BUILDING AND USING AN APPLICATION-SPECIFIC PARTICLE ATLAS

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Application-specific particle atlases can be assembled and successfully applied to solve manufacturing contamination problems. The Intel Particle Atlas is used at Intel as a general materials reference for identification and elimination of contaminant particles in liquids and gases and on semiconductor wafer surfaces.

The Atlas is briefly described. It contains the optical and SEM/EDX (Scanning electron microscope/energy dispersive x-ray) properties of over 100 materials collected from Intel integrated circuit manufacturing sites.

We will describe methods of assembling and using the atlas which may be applied to the production and application of other atlases. A brief description of the analytical methods used for our atlas is presented, and the importance of the sample collection and documentation steps is discussed. Applications of the atlas to specific contamination problems, mistakes to avoid, and the benefits of assembling an atlas are also included.

INTRODUCTION

Particulate contamination limits yields in integrated circuit manufacturing. As circuits and IC manufacturing processes become more complex, the sensitivity to particulate defects increases and more time and money must be expended in identifying and eliminating contamination sources. For example, to achieve a 78% yield in a typical sub-micron process containing 250 steps, each step must contribute no more than 0.001 killer defects/cm². A particle atlas can be a useful tool in the process of particle identification and source elimination.

The McCrone Particle Atlas is a valuable reference which describes particle analysis techniques and properties of a wide variety of particle types. To expedite interpretation of analytical results, an additional atlas was produced internally, which concentrates on materials and analytical techniques which are more specific to our environment.
We believe atlases of this type can be used for applications in pollution control, forensics, and other industries which require control of cleanroom manufacturing areas. Using the atlas provided several valuable lessons about assembling the atlas. We will describe some of those in this paper.

DESCRIPTION OF THE INTEL PARTICLE ATLAS

Format

The atlas includes three main sections:

Introduction. The introductory section describes the purpose and scope of the atlas, and then provides detailed descriptions of all terms and analysis techniques used in the atlas. Several unique terms were used for the particle descriptions, and these are defined in this section.

Indexes. The properties of each of the atlas entries are cross-referenced in a variety of indexes. The materials are indexed by reflected light properties, transmitted light properties, optical fluorescence, source, general materials type, elemental components (EDX), and descriptive name.

Main Body. Two pages are used for each material included in the atlas. One page is used to describe the optical properties, and the other is used for SEM/EDX properties. Notes describing the source of the material and potential for contamination are included. Figures 1 through 4 show two example entries (4 pages total) taken from the Intel Particle Atlas.

ANALYTICAL INFORMATION INCLUDED

The types of analytical information included in the atlas were chosen because of their ease of acquisition, the wide availability of appropriate instruments within the company, and their ability to uniquely identify materials.

All optical properties were collected with a Zeiss UEM microscope in both transmitted polarized light and reflected light modes. Blue-violet excitation was used to determine fluorescence properties.

The reflected light properties include shape, surface texture, luster, color, and fluorescence. The transmitted light properties include color, refractive index (Becke line method), birefringence, and extinction. Descriptive terms for each of the properties are carefully defined in the introductory section of the atlas. The McCrone classification code for each material is also included. A representative color, optical micrograph is included for each entry.

The SEM/EDX properties include a representative SEI (secondary electron image) micrograph and an EDX spectrum for each entry. The EDX spectrum is a compromise which provides the best overall representation of the elements in the sample. All spectra were collected under the same sample conditions (working distance, tilt, live time acquisition) at 20kV accelerating voltage. The spectra are qualitative representations of what elements may be present in the collected material. No attempt at quantitative analysis should be made with these spectra as references.