Application Note B-XRD1072

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B-XRD1072 - Crystallite size analysis of a microvolume of metallic nanoparticles with a benchtop X-ray diffractometer

Introduction

When a particle size is reduced to nanometer scale, the quantum size effect emerges as the specific surface area increases, resulting in the appearance of new physical properties that are not observed in the bulk form. Metal nanoparticles readily grow into polycrystals during the fusion process, so it is necessary to measure not only the particle size but also the crystallite size to elucidate the growth mechanism and study properties. Crystallite size can be calculated from the width of the X-ray diffraction peak. The following is an example of crystallite size analysis by measuring a microvolume of metal nanoparticles using a benchtop X-ray diffractometer.

Measurements and results

When gold (Au) is dispersed in solution as nanoparticles, Au particles absorb light of a specific wavelength. This phenomenon, called “plasmon absorption,” has long been used to color glass for stained glass and fine glassware. Today, it is used in optical sensors, organic electronics, and biosensors.

Calculation of crystallite size by X-ray diffraction is performed by applying the Scherrer equation to the difference in peak widths between a standard sample with large enough crystallites and the measurement sample. Figure 1 shows the X-ray diffraction pattern obtained by measuring a 0.1 ml dried drop of Au nanoparticle solution on a zero-background sample holder.

When the crystallite size was calculated from the peak integrated width using the Scherrer equation, the crystallite size in the direction perpendicular to Au (111) was calculated as approximately 8 nm. As shown in this example, using a benchtop X-ray diffractometer, the crystallite size of metal nanoparticles can be analyzed with high accuracy from a very small sample volume of 0.1 ml.

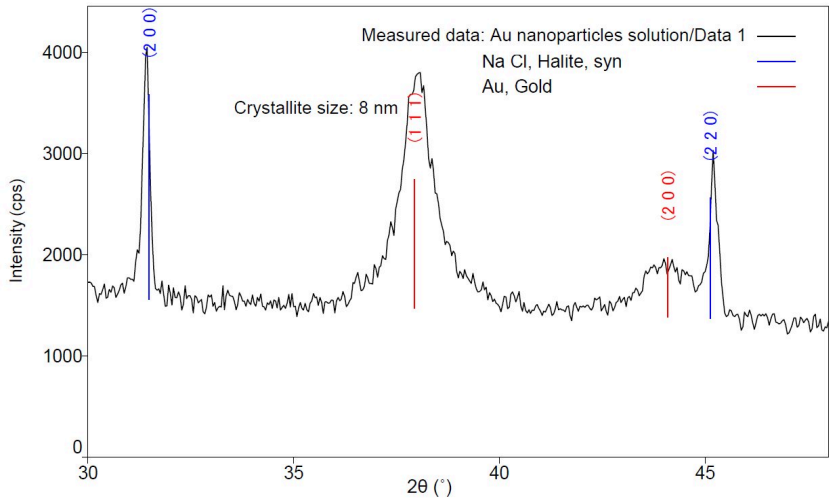

Figure 1: The X-ray diffraction pattern of the Au nanoparticle solution (after drying) (NaCl is the solute precipitated from the buffer solution)

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