REPUBLIQUE ALGERIENNE DEMOCRATIQUE ET POPULAIRE

MINISTERE DE L'ENSEIGNEMENT SUPERIEURET DE LA RECHERCHE SCIENTIFIQUE

OFFRE DE FORMATION MASTER

PROFESSIONNALISANT

Semestre: 1
Unité d'enseignement: UED.1.1.
Matière 1: Matériaux innovants
VHS: 22h30 (Cours :1h30)
Crédits: 1
Coefficient :1

Etablissement	Faculté / Institut	Département
Université Mohamed Seddik Ben Yahia – Jijel-	Faculté des Sciences et de la Technologie	Génie des procédés

Domaine : Sciences et technologiesFilière : Génie métallurgique Spécialité : Génie métallurgique

Année universitaire : 2023-2024

Semestre: 1
Unité d'enseignement: UED.1.1.
Matière 1: Matériaux innovants
VHS: 22h30 (Cours :1h30)
Crédits: 1
Coefficient :1

Semester: 1
Teaching Unit: Unit Teaching Discovery, Code : UTD 1.1
Subject 1: Innovative materials
Semest er timetable volume (15 weeks) STV: 22h30 (Course(Class): 1h30)
Credits: 1
Coefficient: 1

Objectifs de l'enseignement:

Faire comprendre aux étudiants l'importance du choix d'un matériau, son amélioration, sa fonctionnalisation ou sa structuration repose sur une solide connaissance de ses propriétés physiques et chimiques, de ses méthodes d'élaboration et de structuration. La science des matériaux est par nature interdisciplinaire, { l'interface entre la chimie, la physique et aussi la biologie. Un matériau de fonction est un assemblage d'atomes, de molécules réalisé en vue de l'obtention d'une propriété ou de son amélioration, ou mettant en jeu plusieurs propriétés au sein du même assemblage. Les besoins croissants en matériaux innovants ou à hautes performances se retrouvent dans tous les secteurs d'activités : automobiles, composants électroniques, chimie, métallurgie, construction, environnement, santé,… ce qui a stimulé de manière exponentielle les recherches dans ces domaines.

Teaching objectives

To help students understand the importance of choosing, improving, functionalizing or structuring a material, they need a solid understanding of its physical and chemical properties, and of the methods used to develop and structure it. Materials science is by nature interdisciplinary, at the interface between chemistry, physics and biology. A functional material is an assembly of atoms or molecules designed to obtain or improve a specific property, or to combine several properties in the same assembly. The growing need for innovative or high-performance materials can be found in all sectors of activity: automobiles, electronic components, chemistry, metallurgy, construction, environment, health, etc., which has exponentially stimulated research in these fields.

Contenu de la matière:

Chapitre I : Eco-matériaux **(2 semaines)**

1- La conception bioclimatique

2- Intégration progressive de nouveaux matériaux dans la construction3- Procédures suivies pour réduire les émissions du ciment

4- Réductions des émissions dus au Béton

5- Critères d'impacts environnementaux (Critères techniques, de mise en œuvrer, sociaux etEnvironnementaux)

Subject content:

Chapter I: Eco-materials (2 weeks)

1- Bioclimatic design

2- Progressive integration of new materials in construction

3- Procedures to reduce cement emissions

4- Reducing emissions from concrete

5- Environmental impact criteria (technical, implementation, social and environmental criteria)

Chapitre II : Liants alternatifs et produits de substitution **(2 semaines)**

1- Introduction

2- Vers des bétons plus performants

3- Vers des liants avec ajouts minéraux en substitution au clinker

4- De nouvelles substitutions totales au clinker (Poudre de verre, Liants de verre et Liantsbélitiques).

5- Nouveaux liants alternatifs

Chapter II: Alternative binders and substitute products (2 weeks)

1- Introduction

2- Towards higher-performance concretes

3- Towards binders with mineral additions as substitutes for clinker

4- New total substitutions for clinker (glass powder, glass binders and belitic binders).

