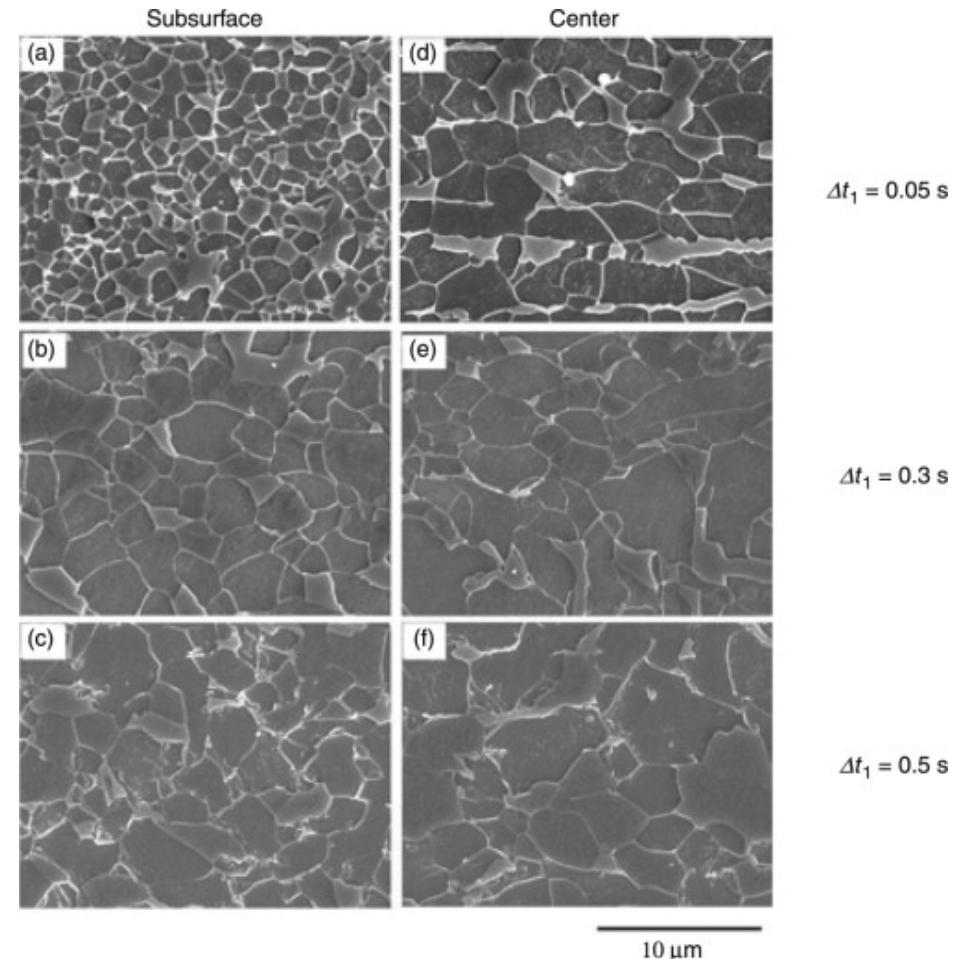


<https://worldsteel.org/media/steel-stories/innovation/>

<https://www.agi.it/economia/news/2023-12-01/musk-tesla-cybertruck-video-lancio-24235581/>

Nanostructured Steel

- Microstructures with a grain size of several hundred nanometers
- High strength hardened by nanoparticles
- Good local deformability
- Good machinability
- Feasible for mass production



Torizuka et al., 2011. T. Tomida et al. 2011. Ultra-fast cooling

Environmental Impacts of Steel production and CO₂

- Steel production accounts for ~ 16% of total carbon emission in China
- Also caused air pollution problems
- More environmentally friendly materials are needed.



https://www.sohu.com/a/111576669_429139

New materials: Polymer

1850s: Rubber vulcanization

1907: The birth of synthetic polymer industry - phenol formaldehyde (酚醛树脂)

1920: Über Polymerisation, marking the development of modern polymer theory.

1953 (Chemistry) Hermann Staudinger for contributions to the understanding of macromolecular chemistry.

1963 (Chemistry) Giulio Natta and Karl Ziegler for contributions in polymer synthesis. (Ziegler-Natta catalysis).

