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Surfaces Characterization by Ionic Bombardment

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Abstract: The causes for the Anisotropy in the angle distribution of sprayed atoms is yet extensively unexplained. Therefore experimental investigations should be carried out to this question. The ions beam was used for comparing investigation between the distributions of back steered ions and sprayed atoms. We know that the pulverization of crystals shows an anisotropic angular distribution of pulverized atoms. The appearance of this phenomenon is initiated once Wehner spots are obtained by putting a receptor in front of the sample, which shows a correlation with the principal crystallographic axes. Another study shows, that till now the studies and works already done are not strongly founded in the sense of the correspondence of the Wehner spots and the principal axes of the crystals. Measurements are represented in many works and during the last years detailed studies on gold crystals (111). Principally the gold atoms emissions have appeared in the directions (110) and (111) for which the intensity to energy ratio of projectile ions is modified. Emissions directions are to be maintained in addition to representations and for omitted raisons directions changes have to be taken into account. After the studies of deviations in the emission directions appear during the copper crystals pulverization. The authors allocate this fact to the influence of the forces of superficial links which should generally lead to a preference of the particles emission in the normal direction to the surface. The question is who it makes that the link ratio for different crystals directions have a different response; however, it is shown that the application of an ionic beam emitter, to examine the interference of the direction emissions of the pulverized atoms with principal crystallographic axes, is necessary.

Key words: Ionic beams, angular repairing, pulverization, Wehner spots, atoms relaxation, crystallographic axes

INTRODUCTION

External surfaces pulverisation phenomena of solid bodies has been possible (Grove, 1952) and the systematic observation of the theoretical work (Sigmund, 1969; Kazuhisa, 2002). The particle details and energy transportation between the incident ions and the solid bodies reflected atoms are not completely understood. Of course, the temporal expiration of the percussion process has a great effect, which explains the non linearity during the energy densities.

The particles details and the energy transport between incident ions and the reflected atoms from solid bodies is not yet completely understood, for sure the time domain expiration of percussion process has an important role, which explain the non linearity during high level energy densities (Anderson and Bay, 1981).

The crystallography structure does naturally exist only in pure crystal network.

In a network disturbed by an ionic bombardment, the regular structure is briefly near completely dissolved.

Consequently, we can conclude that transmission of particles needs to take place along the weakly indicated crystals directions during the penetration of ions in the solid bodies because at all the moments coming after whether the crystallographic structure is dissolved or the energy value for bodies surface atoms extraction is very weak.

From these ideas results the fact that the presentation of the solid bodies pulverisation should be essentially a pure surface process between the very nearly adjacent atoms.

Robinson (1981) concluded the same conclusion through a computer simulation.

To explain the angular distribution of the pulverised atoms the following presentations exist:

- If the amorphs solid bodies are concerned, then increasing the measured pulverisation during the diagonal bombardment, because the ions energy still being contained in the surface and can contribute to increase of the pulverisation.
- For the same raison during the vertical bombardment of ionic beams with an increasing angle with respect to the normal of the surface the intensity decrease, because the distances between the emission locus and that of the energy conversion in the body increases.

In fact, the number atoms vertically transmitted with respect to the surface should be maximum.

Because the ionic beam possesses an impulse and the pulverisation is based on the transfer of impulses between the atoms and not over the evaporation, the solid body atoms movement in the inverse direction of the ionic beam is of small probability. Consequently, the intensity should be also smaller, instead of receiving a cosine distribution, as we are looking for in the case of evaporation, a distribution with a maximal part issued in the diagonal emitting directions.

These distribution curves were calculated theoretically (Yamamura, 1981), they clearly gets out with weak ionic energies and gets closer to the cosine distribution with the ionic high energies, if with sufficient an lot of percussion events in the solid bodies an isotropy in the direction of the impulse is reached.

Using crystals, it follows an energy transfer in a similar manner, only the crystallographic axes can form (preferentially) directions. This can be based on the fact that packaging atoms bodies particularly close to each other along the directions. Directions of crystals weakly indicated and that the impulses are not spread along this chain, but on the contrary of and according to the studies (Silsbee, 1957) are also focalised (focalised percussion consequences), this can take place directly consequently an atoms packages, but in contrary and via the work (Silsbee, 1957) they are focalised (focalised percussion consequences), this may take place directly consequently a closer packaging of atoms chains or indirectly by the lenses effect in the circular arrangement of adjacent atoms. This model of consecutive focalised atoms is always consulted to explain the regular arrangement of Wehner spots clearly formed instead of a sinus distribution in the image receiver of the pulverised structure.

