Research and Reports on Metals

Editorial

A SCITECHNOL JOURNAL

Nanocrystalline and Nanostructured Metals and Alloys

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Abstract

Metallic materials (both pure metals and alloys) have been utilized since old times in widespread areas of human activities. Metals exhibit larger tensile strength, Young's modulus and fracture toughness and they are more resistant to high-temperature heat treatments than polymers. They are also more malleable and less brittle than ceramics. Importantly, the range of applications of metals is not restricted to their use as structural materials; they have become crucial in other areas such as catalysis and electrocatalysis, electronics, anti-corrosion and antibiofouling protective coatings, magnetism, environmental healing, or medicine, amongst many others.

Keywords

Tensile strength; Magnetism; Anti-corrosion; Metallic alloys

The properties of metallic materials critically depend on their composition and microstructure. The precise design of the specimen shape is also of paramount importance for an optimized engineering performance. Nanotechnology has contributed to revolutionize the use of these materials in applications not envisaged a few decades ago, beyond the structural and mechanical ones. In recent years, much progress has been made in developing new synthetic approaches to produce metallic alloys and to control their morphology and their intricate crystallographic structure at the nanoscale. Severe plastic deformation (high pressure torsion, equal channeling), mechanical alloying and extrusion are conventionally used to manufacture bulk metallic materials with tailored grain size (sometimes with a nanocrystalline or even amorphous structure). Physical (sputtering, pulse laser deposition) or chemical vapor deposition, and also electrodeposition and spraying are among the diverse techniques utilized to grow metallic materials as thin films. Optical and electron-beam lithography are being used to pattern thin films into micrometer or submicrometer sized features, respectively, leading to the development of micro/nano-electromechanical systems. Various wet chemical procedures also allow the growth of metallic nanoparticles, sometimes with tailored geometries (cubic, hexagonal, spherical, etc.) including core-shell nanoparticles. Molecular dynamics simulations and ab-initio computer calculations are important tools to design metallic alloys for target applications and also to unravel the fundamental physics and chemistry mechanisms that govern the properties of this important class of materials.

Recently, progress has been made towards the development of metallic materials with enhanced surface area (macroporous or nanoporous alloys). A large surface-area-to-volume ratio is critical in some applications like catalysis or biomedical implants. Control of surface properties is also becoming important in electronics and magnetism. Many magnetic phenomena (spin-glass behavior, voltage-control of magnetic anisotropy, exchange bias, magneto-resistance) rely on surface or interface effects. Template assisted-electrodeposition (using porous membranes, colloidal templating, or simply hydrogen co-evolution as dynamic templates) and surfactant-assisted electrodeposition (using block-copolymers at concentrations larger than the critical micelle concentration, liquid crystals, etc.) can be employed as a means to control the pore size and porosity degree in thin films. Heat treatments in the presence of blowing agents allow producing low-density bulk porous metallic materials (sometimes also termed metallic foams).

Much progress in the synthesis, characterization and applicability of metallic materials is still yet to come. While the utilization of metals is quite extended, there is still significant work to bring novel types of alloys into market. Further studies on fundamental aspects of the performance of these materials are required to open new avenues in their potential wide range of applications. This technological progress needs to be accompanied with sustainability and cost-effectiveness policies, to avoid or minimize the use of rare-earths, noble metals and hazardous chemicals to achieve the target functionalities. This journal aims to publish new developments based on the use of metallic materials. While metals have always been at the frontier of technological progress, the forthcoming years will certainly be an exciting time for new prospects in the field.

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Received: March 13, 2017 **Accepted:** March 15, 2017 **Published:** March 20, 2017

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