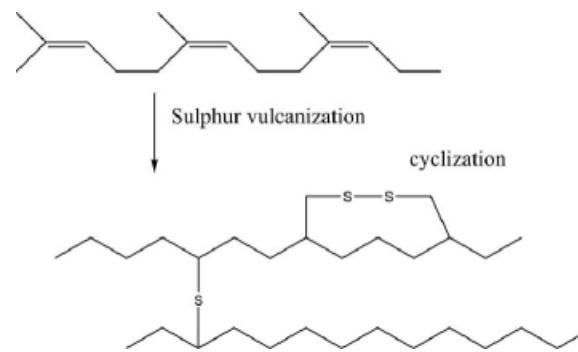
1974 (Chemistry) Paul J. Flory for contributions to theoretical polymer chemistry

1991 (Physics) Pierre-Gilles de Gennes for developing a generalized theory of phase transitions with particular applications to describing ordering and phase transitions in polymers

2000 (Chemistry) Alan G. MacDiarmid, Alan J. Heeger, and Hideki Shirakawa for work on conductive polymers, contributing to the advent of molecular electronics.

2002 (Chemistry) John Bennett Fenn, Koichi Tanaka, and Kurt Wüthrich for the development of methods for identification and structure analyses of biological macromolecules

2005 (Chemistry) Robert Grubbs, Richard Schrock, Yves Chauvin for olefin metathesis