6- New alternative binders

Chapitre III : Béton auto plaçant (BAP) **(2 semaines)**

1- Définition du Béton auto-plaçant2- Principe du Béton auto-plaçant

3- Formulation du Béton auto-plaçant

4- Mise en œuvre du Béton auto-plaçant

5- Propriétés du Béton auto-plaçant

6- Avantages du BAP et Applications

Chapter III: Self-placing concrete (2 weeks)

1- Definition of self-compacting concrete

2- Principle of self-compacting concrete

3- Formulation of self-compacting concrete

4- 5Application of self-compacting concrete

5- Properties of self-compacting concrete

6- BAP benefits and applications

Chapitre IV : Liants organiques **(3 semaines)**

1- Définition du polymère avec (Exemple de polymères)2- Classifications des bétons à base de polymères

3- béton polymère (Propriétés et applications)

4- béton additionné de polymère (Propriétés et applications)5- bêton imprégné de polymère (Propriétés et applications)

Chapitre V : Béton de fibres (BF) **(3 semaines)**

1- Définition du Béton de fibres

2- Propriétés des fibres et des matrices3- Mécanisme de rupture

4- Propriétés typiques des fibres

5- formulation des bétons de fibres6- Ouvrabilité des bétons de fibres 7- Résistance et durabilité

Chapter V: Fiber concrete (3 weeks)

1- Definition of fiber concrete
2- Properties of fibers and matrices
3- Failure mechanism
4- Typical properties of fibers
5- Formulation of fiber concretes
6- Workability of fiber concretes
7- Strength and durability

Chapitre VI : Bétons à performances optimisées (BHP) **(3 semaines)**

1- Définition et principe du béton à hautes performances

2- Formulation et Mise en œuvre du béton { hautes performances3- Propriétés du béton à hautes performances

3- Avantages du BHP et leurs applications

Chapter VI: Optimized performance concrete (OPC) (3 weeks)

1- Definition and principle of high-performance concrete
2- Formulation and processing of high-performance concrete 3- Properties of high-performance concrete
3- Advantages and applications of HPC

Mode d'évaluation:

Examen: 100%.

Assessment Method

Exam : 100 %

Références bibliographiques :

https://www.techniques-ingenieur.fr/actualite/articles/materiaux-metalliques-quelles-proprietes-pour-quelles-applications-110669/

References:

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Introduction

In the field of metallurgy, innovative materials represent a significant area of research and development, as they offer the potential to revolutionize the properties and performance of metals and alloys. These materials are engineered to enhance traditional metallic materials in terms of strength, durability, corrosion resistance, and other critical properties, leading to a wide range of applications across various industries. Here's an introduction to innovative materials in the metallurgical field:

1. Advanced Alloys: Metallurgists and materials scientists are continually developing advanced alloys that exhibit exceptional mechanical properties, such as increased strength, toughness, and ductility. These alloys often result from precise combinations of various metallic elements and may be tailored to withstand extreme temperatures, aggressive chemical environments, or other demanding conditions.
2. High-Performance Steels: Steel is a ubiquitous material in construction, transportation, and manufacturing. Innovative metallurgical advancements have led to the creation of high-performance steels, including high-strength, high-temperature, and corrosion-resistant varieties. These steels open doors to safer and more efficient designs in structures, automotive components, and industrial machinery.
3. Shape Memory Alloys: Shape memory alloys (SMAs) are a class of innovative materials that have found applications in fields like aerospace and biomedical engineering. SMAs can "remember" and return to their original shape after being deformed, making them suitable for applications such as self-repairing components and minimally invasive medical devices.
4. Nanomaterials in Metallurgy: Nanotechnology has introduced a range of innovative materials in metallurgy, including nanocrystalline metals and nanoparticles. These materials often possess superior mechanical properties due to their nano-sized grains, making them ideal for applications that demand high strength and lightweight materials.
5. Lightweight Alloys: In industries such as aerospace and automotive manufacturing, there is a growing demand for lightweight materials to improve fuel efficiency and reduce emissions. Innovative lightweight alloys, such as aluminum alloys, magnesium alloys, and titanium alloys, are being developed to meet these requirements without compromising strength.
6. Smart Coatings and Surface Treatments: Metallurgy also plays a crucial role in the development of smart coatings and surface treatments for metals. These coatings can provide enhanced corrosion

