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SMALL-ANGLE X-RAY SCATTERING SYSTEM WITH LINEAR
POSITION-SENSITIVE DETECTOR

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Small-Angle X-ray Scattering System with Linear Position-Sensitive Detector, A. R. FOROUHI, B. SLEAFORD[†], V. PEREZ-MENDEZ[†], D. DE FONTAINE, and J. FODOR^{*}, Materials Science Department, U.C. Berkeley, Lawrence Berkeley Laboratory[†], and Spectro Labs^{*}. - A linear position-sensitive detector has been constructed for use in small-angle x-ray scattering experiments. It is a one dimensional, pressurized gas-filled detector with a delay line read out. Calculated efficiency of the detector at 8.04 keV and 45 psi for Ar-CH₄ filling is 60%, and for Xe-CO₂ filling is 90% limited only by the thickness of the entrance beryllium window. Inherent resolution of the detector is 0.1 mm for normal incident x-rays. The overall resolution of the detection system is determined by the width and angular divergencies of the point collimated Cu K α beam used in the experiment. The performance of the system is described in terms of measurements on Al-Zn alloy samples.

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SUMMARY

I. INTRODUCTION. We have constructed a linear position-sensitive detector. This instrument was used in a small-angle x-ray scattering set-up to investigate the kinetics of phase transformation in Al-Zn alloy samples.

II. THE X-RAY DIFFRACTION SYSTEM. The small-angle scattering set-up used in this work is shown schematically in Fig. 1. It shows the position of the x-ray tube, monochromator, the two apertures for point collimation, the sample and the detector. Long (161 cm) x-ray flight path was chosen to improve the resolution and the system was evacuated to avoid intensity loss and air scattering.

III. LINEAR DETECTOR. The detector is a proportional counter with delay line read out. Perspective view and cross-section of the sensitive volume of the detector are shown in Fig. 2(a) and Fig. 2(b) respectively. The chamber is made of 2" x 3" x 13½" aluminum case with 1/8" wall thickness. The entrance window is a beryllium foil 0.5 mm thick. The container is designed for a pressure of 50 psi. The sensitive volume, as shown in Fig. 2(b), is bounded by the delay line, the two brass bars and the beryllium entrance window. All of these four sides are at ground potential relative to the external case and to the anode wire. The delay line is

grounded by its characteristic impedance at both ends. The anode is a 0.03 mm diameter gold-plated tungsten wire stretched between two insulating lucite blocks.

The delay line is a plated circuit delay line with phase compensation [1] and has the following characteristics: unit delay = 8 (or 25) nsec/cm, $Z_0 = 135 \Omega$, and rise time ≈ 8 nsec.

The output pulses from both ends of the delay lines are connected to RCA 733 I.C. amplifiers whose outputs drive AM 685 high speed comparators. The AM 685 devices can be biased to a specific threshold which can be selected to minimize the time jitter.

The outputs from the amplifier-comparators serve as the input of the "start" and "stop" of a Time to Amplitude Convertor which is then read out by a Pulse Height Analyzer with a minimum interval/channel of 50 psec. Calculated efficiency of the detector at 8.04 keV and 45 psi for argon filling is 60% and for xenon filling is 90% limited only by the thickness of the entrance window. Inherent resolution of the detector is 0.25 mm with an 8 nsec/cm delay line and 0.1 mm with a 25 nsec/cm delay line.

The overall resolution of the system is determined by the width and angular divergencies of the incident x-ray beam which are appreciably greater than the detector resolution in this application.

IV. APPLICATION TO PHASE TRANSFORMATIONS IN Al-Zn. The scattering intensity around the origin in an x-ray diffraction experiment is the square of the Fourier transform of the concentration variations in the sample. Periodic concentration variations give rise to symmetric satellite peaks whose positions are related to the wavelength of the modulations. Such concentration modulations are known to arise during precipitation from

solid solutions rapidly quenched from a high temperature. Therefore small-angle scattering can be used to investigate kinetics of decomposition of certain alloys.

A previously investigated alloy [2], Al - 22.5 at. % Zn - 0.1 at. % Mg, was chosen in the present experiments. Fig. 3 shows the evolution of the intensity of one satellite in a sample maintained at 125°C for the indicated length of time. The overall feature of these results as well as the long annealing time behavior of the modulation wavelength are consistent with previous theoretical studies [3,4].

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Fig. 1. Schematic diagram of the small-angle x-ray scattering system.

Fig. 2. (a) Perspective view of the sensitive volume of the detector.
(b) Sensitive volume shown in cross section.

Fig. 3. Small-angle scattering spectra for the indicating aging times (in minutes) at 125°C from Al-22.5 at.%Zn-0.1 at.%Mg.