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LETTER TO THE EDITOR

Experimental observations of effects on HOLZ lines induced by a stacking fault in an $Al_{70}Co_{15}Ni_{15}$ decagonal quasicrystal

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Abstract. The effects of stacking faults on higher-order Laue-zone lines have been observed in the $Al_{70}Co_{15}Ni_{15}$ quasicrystalline decagonal phase. This phenomenon suggests that convergent-beam electron diffraction can be used to determine the displacement vector of stacking faults not only in crystals but also in quasicrystals.

In crystals, convergent-beam electron diffraction (CBED) methods can be used to determine the Burgers vector of a dislocation and the displacement vector of a stacking fault. Therefore the splitting and shifting of higher-order Laue-zone (HOLZ) lines induced by dislocations and stacking faults have been studied [1–5]. In quasicrystals (QCs), Dai and Wang [6] and Yan *et al* [7] experimentally observed and theoretically simulated HOLZ line patterns in $Al_{76}Si_4Mn_{20}$ icosahedral quasicrystal (IQC) and $Al_{70}Co_{15}Ni_{15}$ decagonal quasicrystal (DQC). Wang and Cheng [8] extended the dynamical theory of electron diffraction from the case of crystals to the case of QCs. Wang and Dai [9, 10] and Dai *et al* [11] studied the effect of dislocations in QCs on the shifting and splitting of HOLZ lines both experimentally and theoretically using the dynamical theory of electron diffraction. These studies show that the method of Burgers vector determination using the CBED technique may be used for dislocations in QCs. Based on this understanding Yan *et al* [12] determined the Burgers vectors $\boldsymbol{b}$, including their directions, senses and magnitudes, of dislocations in an $Al_{70}Co_{15}Ni_{15}$ DQC by a large-angle CBED (LACBED) technique. Up till now there has been no experimental report on the observations of effects of stacking faults on HOLZ lines in QCs. The purpose of the present work is to explore the phenomenon of the effects of the HOLZ lines induced by stacking faults in the QC phase.

The stacking faults studied in the present letter were induced by high-temperature deformation [13]. The details are as follows: the alloy of composition $Al_{70}Co_{15}Ni_{15}$ was prepared by melting the pure metals using an induction furnace under an Ar atmosphere. After being slowly cooled to room temperature, the ingot was cut into slices. The slices were annealed at 1070 K for 4 h, deformed by means of compression and then air cooled. Thin foil specimens for transmission electron microscopy were prepared by mechanical thinning and subsequent ion milling. Diffraction contrast images and LACBED patterns were obtained using a Philips CM12 transmission

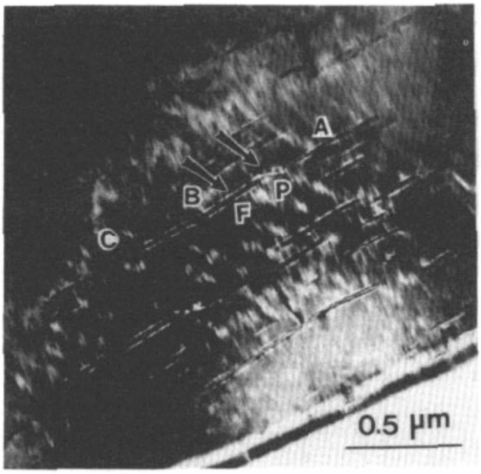

Figure 1. Bright-field image of the stacking faults AP, PB and BC and a partial dislocation P induced by high-temperature deformation in an $Al_{70}Co_{15}Ni_{15}$ decagonal phase with g = (2 0 0 0 1 0).

electron microscope at an accelerating voltage of 120 kV. Defocused CBED patterns have been obtained by using the LACBED technique [14].

Figure 1 shows the bright-field (BF) image of the stacking faults induced by high-temperature deformation under g = (2 0 0 0 1 0) two-beam conditions. According to the contrast analysis [13], the displacement vector of the stacking faults is along a twofold axis. In order to discern the position of the stacking fault in LACBED patterns, three contamination spots marked with the letters A, B and C were made at both ends and the middle of the stacking fault. Between the contamination spots A and B, there is a partial dislocation marked by the arrow P.