resistance, self-healing capabilities, and even specific optical or electronic properties, making them valuable in fields like energy production, electronics, and automotive industries.

7. Additive Manufacturing: Innovations in metallurgical processes have enabled the advancement of additive manufacturing, particularly in 3D printing with metals. This technology allows for the production of highly intricate and customized metal components with complex geometries, which can be challenging to achieve using traditional manufacturing methods.

In summary, innovative materials in the metallurgical field are transforming the way we use metals and alloys across various industries. These advancements have the potential to enhance the performance and durability of metallic materials while opening up new possibilities for engineering solutions in areas such as aerospace, automotive, energy, and healthcare. Continued research and development in metallurgy are essential for pushing the boundaries of what is achievable with these innovative materials.

Chapter 1

Innovative Materials in General

By Pr. MAHAMDIOUA Nabil

1. Introduction

- The advancement of materials is a key area of scientific research and technological innovation.
- It includes the study, development, design and application of new materials, as well as the improvement of existing materials.
- This progress certainly leads to the "creation" of so-called "innovative" materials.
- These materials are constantly being developed. Advances in innovative materials enable us to create products that perform better, last longer and are more respectful of the environment.
- These advances are generally the result of scientific discoveries, new manufacturing technologies, interdisciplinary collaborations and significant investment in research and development.
- Innovative materials open the way to new opportunities and innovative solutions for current and future challenges.

2. Definition

What is an Innovative Material ?

- An innovative material is one that offers new and advanced properties, characteristics or applications compared to traditional materials. These materials are generally the product of scientific research and technological development aimed at improving or pushing back the limits of existing materials.

3. Characteristics of innovative materials

What are their characteristics ?

- The characteristics of innovative materials can include properties such as : lightness (légèreté), strength (résistance), electrical conductivity, thermal conductivity, biocompatibility, chemical reactivity, flexibility, transparency, high-temperature resistance, durability, self-repair, and so on.

- These properties are often exploited to create new products, improve existing technologies or solve specific problems.

4. Use of innovative materials

What are they used for ?

- Innovative materials are widely used in many fields, including aerospace, automotive, electronics, medicine, construction, energy, the environment and many others.

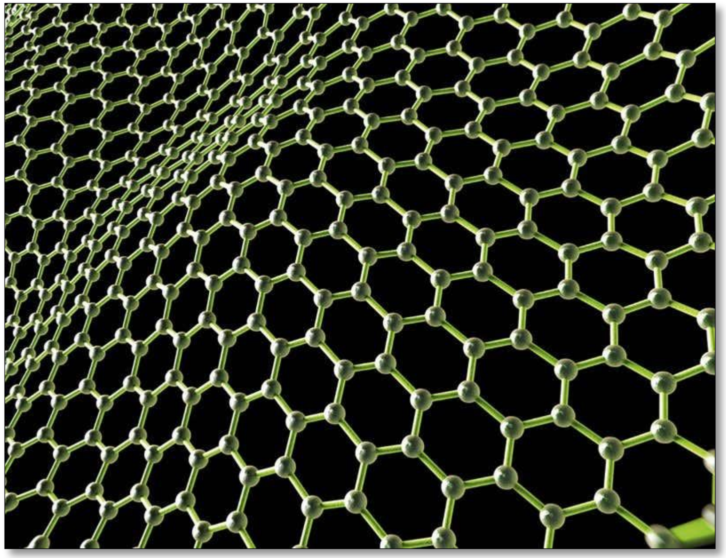
- They enable us to design products that are more efficient, more durable, better performing and more respectful of the environment.

