Low Energy Electron Diffraction (low energy electron diffraction (LEED))

Lucas Hirschfeld, s6luhirs@uni-bonn.de

Supervisor: Morris Mühlpointner

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Low Energy Electron Diffraction (LEED) is a powerful technique for the structural analysis of crystalline surfaces. This report explores the principles, experimental setup, and applications of LEED in surface science.

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LEED has established itself as one of the most powerful and widely used techniques for determining the surface structure of crystalline materials[1]. The technique exploits the wave nature of electrons, first proposed by de Broglie in 1924, utilizing electrons with energies typically between 20-200 eV. At these energies, electrons possess wavelengths comparable to interatomic distances (0.1-0.3 nm) while exhibiting limited penetration depths of only a few atomic layers[2].
The historical significance of LEED extends back to 1927 when Davisson and Germer first observed electron diffraction from a nickel surface, providing experimental confirmation of de Broglie's matter wave hypothesis[3]. However, it was not until the 1960s that LEED evolved into a reliable analytical technique, coinciding with advancements in ultra-high vacuum technology and computational methods[4].
The fundamental principle of LEED relies on elastic scattering of low-energy electrons from a periodic crystal surface. The resulting diffraction pattern directly reflects the reciprocal lattice of the surface structure, allowing determination of the surface symmetry, lattice parameters, and reconstruction phenomena[5]. In contrast to X-ray diffraction techniques that probe bulk properties, LEED's surface sensitivity arises from the limited mean free path of low-energy electrons in solid materials, making it uniquely suited for surface crystallography[6].
Modern LEED analysis extends beyond qualitative pattern interpretation to include quantitative structural determinations. By systematically measuring diffraction spot intensities as a function of electron energy (I-V curves) and comparing them with theoretical calculations, atomic positions within the surface unit cell can be determined with precision approaching 0.01 nm. This approach has been crucial in elucidating complex surface reconstructions, adsorbate structures, and the atomic mechanisms underlying surface phenomena[7].
The integration of LEED with complementary techniques such as scanning tunneling microscopy (STM), x-ray photoelectron spectroscopy (XPS), and auger electron spectroscopy (AES) has created powerful methodological combinations for comprehensive surface characterization[8]. Furthermore, recent innovations including spot-profile analysis low energy electron diffraction (SPALEED) and low energy electron microscopy (LEEM) have extended the capabilities to include analysis of surface defects, domain sizes, and dynamic processes[9].
This report explores the experimental foundations, working principles, and practical applications of LEED in surface science. Particular emphasis is placed on the interpretation of

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diffraction patterns, quantitative analysis methodologies, and case studies demonstrating LEED's role in solving significant surface structural problems in heterogeneous catalysis, thin film growth, and materials science.

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References

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LEED low energy electron diffraction

LEEM low energy electron microscopy

STM scanning tunneling microscopy

XPS x-ray photoelectron spectroscopy

AES auger electron spectroscopy

SPALEED spot-profile analysis low energy electron diffraction