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On the Localized Weak Cleavage in FeS_2 Crystals

1. Introduction

Iron Pyrite (FeS_2) is a semiconductor of the n and p types (MILOVSKY, KONONOV). The crystals also have thermo electric property (BETEKHTIN). The crystals have a hardness of 6 to 6.5 and they are rather brittle (BETEKHTIN). Magnetic and electrical anisotropy (HIRAHARA, MURAKANNI), micro-hardness, IR absorption and band energies (NICKEL et al.), deformation in natural FeS_2 crystals (FONT, ALTABA) etc., have been reported. Optical topographic studies of natural FeS_2 crystals (PRASAD) and some SEM studies related to the growth process (PRASAD, DURGA PRASAD) have also been reported. Further, the FeS_2 crystals have uneven fracture and occassionally conchoidal (BETEKHTIN; KUZIN, EGOROV). However, description on the cleavage aspect is not clear. For example the descriptions given are: the cleavage is absent in FeS_2 crystals (MILOVSKY, KONONOV); cleavage is indistinct (KUZIN, EGOROV); crystals have cleavage having {100}, {111}, {110} as the cleavage planes (BETEKHTIN). Therefore it is worthwhile to re-examine the question of cleavage in FeS_2 crystals. Scanning electron microscopy and reflection light microscopy (employing sodium light) studies have been made on FeS_2 crystals and the results are presented in the present report.

2. Samples

The crystals used in the present study belong to the same batch of natural crystals, which were studied earlier (PRASAD; PRASAD, DURGA PRASAD). The habit is cubic; the crystals often show the striations on the faces.

3. Observations and discussion

The deliberately fractured surfaces are examined. Complete cleavage along any plane is never observed. Cleavage limited to small areas in abundant (Fig. 1). Such cleavage, limited to small areas can be called localized cleavage. Fracture formed at one of the

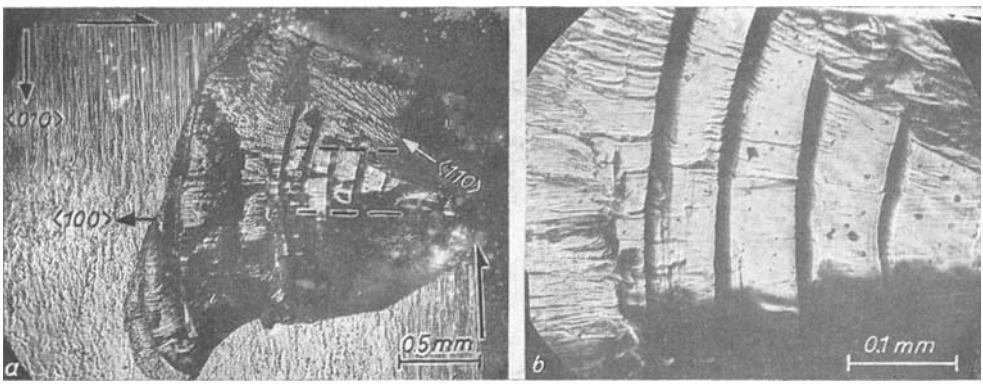

Fig. 1. a) Fractured surface close to a corner of the FeS_2 cubic crystal. The half arrows indicate the edges of the cube. Striations having ⟨010⟩ are visible. The demarcated region is shown in Figure 1 b. Reflection light micrograph; b) Localized cleavage in successive layers; cleavage parallel to the (001), (010) and (100) planes. Reflection light micrograph

corners of a cubic crystal is shown in Figure 1. The striations present on the crystal face can also be noticed in Figure 1 a. The arrows indicate the edges of the face under observation. The demarcated region of Figure 1 a is shown in Figure 1 b at a higher magnification. It can readily be noticed that the pattern have a step-like structure.

It can be recognised that the small planes between the thick dark strips have uniform and equi-illumination in the reflected sodium light. Therefore it can reasonably be assumed that these planes are parallel to each other and also parallel to the (001) face that is under observation. These planes are the horizontal components of the steps-like system and represent the (001) cleavage planes. It can be recognised that the thick dark strips are formed by the planes which are at normal to the small (001) planes. Such vertical planes form the vertical components of the step-like structure. Thus they represent another set of cleavage planes that are almost perpendicular to the set of (001) planes. It can be seen (Fig. 1 b) that the planes (responsible for the formation of the thick dark strips) are also parallel to the striations that are present on that face. If the direction of the striations is indicated by ⟨010⟩ direction, then the planes represented by the dark thick strips are the (010) cleavage planes. Low level lines or marks that are at normal to the dark thick strips, can also be noticed in Figure 1 b. With the help of Figure 2 b, the low level lines can be identified as (010)