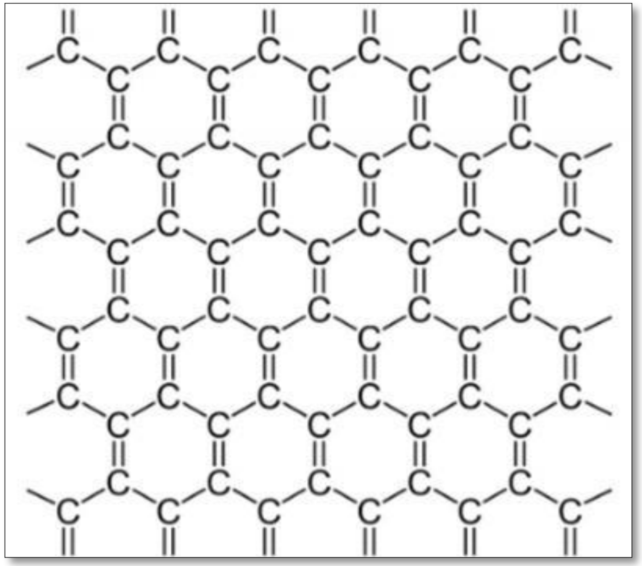
5. Exemple de matériaux innovant

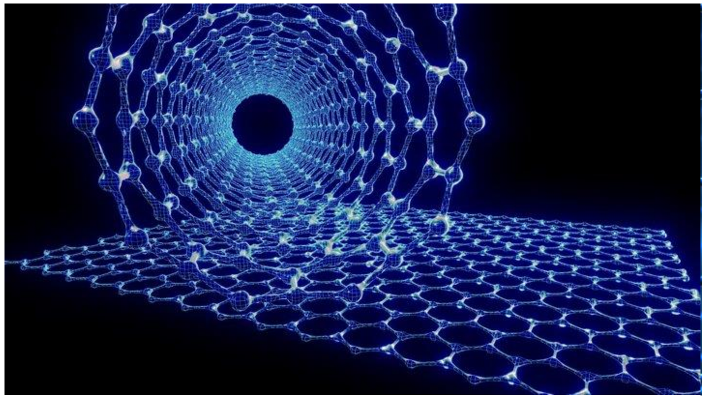
Can we get an example of innovative materials ?

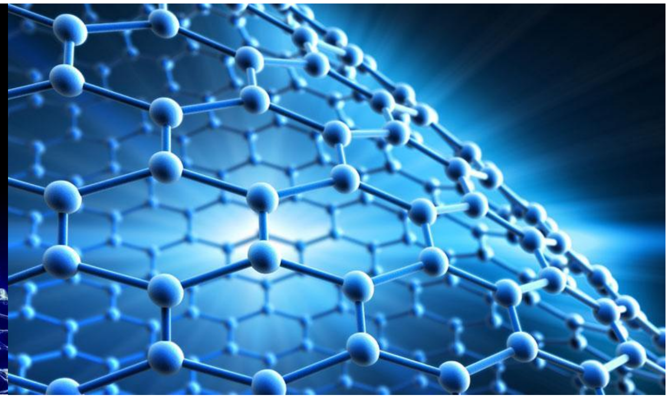
- An excellent example of an innovative material is graphene,
- Graphene is a material consisting of a single layer of carbon atoms arranged in a hexagonal structure.
- Graphene has extraordinary properties in terms of electrical conductivity, thermal conductivity, lightness and strength, making it a highly innovative material with a wide range of potential applications.

Example of an innovative material is graphene









6. Objective

What can e as objectif of the innovative materials

- Innovative materials are essential for :
  - the advancement of technology ;
  - help to solve major challenges in many areas of science and industry.

- They are the driving force behind
  - innovation
  - research in the modern world.