However, it has to be supposed that the solid body monocrystalline structure continue to exist during the bombardment in the energy conversion. The strong influence of the external parameters as the temperature, the mass of ions and the ions energy on the Wehner spots acuteness (Bethge and Baumann, 1974; Linders, 1988) indicate that the Spike process are frequently consulted to explain the solid bodies phenomena during the energy conversion, for the pulverisation has a secondary role and that the disturbances in the crystals structure is sensitively reflected in Wehner spots.

All this consider the non importance of the focalised impact sequences to give rise to Wehner spots.

All of this indicates the non importance of the focalised shocks to give rise to the Wehner spots. As an alternative proposed by Lehmann and Sigmund (1966) the interaction between the first and the second atoms position because the animated atoms energy distribution decreases by E^{-2}, hence the atoms energy E directed towards a number of atoms in this state (position) falls rapidly, the atoms in the superficial layer can possess only a small energy if it receives their energy from the deeper atomic positions.

Due to the firm relation of the first position atoms, the energy values should be transmitted by the second position atoms and allows the surface atoms to overcome their link forces. This is best insured if they receive percussion along the link directions.

In all the other cases, only the components in the percussion directions are efficient, from this results a preferred emission along the crystals axis. We can see the presentation, that due to the chemical links forces, the atoms are found too close from each other, if a percussion takes place between the adjacent atoms and with an energy transmission of the order of the chemical links forces, we can understand that the central shock is along the right lines of the collision and an impulse component is found to be vertical. The central shock is along the crystals directions and transmits energy, in the other hand the vertical component doesn’t cause any shifting of the shock parameters, consequently it stills only the shifting of the bombarded particle along the junction line between the gravity points.

With this presentation we don’t need indications about the links forces directions or about energy transport mechanism along the atoms chains that are surely greatly absorbed; we need only that during the ions penetration in the atoms of the first position sufficient energy should be transferred and that during the process changes due to the regular structure of crystals and by the cohesiveness of the network levels as consequent collision layers emitted by the atoms of the first position. With this presentation we can agree that the temporal expiry of the ions penetration and the energy conservation don’t intervene in the pulverisation process or at least it has only a weak influence and also the links effects for the emission process are of the secondary importance.

It seems with a judicious consequent to do more precise measurements for the angular repartition of the pulverised atoms with respect to the emission direction. As material, copper crystals have been used.

EXPERIMENTAL DETERMINATION OF EMITTED ATOMS DIRECTIONS

The principle of the exact determination of the angle distribution sprayed atoms and the crystal directions was

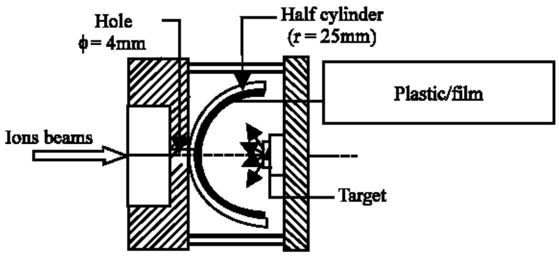

Fig. 1: Schematic representation of radiation

based upon the registration of the particle currents in the pulverisation through precipitation development on a transparent plastic foil and through photographic registration of the particle current reflected Proton arrangement shows in Fig. 1. In a reason disk out of aluminium, a hole is bored in the middle to the reception of the copper-monocrystals. Around the crystal as an axis, a cylindrical screen is mounted, that is connected with the circular disk firmly. This screen contains in the middle a hole through which the ions ray is arranged on the sample. The screen consists of a film stage, in which a transparent plastic film could be inserted to measure the distribution angle of sprayed atoms or a photographic film, with which an over energy, reflected Proton become (Protonogramm) recorded.

Because in the 2 cases the disposal (arrangement) of the film support is the same with respect to the crystal, we can superpose the film and the transparent to observe that the correspondence of the emitted particles and the crystallographic axes of the sample.

DETERMINATION OF WEHNER SPOTS

To determine the angular distribution of the pulverised atoms a transparent sheet is inserted in film carrier linked to the device in which is placed the sample (copper monocrystal) with the wanted direction, the device being connected to the last electrode placed under the ions optics land of the beams emitter.

With a current of about 100 μA, the sample is bombarded with Ne and Ar ions during 15-30 min, as a result we obtain the matter distribution on a plastic sheet and because it consists of a cylindrical arrangement, it is important to place the emission direction in the meridian plane of the device, in addition the crystal should be turned in parts around its axes until the geometry is optimal to measuring angle, this has been reached after 2-3 tests.

