

Preface

Since the Bronze Age, 4000 years ago, man has applied the common saying “unity is strength” to materials science by using metallic alloys for their fascinating physical properties. With the development of metallurgy since the industrial revolution, many combinations of metals have been exploited to meet the technological needs created by the world modernization. Nowadays, recent technological advances in materials science go through their size reduction. In a general manner, when the dimensions of a material raise the same order of magnitude as a characteristic length of the system (mean free path of electrons, correlation length in phase transitions, Bohr radius of the exciton), its properties may be modified from those of bulk, being then dominated by finite-size effects. The size-dependent properties of materials have generated a tremendous interest in nanoscale systems for the last 30 years. Although discovered in 1857 by Faraday, metallic nanoparticles are still at the center of this intense research effort. The development of nanoscale investigation techniques allowed studying the unusual properties of metallic nanoparticles, which are now well documented and exploited in electronics, optics, magnetism, catalysis and medicine. The idea to combine finite-size effects with the adaptability of metallic alloys has added a new dimension to the study of metallic clusters. Understanding the variability of the properties of bimetallic or multi-metallic alloy clusters—so-called nanoalloys—has emerged as one of the most exciting topics in nanoscience, fascinating both physicists and chemists. The unique potential of nanoalloys arises from the fact that their physical or chemical properties can be tuned by varying their composition, their type of atomic arrangement (segregation, solid solution, ordering), as well as their size and morphology. However, the complexity of nanoalloys requires a multidisciplinary approach, because well-controlled synthesis methods and both experimental and theoretical studies of their atomic structure are essential to understand their many technologically relevant properties.

Although the interest of the scientific community in nanoalloys is substantial, there was, so far, no book dedicated to this topic. The authors of the following 11 chapters have all been studying specific aspects of nanoalloys for many years, from fabrication (chemical and physical routes) to physical and chemical

properties using various dedicated methods of characterization. This collaborative effort aims to give, from both experimental and theoretical points of view, the basis for the comprehension of such complex nanosystems. This book should provide a deeper understanding of the mechanisms involved in the growth of bimetallic nanoparticles and their essential properties (thermodynamic, electronic, optical, magnetic, and catalytic), depending on their size and chemical composition. This work is divided into three parts.

- (i) *Growth and structural properties* (Chaps. 1–4). Part I aims to describe the nucleation and growth mechanisms, while taking into account the important kinetic limitations involved in nanoalloy synthesis. This part also presents a broad overview of the experimental techniques giving access to morphological, structural, and chemical information at the atomic scale (scanning probe microscopy, X-ray synchrotron experiments and transmission electron microscopy).
- (ii) *Theoretical investigations of electronic, atomic structure, and thermodynamics* (Chaps. 5–8). In Part II, the electronic properties of alloys and nanoalloys are developed giving rise to their energetics and thermodynamics in order to predict the most favorable structures and chemical arrangements as a function of their composition, temperature, and size.
- (iii) *Technologically relevant properties* (Chaps. 9–11). In Part III the authors describe the complex phenomena that arise from combinations of size and composition effects in the fields of magnetism, optics, and catalysis.

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