7. Innovative materials in metallurgy (Matériaux innovant en métallurgie)

In metallurgy, materials innovation is essential to improve the performance of metals, alloys and production processes.

1. *High-performance alloys (Alliages à haute performance) :*

Innovative metal alloys are designed to be stronger, lighter and more durable, making them suitable for applications such as aerospace, automotive and the oil industry.

1. Superelastic alloy (Inconel) ;
2. Copper-aluminium-nickel shape memory alloy ;
3. Magnesium-based alloys ;
4. Titanium-based alloys ;
5. Rare-metal alloys ;
6. Refractory alloys ;
7. Copper alloys ;

a. *Shape memory alloy (Nitinol):*

Nitinol is an alloy of nickel and titanium that has the ability to return to its original shape after being deformed.

Here a video on shape memory alloy

b. *Superelastic alloy (Inconel):*

Inconel alloys, based on nickel and chromium, offer excellent resistance to heat, corrosion and high elasticity.

c. *Copper-aluminium-nickel shape memory alloy:*

This alloy is used in thermal control systems and automatic switches in response to temperature variations, for example, in thermostats.

d. *Magnesium-based alloys:*

Magnesium alloys, such as AZ91, are lightweight and corrosion-resistant. They are used in the automotive industry to reduce vehicle weight.

e. *Titanium-based alloys:*

Titanium alloys, such as Ti-6Al-4V, are lightweight and corrosion-resistant. They are widely used in aerospace, prosthetics and medical implants.

f. *Rare-metal alloys:*

Alloys that incorporate rare elements, such as terbium, dysprosium or neodymium, are used in permanent magnets, electric motors and clean-energy technologies.

g. Refractory alloys:

Refractory alloys, such as molybdenum-tungsten, are used in high-temperature environments, such as vacuum furnaces and aerospace applications.

h. Copper alloys :

such as Cupronickel, are corrosion-resistant and are used in cooling systems, hydraulic systems and marine applications.

Proprétés et Applications de quelques alliages à hautes performance

1. **Alliages à base de nickel (Inconel, Hastelloy) :**

- *Applications :* Industrie chimique, aérospatiale, pétrolière et gazière, nucléaire.
- *Propriétés :* Résistance à la corrosion, haute résistance mécanique à des températures élevées.
- *Exemple :*