With this arrangement and the desired image we undertake the copper crystal direction in the film carrier and this is done due to the angular distribution recording of the reflected protons.

DETERMINATION OF THE CRYSTAL DIRECTION

We bombard the copper monocrystal with weight and rapid particles; hence those penetrate deeply in the crystal.

For protonogram photography we have taken 300kV protons with a 2 μA current, an exposure time of 10s and a desensitized film of type FN52, the desensitizing of the film necessitate the device installation in the dispersion room under the green light.

The protonogram is based on the reflection of the weight projectiles on the heavy atoms sample, the weight and rapid protons deeply penetrate in the monocrystal. During a redispersion of the protons in the total angle sector around atoms network can be lighted up, a proton can be also reflected due to a collision with the atoms network in all the direction of observation, here however every atoms network is surrounded with adjacent atoms, regularly distributed and this for every adequate atom is repeated in the depth direction and the side.

The protons can not be emitted by the effect protecting the adjacent atoms along their distribution direction. Even though, the protons are reflected in all the directions during the particular spreading process on the atoms network, they are however, stopped by the surrounding adjacent atoms in this direction of emission. Because in this direction no proton is emitted, given rise on the gleam screen or on photographic film as an plane image of the network with darken films on the illuminated background plane which is produced by irregular spread protons.

Because of the effect protecting adjacent atoms we call the process "Blocking Effect" or the "Shadow Effect" (Barett, 1973).

RESULTS AND DISCUSSION

As it is shown in the Fig. 2 that with direction crystals of surface (100), the emission directions and the crystallographic axes are well joined.

On the other hand, for crystals (111) (Fig. 3) the directions correspondence with pulverisation images exist; while for the directions (100) a deviation is clearly observed with respect to (100) direction in the protonogram of around 2 mm with a radius of 25 mm of the film carrier of cylindrical form corresponds to a 20° of angle shifting. The emission direction of the normal is preferred.

Similar observation are already done by the work (Niedrig *et al.*, 1987), if the cause should be the engagement energy of the surface, this should also affect the directions (100), because they passes also to the

a)
b)
c)

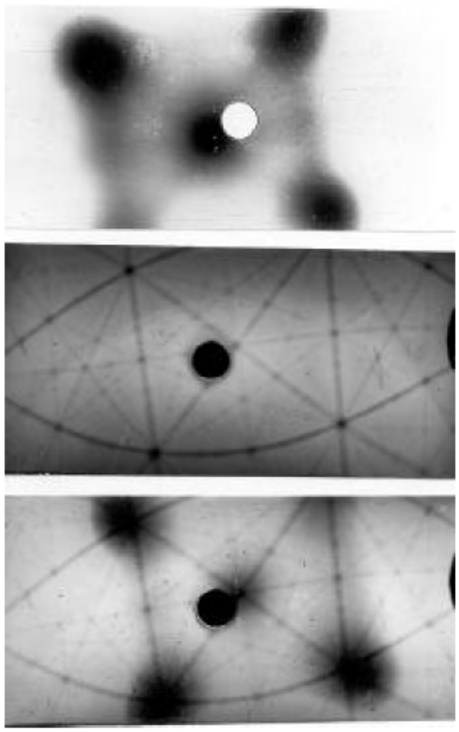

Fig. 2: Comparative representation of the network plane structure of a mono crystal Cu-(001) obtained by the dispersion measurement using protons (protonogram). With the Wehner spots arrangement, during the same angle deviation between the surface and the axis of the crystal, a) Wehner spots b) Protonogramc) Common copy of the two photographies: Wehner spots and monocrystal principal axis directions that correspond well

a)
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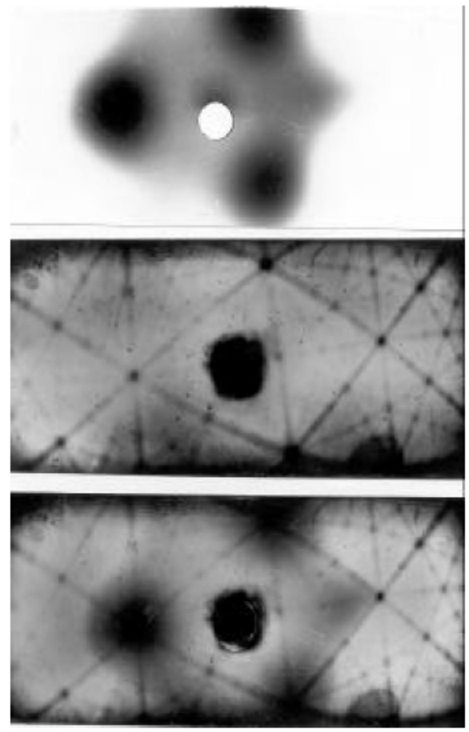