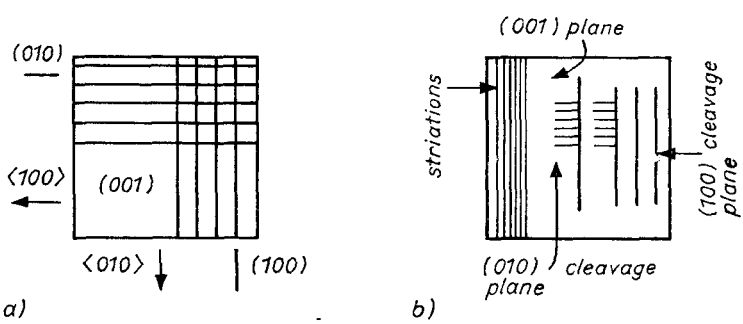

Fig. 2. a) Identification of the principal planes in a cubic crystal; b) A sketch showing the marks of (100) and (010) cleavage planes on the (001) plane. Compare the sketch with Figure 1

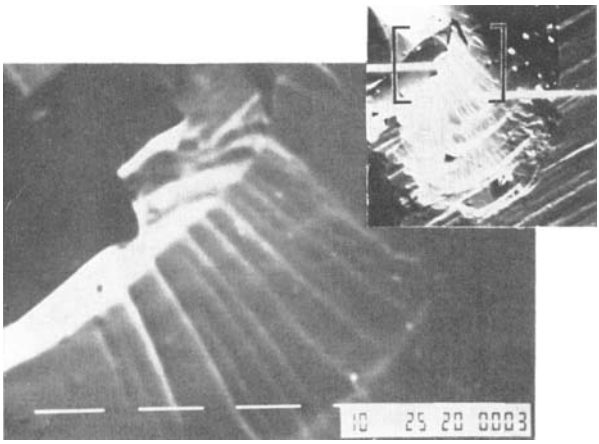

Fig. 3. The (010) cleavage marks are shown at higher magnification (SEM: scale bar 10 μm). Inset shows the fractured surface near a corner of the cube

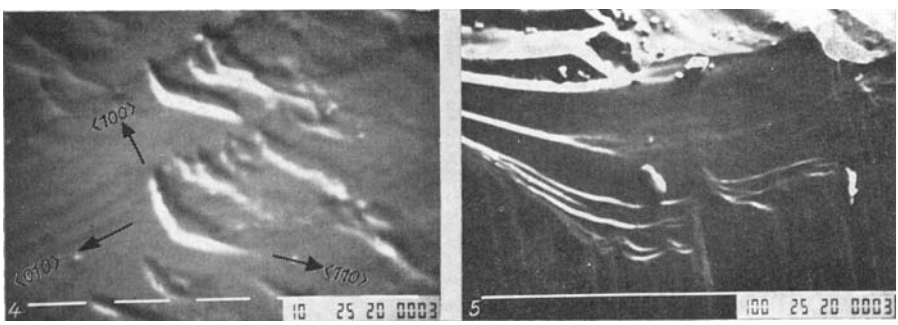

Fig. 4. Localized cleavage patterns bounded by planes having ⟨100⟩ and ⟨110⟩ directions; striation direction is ⟨010⟩. SEM: scale bar 10 μm

Fig. 5. Edges of the cleaved layers and the striations combindly exhibit a continuity. SEM: scale bar 100 μm

cleavage planes. Figure 3 further illustrates the (010) cleavage marks. It can also be noticed from Figure 1 a that there are some low level marks that have either ⟨110⟩ or close to ⟨110⟩ direction.

IIt canfurther be noticed that the localized cleavage patterns (Fig. 4) are bounded by planes having the directions ⟨100⟩ and ⟨110⟩, when the direction of striations on that face are labelled as ⟨010⟩. However, the directions are not scrupulously followed. For example in place of ⟨110⟩, one finds ⟨340⟩ or ⟨430⟩; and ⟨50$\bar{6}$0⟩ in place of ⟨100⟩. The inclination of such bounding planes with respect to the (001) plane could not be ascertained. Sometimes a link could also be observed between a localized cleavage pattern and the striations in case of fractured surface (Fig. 5). It can be noted from Figure 5 that each striation can be linked to one layer. Such observation leads to the interpretation that the striations are nothing but the edges of the long growth layers responsible for the growth of the FeS_2 crystals. This interpretation is in agreement with the previous reports (Prasad; Prasad, Durga Prasad).

Conclusions

FeS_2 crystals have weak cleavage; cleavage parallel to (100), (010), (001), and possibly along (110) planes are noticed. It may exist along some intermediatory planes also. It is ascertained that cleavage parallel to {100} has highest frequency of occurrence. The cleavage is characteristically a local cleavage. Complete cleavage in FeS_2 crystals, it seems, must be extremely rare.

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