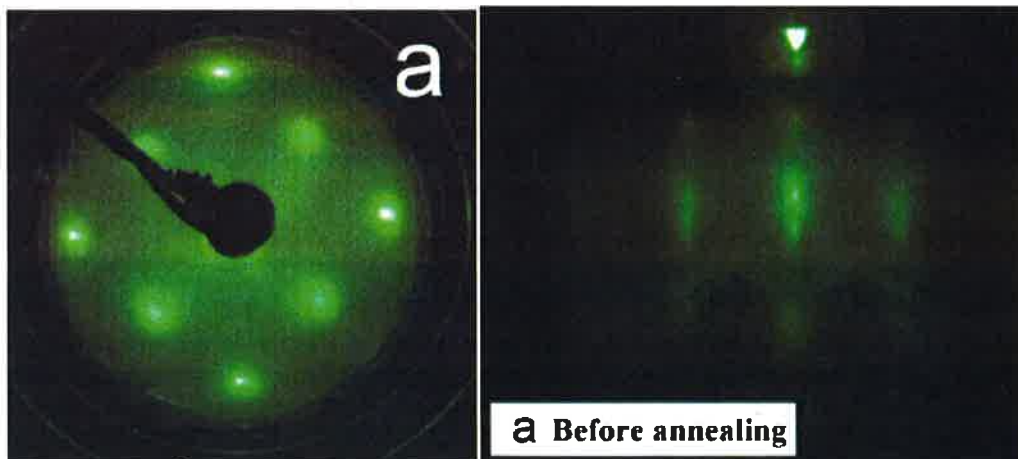


Surface Physics (MATR308) 2023

Written exam 2023-12-19

1. Consider two surfaces the structure of which is described by a square and a hexagonal 2D lattice. The two surfaces are subjected to a flux of adsorbates which form 3×1 and 2×1 superstructures on the square and the hexagonal surface, respectively. Draw schematically the real-space lattices of the two superstructures, including the atomic positions of both the surface and adsorbate atoms. Also draw schematically the reciprocal-spaces lattices of the two superstructures as they would appear during a diffraction experiment (e.g., by low energy electron diffraction). (4p)
2. You are tasked with designing the pumping system of a vacuum chamber which will be used for performing x-ray photoelectron spectroscopy measurements. What type of pump(s) you will choose? Justify your answers. (4p)
3. The low energy electron diffraction (LEED) and reflection high-energy electron diffraction (RHEED) patterns of the MgO(100) surface are presented below (left and right panel, respectively). Why are the spots in the LEED pattern round and well defined and the spots in the RHEED pattern elongated? (2p)



4. A beam of electrons (hereinafter primary electrons) with energy E_p impinges on a surface. The interaction of the primary electron beam with the surface results in emission of secondary electrons. List the type of secondary electrons that are emitted from the surface, draw qualitatively their energy spectrum, and briefly describe how they can be used for studying surfaces. (10p)
5. Metal surfaces often exhibit relaxation, i.e., the interplanar spacing along the surface normal either contracts or expands with respect to the bulk interplanar spacing. Often this behaviour extends over multiple layers from the surface exhibiting a damping

oscillatory pattern (i.e., contraction-expansion-contraction...). Explain the reason behind this behaviour. **(4p)**

6. The Si(100) surface exhibits two reconstructions, i.e., the 2×1 dimer reconstruction and the $c(4 \times 2)$ reconstruction. Draw schematically (along with the Si(100) surface bulk termination), and briefly describe the key features and origin of the two reconstructions. Under what conditions is the $c(4 \times 2)$ reconstruction observed? For the schematic drawing both top and side views depicting the first three atomic layers of the surface are accepted. **(6p)**

7. What is a singular and what is a vicinal surface and how are they related? Which of the two surfaces has higher energy and why? **(4p)**

8. Diffusion of adatoms on a surface is typically described as a "random walk". What is the meaning of this and what are the requirements for a diffusion process to be classified as random walk? What does the diffusion rate during a random walk depend on? **(6p)**