2. Nickel-based alloys (Inconel, Hastelloy):

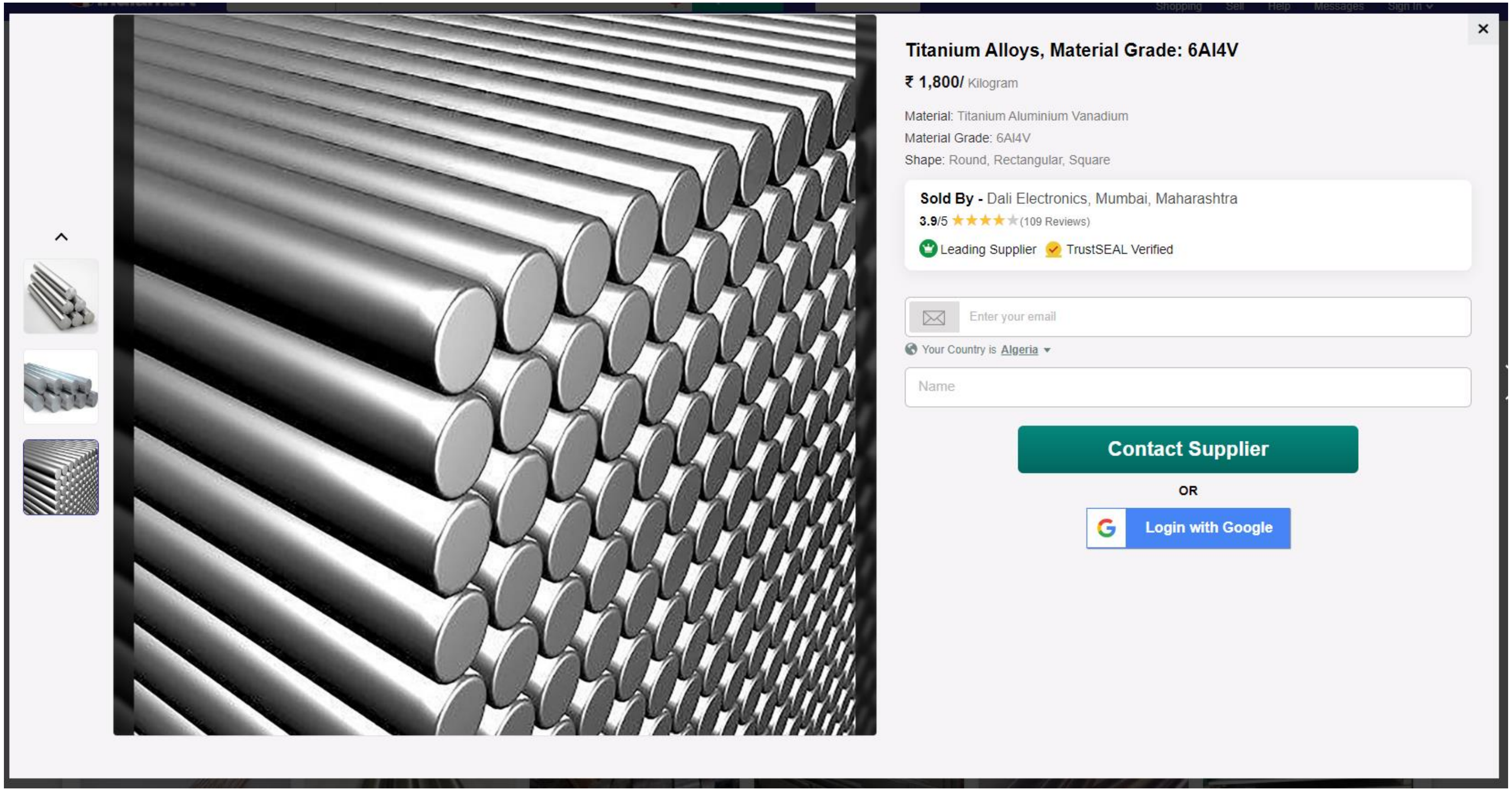
- *Applications: Chemical industry, aerospace, oil & gas, nuclear.*
- *Properties: Corrosion resistance, high mechanical strength at elevated temperatures.*
- *Example*


Nickel Alloy Inconel 625hastelloy B-2 X C-22 C-276 Plate Sheet Application for Offshore and Oil and Gas Components Industrial Aviation Chemical


Nickel Alloy Ni200/201hastello...
US $18-30 / kg
Nickel Alloy Ni200 Hastelloy B X C-22...
US $18-30 / kg
Nickel Alloy Ni200 C-276 Plate Sheet...
US $18-30 / kg
Nickel Alloy Pure Ni Hastelloy B X C-22...
US $18-30 / kg
Nickel Alloy Ni200 Hastelloy B X C-22...
US $18-30 / kg

3. Titanium alloys :

- *Applications: Aerospace, biomedical, military.*
- *Properties: Low density, high strength, corrosion resistance.*
- *Example*