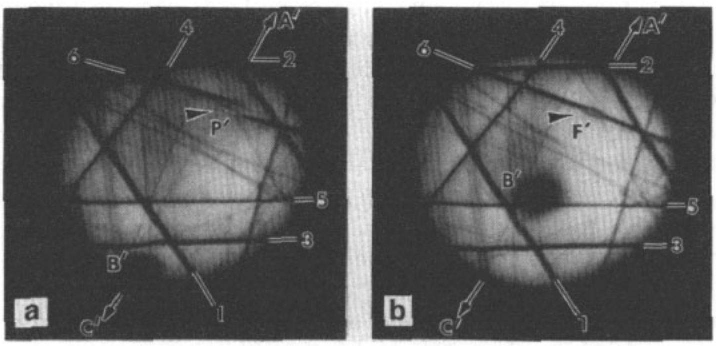

Figure 2. Twisting and splitting of HOLZ lines induced by the partial dislocation (a) and stacking fault (b).

Figure 2 shows LACBED patterns of the $Al_{70}Co_{15}Ni_{15}$ decagonal phase specimen containing a partial dislocation and a stacking fault oblique to the specimen surface shown in figure 1. The main HOLZ lines in the LACBED patterns were indexed. In the present work an index system for decagonal quasicrystal given by Yan *et al* [15] is used, where the first number corresponds to the tenfold axis A10 with a period of 0.8 nm. The intensities I/I_0, the reflection indices n_1^*, n_2^*, ..., n_6^*, the moduli of the three-dimensional reciprocal vectors $g_{\|}$ and the Bragg angles θ of these HOLZ lines are listed in table 1. The stacking fault positions in the LACBED patterns are denoted by A′, B′ and C′, corresponding to A, B and C in figure 1.

Table 1. Calculated intensities and indices of HOLZ lines of the $Al_{70}Co_{15}Ni_{15}$ decagonal phase.

N	I/I_0	n_1^*	n_2^*	n_3^*	n_4^*	n_5^*	n_6^*	$g_{\|}$	θ
1	0.37	1	−1	−1	1	1	0	1.29	1.37
2	0.35	2	1	1	0	0	0	0.83	0.88
3	0.35	−2	−1	−1	0	0	0	0.83	0.88
4	0.33	5	0	0	0	0	−1	1.28	1.36
5	0.35	−3	−1	−1	0	1	0	1.30	1.38
6	0.25	1	0	1	−1	−1	0	0.92	0.98

Figure 2(a) is the LACBED pattern with the incident beam illuminating the stacking fault AB. In this case, the HOLZ line 6 crossing the partial dislocation marked by the arrow P in figure 1 splits into two nodes (marked by the arrow P′). This characteristic is similar to that in the case of crystals. The HOLZ lines 1, 3 and 5 cross the stacking fault PB. There is no effect of the stacking fault on the HOLZ line 5. The effects of the stacking fault on HOLZ lines 1 and 3 are very weak. On moving the incident beam, until HOLZ line 6 also crosses the stacking fault PB at the position pointed to by F (figure 1), the LACBED pattern shown in figure 2(b) was obtained. From figure 2(b), it can be seen that HOLZ line 6 splits into two lines whose separation reaches a maximum at the midpoint of the stacking fault (marked by an arrow F′). This splitting behaviour is symmetrical about the midpoint of the stacking fault. Such behaviour corresponds exactly to the dependence of the widening and splitting of the HOLZ line on the fault depth z_0 observed in crystal by Wang and Wen [4]. The HOLZ lines 1, 3 and 5 cross the stacking fault BC. There is also no stacking fault effect on HOLZ line 5. The stacking fault effects on HOLZ lines 1 and 3 are also very weak.

This work shows that, as in the case of crystals, the stacking fault in the quasicrystalline decagonal phase can also induce splitting of HOLZ lines. The splitting behaviour is the same as in the case of crystals. Therefore, defocused CBED HOLZ lines can also be used to determine the displacement vector of a stacking fault in quasicrystals. Theoretical simulation of the splitting of HOLZ lines, identification of the displacement vector of the stacking fault, and studies of the variation of the splitting behaviour with experimental parameters are in progress.

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