Z17 - Studying Models of Crystalline Surfaces Using Diffraction Based Methods

Physics Laboratory II
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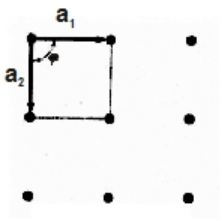
The purpose of the exercise is to understand the diffraction based methods for studying the surface crystallographic structures. As a part of the exercise, students record diffraction images of several two-dimensional periodic patterns (lattices) corresponding to the simple surfaces of typical crystals (eg, of square, rectangular, hexagonal symmetries) and also to reconstructed surfaces – eg. (7x7) Si (111) or c (8x2) InSb (001). This exercise gives also some introduction to low energy electron diffraction (LEED) method. As an extension students may prepare their own lattice models or examine the rules of optical filtration.

Preparatory questions

1. Diffraction of waves on a two-dimensional grid. Laue conditions. Reciprocal lattice [1].
2. Surface atomic structure and surface reconstructions [1].
3. Diffraction methods for studying of surfaces [1].
4. The Fourier transform [1].

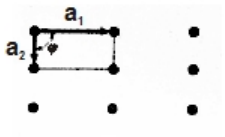
Computational assignments

We have the following two-dimensional lattices:



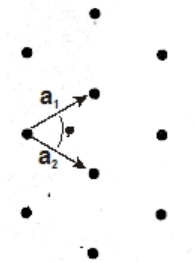
quadratic: $|a_1|=|a_2|=a$, $\varphi=90°$

$a_1=(a,0)$, $a_2=(0,-a)$



rectangular: 2/1: $|a_1|=2|a_2|=2a$, $\varphi=90°$

$a_1=(2a,0)$, $a_2=(0,-a)$



hexagonal (rhombic) : $|a_1|=|a_2|=a$, $\varphi=60°$

$a_1=a(\sqrt{3}/2, 1/2)$, $a_2= a(\sqrt{3}/2, -1/2)$,

For each of the lattices find the reciprocal lattice vectors $\mathbf{b_1}, \mathbf{b_2}$, that is vectors that fulfill the following conditions: $\mathbf{a_i b_j} = 2\pi\delta_{ij}; i,j = 1,2, \delta i,j$ is Kreonecker delta.

Apparatus and materials

Experimental set-up is shown on the Fig 1. It consists of:

- Optical bench with optical elements
- He-Ne Laser
- Digital camera
- Computer
- Models of crystalline surfaces.

Experiment

(The detailed exercise plan is to be decided by the instructor and the student together, the following plan should be considered as exemplary)

- Get familiar with and understand all elements of the experimental apparatus.
- Align the optical system, i.e. position/rotate all optical elements to get a uniform parallel beam of coherent light about 1.5 cm in diameter.
- Get familiar with the acquisition and processing programs.
- Record diffraction patterns for the supplied set of solid surface models (masks).
- Record the mask images in real space by projecting them onto the wall using a slide projector.

Data analysis

- Prepare the Fourier transforms of the recorded diffraction patterns.
- Prepare the Fourier transforms of the recorded mask images (periodic patterns)

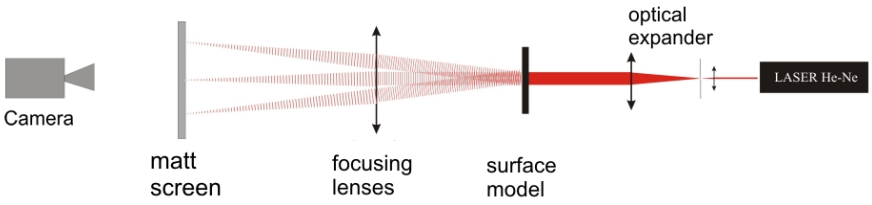


Figure 1: Experimental setup

Discuss the results you have received. Please note that all masks in a given group (square or hexagonal) have a common base lattice constant. For example, a square mask of "2x1 missing rows" was created by deleting every second row on a square mask straight but otherwise nothing has been changed.

Safety rules

Work with protective glasses. Do not look directly into the laser light source!!!

References

[1] J.J. Kołodziej, Z. Postawa, *Badanie modeli powierzchni krystalicznych metodami dyfrakcyjnymi*, Uniwersytet Jagielloński, 2008.