Multi-element cylindrical electron gun systems for focusing and controlling electron beam

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The electron gun plays an important role in atomic, molecular, plasma, thin film, lithography and surface physics. Different types of electron gun have been designed for producing different electron beam energies. Cylindrical lenses are used to control electron beams with various energy and directions in several fields. It is well known that a two/three element lens systems cannot keep the image position constant especially in small electron energies. For that reason, it is necessary to add further lens elements to the gun system.

Details of the properties several types of lens systems can be found in the literature. Although multi-element lenses are expected to be more flexible and allow controlling of many independent lens parameters. A variety of electron gun designs have been used to create well-defined electron beams with varying degrees of success and satisfaction. In this study, we could present the modeling and construction of a multi-element electron gun system for electron impact studies in intermediate energy levels.

Много-елементни системи с цилиндрични електронни пушки за фокусиране и контрол на електронния лъч (Мевлут Доган). *Електронната пушка играе важна роля в атомната, молекулната, плазмената физика, физиката на тънките слоеве и литографията. Различни видове електронни пушки са били проектирани за получаване на електронни лъчи с различни енергии. Цилиндрични лещи се използват за управлението на електронни лъчи с различна енергия и направления в няколко области. Добре известно е, че система лещи с два / три елемента не може да запази позицията на образа постоянна, особено при малките електронни енергии. Поради тази причина е необходимо да се добавят допълнителни елементи на лещите към системата на пушката.*

Детайли от свойствата на няколко вида системи лещи могат да бъдат намерени в литературата. Многоелементните лещи се очаква да бъдат по-гъвкави и позволяват контролирането на много независими параметри. Разнообразие от дизайни на електронни пушки са били използвани за създаване на добре дефинирани електронни лъчи с различна степен на успех и удовлетворение. В това проучване, ние може да представим моделирането и изграждане на мулти-елементна система на електронна пушка за изследвания на влиянието на електроните при междинни нива на енергия.

Introduction

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Details of the properties several types of lens systems can be found in the literature. Although multi-element lenses are expected to be more flexible and allow controlling of many independent lens parameters. A variety of electron gun designs have been used to create well-defined electron beams with varying degrees of success and satisfaction. In this study, we could present the modeling and construction of a multi-element electron gun system for electron impact studies in intermediate energy levels.

Multi-element cylindrical electron gun system

In the electron collision experiments, a well-focused primary beam of electrons must be supplied by a high current electron gun ($\leq 10^{-5}$A), stable long period of time and accurately directed through the centre of the gas beam. The electron spectrometer consists of an electron gun, two hemispherical analyzers and Faraday cup in e-COL laboratory, Turkey (Fig. 1). All these components are housed in a vacuum chamber and the base pressure of the chamber is ≈ 8.10^{-8} mbar. The spectrometer is kept in the vacuum chamber with μ-metal shielding that reduces the surrounded magnetic fields in addition to Helmholtz coils [1]. In coplanar asymmetric geometry; incident, scattered and ejected electrons are detected in the same plane.

Fig. 1. A photo of one of the electron spectrometer in e-COL Lab in Turkey.

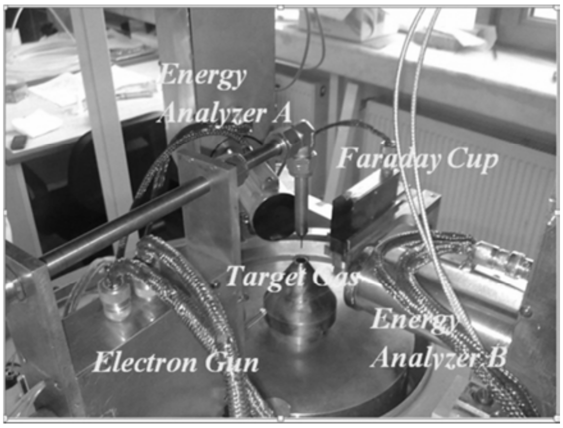

Fig. 2. A photo of the interaction region in the experimental system.

The electron gun was based on a monochromator. An indirectly heated cathode is used in preference, as the energy resolution of the electron beam produced is much better but generally a directly heated cathode is preferred for proper collision experiments [2]. The gun lens system consists of a series of cylindrical elements, quadrupole deflector and apertures and is shown in fig. 3 [3-7]. Molybdenum is used for the apertures because of its low uniform surface potential and reduced secondary emissions.

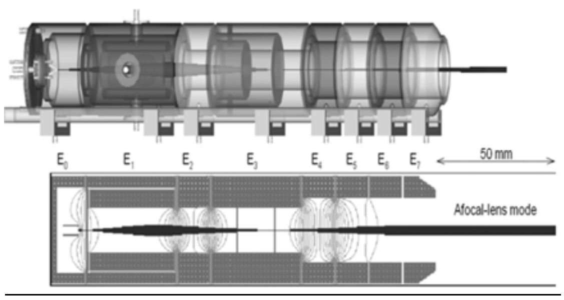

Fig. 3. 3D-AutoCAD view of the electron gun used in the electron trajectories simulations.

All lens elements of the electron gun were made from dural (aluminium) and were supported on glass rods and positioned with leaf springs. The whole assembly was housed in an earthed aluminum box. All internal surfaces of the lens elements facing the electron beam were sooted. The sooting reduces the reflection and secondary emission coefficients for low energy electrons impinging on the surface.

The filament is activated by slowly increasing the current, over a period of a few hours; up to the working voltage ~7 V. A reliable filament can operate satisfactorily over a period of a few months.

The electrostatic focusing of the electron beam is achieved by applying suitable voltages to the series of lens elements. The filament is housed in the first lens element, E_0, and both this element and the outer case of the filament are held at a negative potential so that the emitted electrons are accelerated towards the anode E_1. Since the final element E_7 is held at ground potential, the voltage applied to the element E_0 determines the energy of the electron beam. When the cathode produces electrons, they will go in different directions. An aperture A_1 is located between E_0 and E_1 as the first stage in producing a well-directed beam. A set of X, Y deflector plates are housed in the element E_1, and these allow the beam to be steered horizontally or vertically to correct for any misalignment of the filament or for the effect of stray magnetic fields on the electron beam.

The basic arrangement of the electron gun cylindrical electrostatic lens system is that described by Ulu et al [8]. The gun consists of two identical three-element lenses arranged so that the second focal point of the first lens and the first focal point of the second lens coincide. The lens elements and electrical connections are shown in fig. 3.

The optical properties of a multi-element lens have been analyzed in our previous works [3-6]. In the original gun, designed as the input stage of a monochromator, elements E_5 and E_6 were not present.

Element E_5 permits an extra degree of freedom, which allows an image of a fixed object to be kept constant in space while the energy is varied. The addition of element E_6 improved the performance of the gun at lower electron energies [8].

The focusing was achieved electrostatically by varying the voltages applied to each of the elements. The quality of the focusing was monitored using a Faraday cup. The properly aligned electron gun delivers up to 10 μA of well-focused Faraday cup current. The electron beam diameter is 2 mm. Of most significance for a crossed beam experimental geometry is the ability of the electron gun to deliver its well-focused beam through the center of the gas jet (fig. 2).

Conclusions

The results reported in this study will present data for developing design, simulation and construction of electron gun for getting better electron beams.

Acknowledgements

Thanks to all of my students, which they completed their thesis in the e-COL laboratory. This work was supported by the Scientific and Technological Research Council of Turkey (TUBITAK) through Grant No. 109T738 and by BAPK through Grant No. 15.HIZ.DES.130 and 15.FEN.BİL.15.

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