3A/2002G221

Influence of Diffraction Angle on the IP/cosα Method Through Synchrotron Radiation

Toshihiko SASAKI*
Department of Materials Science and Engineering, Kanazawa University, Kakuma-machi,
Kanazawa, Ishikawa 920-1192, Japan.

Introduction

A new type of the X-ray stress measurement method (the IP/cos α method), in which an Image Plate and the cos α method are utilized, has some hopeful advantages. Using this method with synchrotron radiations, we would be able to perform the materials evaluation for much variable materials with higher accuracy. For example, one of them is the measurement at the high diffraction angle such as 2θ >170°. The measurement with this range of the diffraction angle has been thought to be impossible up to now because the diffraction beams are generally interrupted by a part of an instrument. However, it is well known that the precision of the stress measurement increases with 2θ and, therefore, the range of 2θ>170° is the most desirable condition. Since the optics for the IP/cos α method is so simple that nothing cuts of the diffraction beams, we can realize the measurement at this hopeful condition. In order to confirm these possibilities, the experiment was performed with synchrotron radiations. It was also investigated to elucidate the relationship between the precision of the IP/cos α method and the diffraction angle under the some wave lengths.

Experimental

The experiments were made using the BL-3A of the Photon Factory at KEK. A steel plate (JIS S55C) was used as specimen. The principal diffraction conditions were; the wave length of 0.233 nm (2θ=170°), 0.209nm (2θ=156°) and 0.209 nm (2θ=127°) were selected. The incident angle of the beam was 30°. The applied strains were given to the specimens up to 1000×10^{-6}. The image data stored in IP were read with Fuji Film BAS-2000 under the condition of Latitude=5, Sensitivity=10000, Resolution=100 μm. The diffraction profiles in radius direction were calculated from the diffraction image with 1° interval of the central angle. Then, 360 peak locations were determined for each diffraction image using the half-value breadth method. They were then converted to the lattice strains using the Bragg's condition. The stress within the material was obtained from a diffraction image with the following equations,

$$\sigma_x = -\frac{E}{(1+\nu)}\frac{1}{\sin 2\eta}\frac{1}{\sin 2\psi_0}\left(\frac{\partial \bar{\varepsilon}_\alpha}{\partial \cos\alpha}\right)$$

$$\bar{\varepsilon}_\alpha = \frac{1}{2}\left\{(\varepsilon_\alpha - \varepsilon_{\pi+\alpha}) + (\varepsilon_{-\alpha} - \varepsilon_{\pi-\alpha})\right\}$$

where E is Young's modulus, ν is Poissson's ratio, η is a supplementary angle of 2θ and ψ_0 is a incident angle of X-ray.

Results and Discussion

Figure 1 shows the diffraction rings obtained from three kinds of the wave length. Figure 2 shows the relation between measured and applied stresses.

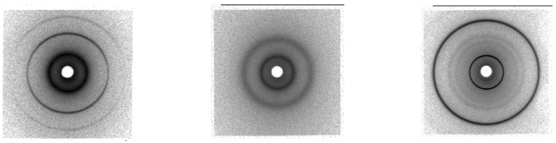

Fig.1 Comparison of 211 diffractions for three kinds of wave length
(left: 2θ=156°, middle: 2θ=170°, right: 2θ=127°).

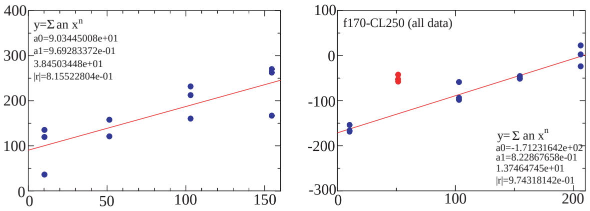

Fig.2 Comparison of stresses under two kinds of wave length
(left: 2θ=170°, right: 2θ=156°).

Comparing the data scattering in the graphs, we see that the precision of the stress measurement is not improved with the diffraction angle. The order of the reliability was 156°, 170° and 127°. It is found that there are some negative factors for stress measurement in high 2θ condition, such as the increase of the full width at half maximum and decrease of the range of the orientation of the strain.

*sasakit@kenroku.kanazawa-u.ac.jp