www.taiwanpu.com

Applications of Polymer Materials

Adhesives



Paints

Carpeting



Rubber

Cosmetics



Fabrics

Fertilizers



Plastics

Further evolution of materials

Stone Age

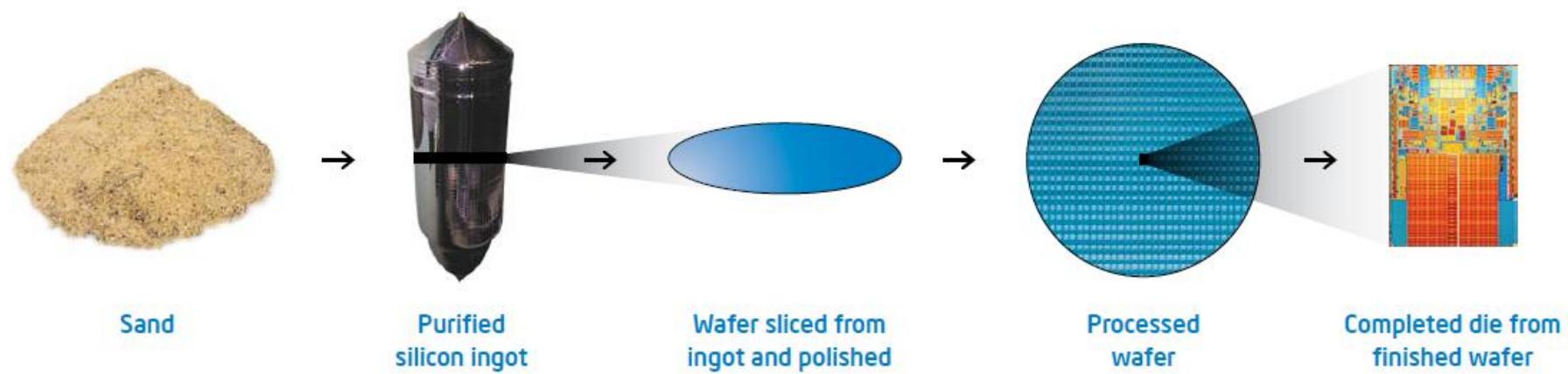
Bronze Age

Iron Age

Steel

Polymer

» **Silicon Age**

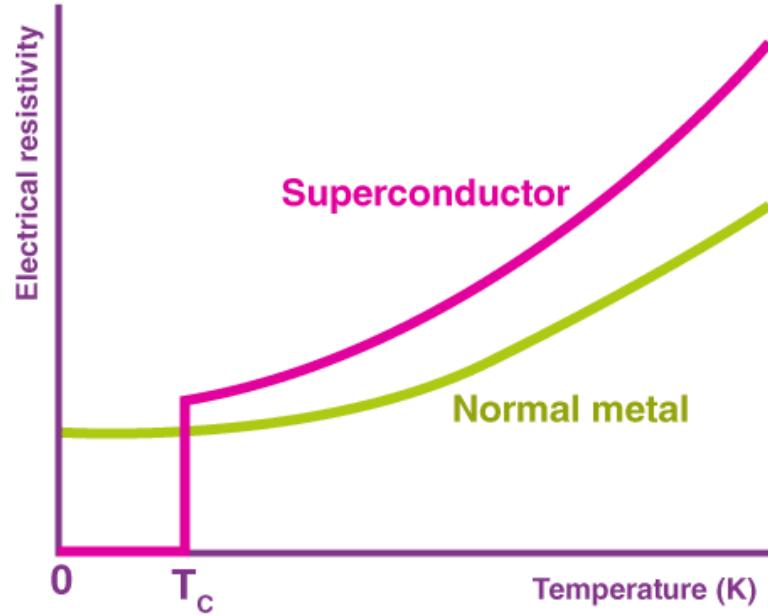


<https://techovedas.com/the-gypsy-chip-how-a-tiny-semiconductor-travels-the-world/>