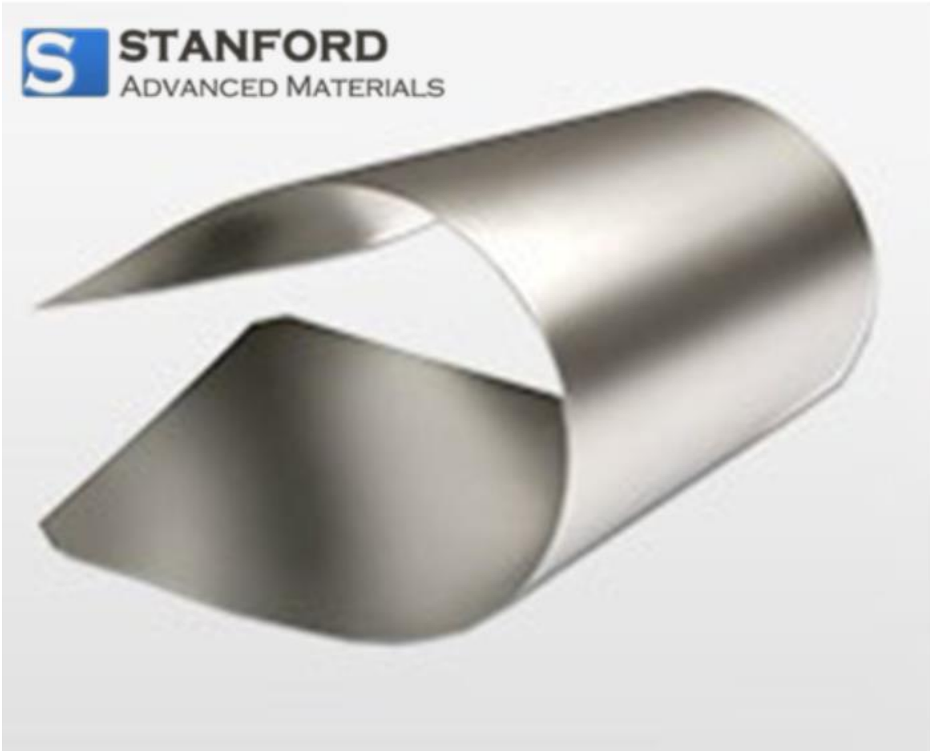
4. **Cobalt-based superalloys : Superalliages à base de cobalt :**

- *Applications: Gas turbines, aerospace industry, medical prostheses, Marine, Oil and Gas,automotive ...*
- *Properties: High resistance to heat, oxidation and corrosion.*
- *Example*
  - 

-

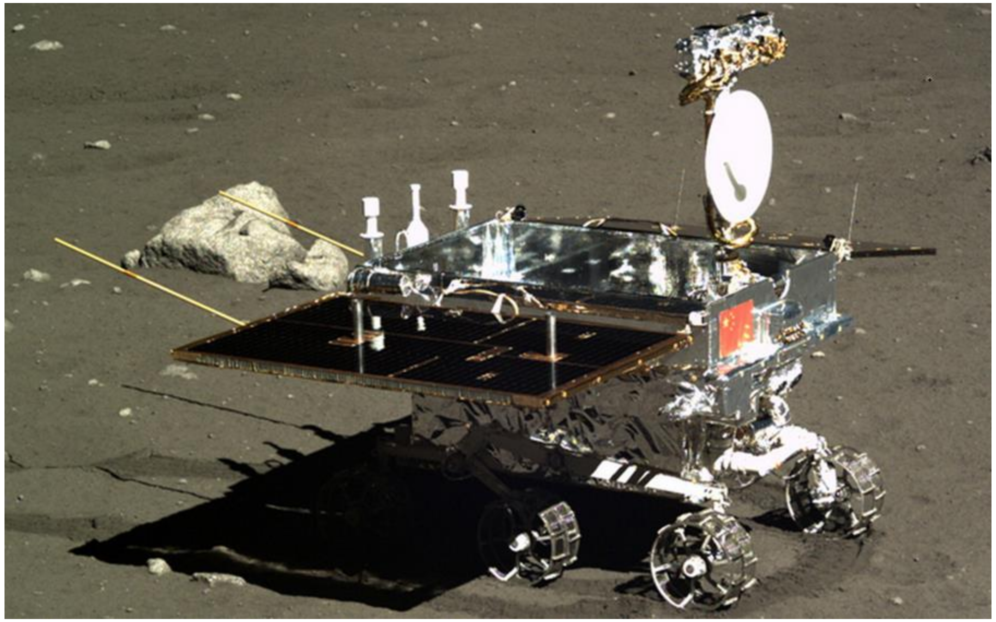
5. Shape memory alloys (Ni-Ti, Cu-Al-Ni): Alliages à mémoire de forme (Ni-Ti, Cu-Al-Ni) :

