

12-Amorphous, Imperfectly Ordered and Quasi-periodic Materials

forms of Mössbauer diffraction spectra also occur due to interference. So we suppose a possibility to separate the quadrupole doublets in the Mössbauer spectra. The only problem for realization of the method is the necessity to have a single crystal sample with quasicrystal structure, enriched in the Mossbauer isotope Fe⁵⁷.

12.02 - Disordered Materials

DS-12.02.01 ELECTRON DIFFRACTION AND MICROSCOPY OF DISORDERED SOLIDS. By J.M. Cowley, Department of Physics and Astronomy, Arizona State University, Tempe, AZ 85287-1504, USA

For both high resolution electron microscopy and electron nanodiffraction, possibilities exist for the derivation of information of ordering in thin films when the correlation lengths are in the difficult range of 1-3nm. These possibilities may be enhanced by holographic methods but are essentially limited in that they give data only on two-dimensional projections of three-dimensional disordered structures. Nanodiffraction, using electron beams of diameter 1nm or less in a scanning transmission electron microscope, used in association with various imaging modes, has proved useful for studying many poorly ordered systems. The structures of small metal catalyst particles and their crystallographic relationship to the supporting material have been found. It has been shown that the local symmetries of quasicrystalline materials persist when the material is almost amorphous. It has been found that the multi-layer walls of carbon graphite nanotubes may be cylindrically bent or may have near planar regions and certain regions of hexagonal or rhombohedral ordering or may be heavily disordered with mutual translations and rotations of the carbon sheets.

DS-12.02.02 MEASUREMENT OF DISPLACEMENT PAIR CORRELATIONS IN CRYSTALLINE SOLID SOLUTIONS BY ANOMALOUS DIFFUSE X-RAY SCATTERING.*
By C. J. Sparks**, G. E. Ice**, P. Zschack***, L. Robertson**, and L. Shaffer****
**Oak Ridge National Laboratory, Oak Ridge, TN 37831-6118 (U.S.A.)
***Oak Ridge Institute of Science/Education, Oak Ridge, TN 37831 (U.S.A.)
****Anderson University, Anderson, IN. (U.S.A.)

The measurement of near-neighbor pair correlations in crystalline solid solutions from diffusely distributed intensity gives us a description of the local chemical order and atomic displacements. Measurements made at multiple x-ray energies provide changes in contrast to separate the chemical order and displacements into their individual values for the various chemical pairs (AA, AB, BB). Results are presented for binary alloys where anomalous scattering has been used to change the real part of the anomalous scattering factor of the constituent atoms. For binary alloys with elements of similar atomic number, sufficient change can be obtained to reverse the contrast from the first-order static displacements. X-ray energies can also be chosen to make the scattering factor difference between the two elements practically zero to provide for the effective removal of thermal scattering. Thus, the Laue scattering can be recovered and the individual pair correlations separated. Several Ni-Fe alloys have been measured from the Ni rich to the Invar composition. Insights to the magnetic behavior of these alloys are discussed in terms of the interatomic distances between atom pairs.

*Research sponsored by the Division of Materials Sciences, U.S. Department of Energy, under contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc.

DS-12.02.03 A THREE-DIMENSIONAL (3D) MODEL FOR THE DIFFUSE SCATTERING IN CUBIC STABILIZED ZIRCONIAS. By T.R. Welberry*, Research School of Chemistry, Australian National University, GPO Box 4, Canberra City, ACT 0200, Australia.

A position-sensitive detector (PSD) system has been used to make measurements of the diffuse X-ray scattering in a cubic Y₂O₃ stabilized zirconia, (Zr_{0.61} Y_{0.39} O_{1.805}), in far greater detail than has hitherto been reported. In addition to the fairly prominent diffuse peaks visible in [1 1 0] sections that have been the centre of discussion in many previous studies we see a number of other characteristic diffraction features.

We describe the development of a three-dimensional (3D) model which provides a simple explanation of virtually all the features that occur in the complex diffuse X-ray diffraction patterns. The model consists of two stages: a scheme for ordering the oxygen vacancies, followed by the relaxation of the cations around these vacancies. Monte Carlo simulation is used in both these stages, followed by direct computation of the diffraction patterns from the resulting lattice realisations. The model which at present best fits the observed scattering patterns is one in which the oxygen vacancies order in such a way as to avoid nearest neighbour $\frac{1}{2}$ (1 0 0) pairs, next-nearest $\frac{1}{2}$ (1 1 0) pairs and third-nearest $\frac{1}{2}$ (1 1 1) pairs across empty cubes of oxygens, but allows third-nearest $\frac{1}{2}$ (1 1 1) pairs across cubes of oxygens containing the cations. These vacancy-pairs, which essentially provide octahedral coordination of the enclosed cation, are therefore present almost entirely as either single isolated octahedra or neighbouring \langle 1 1 0 \rangle pairs of octahedra. A comparison of the diffuse patterns with those from a calcia stabilized zirconia is also made.

DS-12.02.04 DISORDER IN NON-STOICHIOMETRIC OXIDES: ZrO₂, CeO₂, LiNbO₃. By F. Frey and H. Boysen*, Institut f. Kristallographie, Universität München, Germany.

Many technologically important properties of oxide materials such as ionic conductivity, mechanical strength, ageing behaviour etc. are strongly influenced by deviations from stoichiometry and the underlying disorder. Although the most direct information about the defects and their correlations is obtained from diffuse scattering valuable information may be obtained from Bragg scattering too. From a careful analysis of site occupations and temperature factors, including anharmonic terms, and the corresponding probability density functions (pdf) the atoms involved in the disorder may be identified and their (average) displacements be determined. The temperature dependence of the B-factors helps to distinguish between static and dynamic disorder.

Zirconia, ZrO₂ doped with various amounts of oxides like CaO, Y₂O₃ etc. is a particularly interesting example due to its wide range of applications. The doping leads to the stabilization of the (high temperature) cubic (fluorite) and tetragonal (distorted fluorite) polymorphs, the creation of vacancies on the oxygen lattice and an enhanced anionic (oxygen) conductivity. A quantitative analysis of the diffuse scattering in single crystals of (cubic) CSZ (Zr_{1-x}Ca_xO_{2-x}, 0.07 ≤ x ≤ 0.15) up to 1750 K revealed two types of correlated microclusters based on single and double O-vacancies with relaxed neighbours. These clusters lead to an immobilization of the oxygens and in turn a reduced conductivity. Around 1300 K the number of clusters decreases (without dramatic changes in the correlation) in agreement with an increasing conductivity in this temperature range. A similar behaviour was observed in powders with additional weak and broadened superlattice peaks indicating the distortion of a sublattice with correlation length of about 30 Å. After annealing for several weeks precipitates of the so called Φ₁-phase develop, i.e. the