Silicon-based electronics



Superconductor Materials



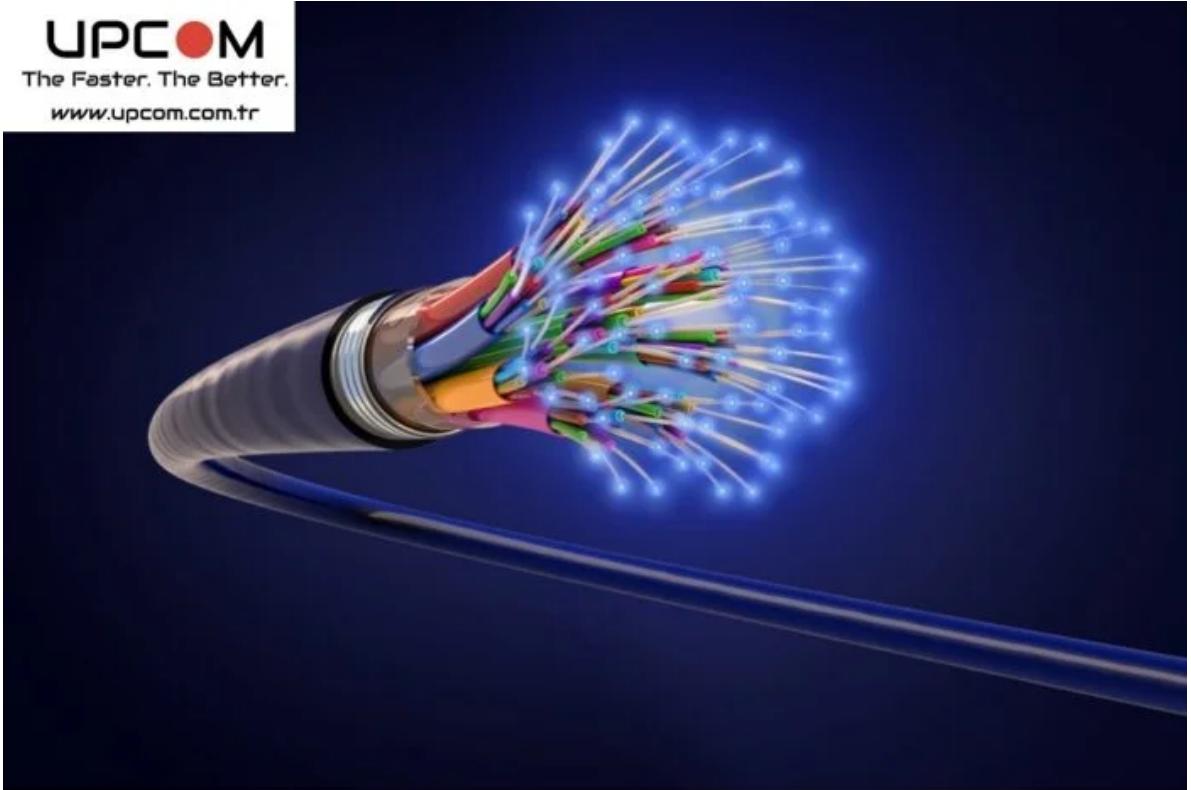
 BYJU'S
The Learning App



magnetic levitation (maglev) trains
<http://www.sscline.com/?p=74&lang=en-us>

Optical Materials

UPCOM
The Faster. The Better.
www.upcom.com.tr



Optical Fibers



light emitting diode

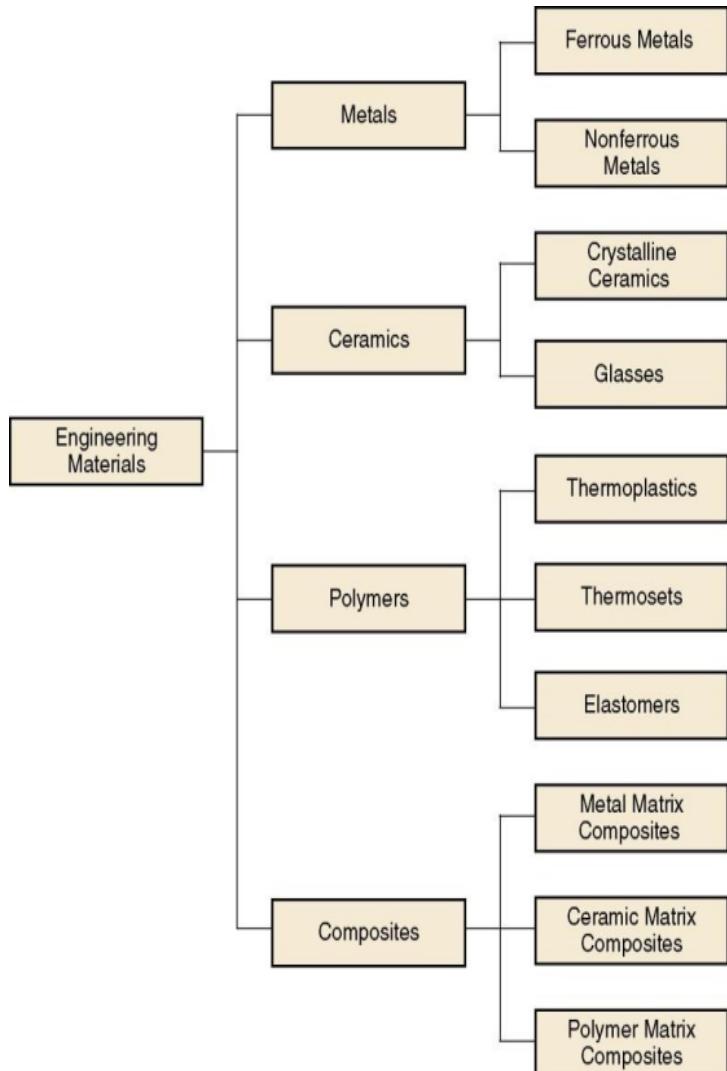
Composite materials



<https://news.cctv.com/>

<https://www.azocleantech.com/article.aspx?ArticleID=1209>

Materials and civilization



Stone Age

Pottery Age

Bronze Age

Iron Age

Steel Age

Polymer Age

Silicon Age

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- The evolution of materials is incremental and continuous, driven by the needs of human beings.
- New materials are revolutionary and have shaped the development of civilization
- More advanced civilization is often characterized by using more advanced and sophisticated materials.

New trends in material development

- **New High-Performance Materials Drive Disruption Across Industries.**
- **Sustainability is considered when developing new materials.**
- **Complex Materials Require Novel Manufacturing and Testing Techniques.**
- **Modeling is adopted in developing new materials.**

<https://www.zwickroell.com/>

Material Science



The four components of the discipline of materials science and engineering and their interrelationship

- Materials Science is the investigation of relationships that exist between the **processing, structures, properties, and performance** of materials.
- An interdisciplinary area of chemistry, physics, and engineering.
- Materials Science has a long history and is evolving rapidly.

AMAT Thrust



Tong Yi ZHANG
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Chair Professor

Materials Informatics



Ping GAO
高平
Professor

Polymer
nanomembranes and
metamaterials



Wei Jia WEN
温维佳
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Wavefunctional
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Xia Kun CHU
楚夏昆
Assistant Professor

Computational biophysics



Ze Cheng GAN
干则成
Assistant Professor

Scientific computing

..... 17 Faculty members



Section 1, Lecture 1

- * 1. Do you have any questions about this lecture?

- * 2. Any suggestions or comments to this lecture?

提交