Fig. 3: Comparative representation of the network plane structure of a monocrystal Cu-(111) obtained by measurements of dispersion with protons (protonogramme). With the arrangement of Wehner spots, during the same angle of deviation between the surface and the axis of the crystal, a)Wehner Spots b) Protonogram c) Common copy of the two photography that shows clearly the Wehner spots deviation very weak compared to the desired emission direction according to the protonogram

surface normal. For the other directions of the crystal also, we could observe the shifts. According to work (Robinson, 1981), overcoming the voltage barrier at the surface should cause angle enlargement at the output during the extraction of atoms relatively the normal, however the opposite shift is observed. For centred crystals clear deviations of the position of Wehner spots is also observed.

Consequently, it is evident to postulate to surface atoms relaxation,, this should be easily seen, because the atoms of the centred side position possess the shortest path of link compared to the atoms at the cubic corner points of the crystal network with centred fronts. If a crystal of this type is cut along the surface diagonals, these atoms arrive to the surface because they are under pressure due to their short link distances, they can be relaxed; this relaxation should be recovered on the first and the second atoms positions.

Is it about the surfaces (100) or (110), the relaxations in the pulverisation image are not shifted, because the percussion direction coincide with the relaxation direction.

If it is about however, more surface (111), the relaxation direction and the percussion direction between the atoms of the first and the second position do not correspond anymore.

If we evaluate quantitatively the shift on the basis of the model shown in Fig. 4. A relaxation of atoms on the surface, 50% of this value is calculated by the adoption of the appearance or creation of Wehner spots comes from the percussion interaction between the adjacent atoms is always a central percussion, i.e: There exist no preferred percussion direction of second position atoms, however the atoms possess percussion energy of second position atoms in the preferred direction, which coincide with the packed and close balls directions. Hence, the oblique percussion between adjacent atoms are also possible. In

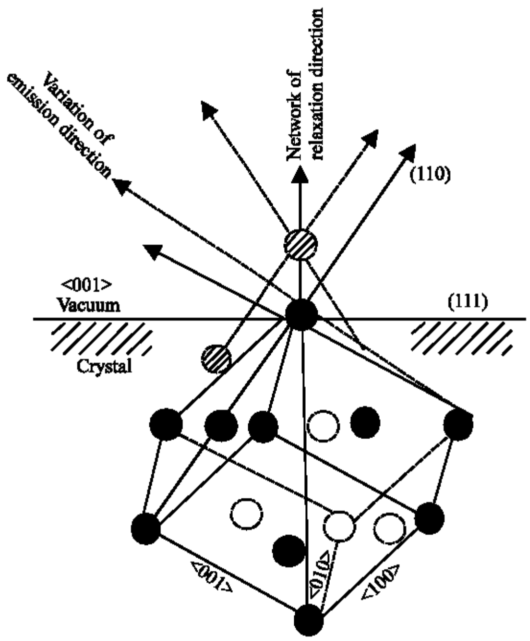

Fig. 4: Schematic representation of the process, For the relaxation of atoms vertical with respect to the surface emerges a modification in the Wehner spots situation. While for the spot (100) stills not influenced by the relaxation, It is produced for the axe (001) a change in the particles emission direction

this case, the network atoms are not concerned, but the percussion radius which is crucial and the ratio between the distance and the percussion radius of atoms which decide on the percussion oblique if it increases or decreases. With percussion radii which are small with respect to network gap, the oblique deviation increases concerning the central percussion, because the transferred energy of the surface atoms during the pulverisation increase in a multiple of links energy, the percussion radii can be ten times less than network distances, hence the network relaxation values are reduced from 50-5%. Similar values have been found (Davies *et al*., 1975; Saris, 1982) with the measurement of Surface-Blocking-Effect, this method is relatively expensive and necessitate very high vacuum conditions, the arrangement of the Wehner spots relaxation process is in the other hand simpler and possible under the high vacuum conditions, if we increase also the sensitivity of the measurement method with the use of a particle test, it can be possible not only to determine the metals structure, but also the arrangement arbitrary matters atoms on the surface, if it is sufficiently regular.

Consequently, it appears very important also to examine very far the monocrystals surface particles emission question and other matters, because new structural analysis methods of solid bodies surfaces can emerge.

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