- *Applications : Medical devices, aerospace, electronics.*
- *Properties: Ability to return to a predefined shape after deformation, excellent elasticity.*
- NT0408 Ti-Ni-Cu & Ti-Ni-Nb Shape Memory Alloy



6. Tungsten-based alloys : Alliages à base de tungstène

- *Applications: Electronics, hard metals industry, aerospace.*
- *Properties: High density, corrosion resistance, high melting point.*



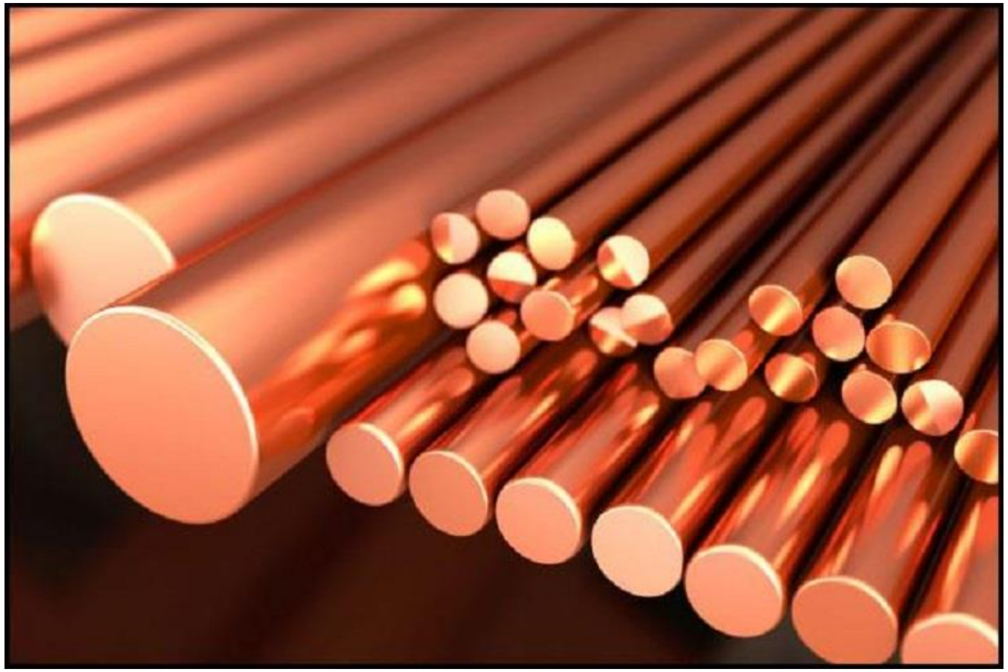
7. Dispersion-strengthened aluminum alloys (Duralumin): Alliages d'aluminium renforcés par dispersion (Duralumin)

- *Applications: Aerospace, light construction.*
- *Properties: Low weight, corrosion resistance, mechanical strength.*

https://www.kansaipipe.co.jp/en/products/aluminum-oxide-dispersion-strengthened-copper/

8. Copper-based alloys (Beryllium-Copper): Alliages à base de cuivre (Béryllium-cuivre)

- *Applications: Electronics, measuring tools, space equipment.*
- *Properties: High electrical conductivity, corrosion resistance, high hardness.*



AA series of **beryllium copper alloys** can be formed by dissolving about 2% of **beryllium** in copper

https://www.refractorymetal.org/uses-of-beryllium-copper-alloys/

These high-performance alloys are the result of advanced metallurgical engineering aimed at optimizing the specific properties required for particular applications. They play an essential role in the development of advanced technologies and in solving complex technical challenges.