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Comparative Analysis of Electron Emission Mechanisms and Evaluation of a Suitable Method for Practical Electron Sources

Mohammad Bilal Hilal[1*], Arash Gharibi[2], Ahsanullah Saqib[3]
[1] Kabul University, Physics and Electronics Department, Physics Faculty, Kabul, Afghanistan
[2] Kabul University, Physics Faculty, Kabul, Afghanistan
[3] Department of Physics, Faculty of Education, Nangrahar University, Nangrahar, Afghanistan

ABSTRACT: Electron emission is a fundamental process in electron sources used in scientific, medical, and industrial applications. This study aimed to comparatively evaluate major electron emission mechanisms and identify their suitability for practical electron sources based on emission performance, beam quality, vacuum requirements, thermal stability, and operational lifetime. A comparative analytical review was conducted using scientific literature obtained through structured searches of major academic databases and scholarly platforms. Five emission mechanisms were evaluated: thermionic emission, field emission, photoelectric emission, secondary electron emission, and plasma cathode emission. Relevant parameters, including current density, operating pressure, beam stability, thermal effects, emission efficiency, and cathode lifetime, were extracted and comparatively analyzed. The findings show that plasma cathodes provide a major advantage for high-current electron sources, achieving current densities of approximately 100 A/cm² and stable operation under fore-vacuum conditions. The analysis also demonstrated that plasma-cathode beam current is strongly influenced by gas pressure and accelerating voltage, with excessive pressure increasing electron scattering and ion neutralization. Thermionic cathodes provide stable operation but are affected by high-temperature requirements and associated thermal deformation. Gallium arsenide photocathodes provide high beam quality and low emittance but require stringent vacuum conditions for stable operation. Discharge-control techniques, including cathode-spot localization and negative current feedback, were also found to improve plasma-source stability. Overall, plasma cathodes are particularly suitable for high-current electron sources operating under non-ideal vacuum conditions, whereas photocathodes are advantageous for applications requiring high beam quality and low emittance. The selection of an emission mechanism should therefore be based on the specific operating and performance requirements of the intended application.

KEYWORDS: Electron emission, electron sources, field emission, photoelectric emission, plasma cathode, thermionic emission.

INTRODUCTION

Electron beams serve as a cornerstone in modern scientific and industrial applications, ranging from medical radiotherapy and X-ray scanners to high-energy particle accelerators and industrial processing (Adil et al., 2024; Valković, 2022). The fundamental step in any electron-based system is the effective liberation of electrons from a surface, a process known as electron emission (Forbes, 2016; Koivisto, 2013). Traditionally, this is achieved through four primary mechanisms: thermionic emission, which utilizes heat energy; field emission, which employs strong electrostatic fields; photo-electric emission, which relies on photon energy; and secondary emission, induced by particle bombardment (Koivisto, 2013; Schaber et al., 2023). Recently, plasma cathodes have emerged as a robust alternative, providing a filamentless or cold cathode source of electrons that can operate reliably even at higher background gas pressures, such as those in the fore-vacuum range (Pal et al., 2012.

Despite the established nature of these mechanisms, significant challenges remain in the design of stable and precise practical electron sources. In thermionic sources, for instance, the necessity of high operating temperatures often leads to thermal stress, which causes mechanical deformation of the electrodes and filaments (Zhang et al., 2025). This deformation undermines beam focusing performance, resulting in an enlarged beam spot and reduced irradiation precision (Zhang et al., 2025). Furthermore, solid cathodes are highly susceptible to ion back-bombardment and surface contamination by residual gas molecules, which can permanently alter their work function and emitting characteristics (Gondol & Tajmar, 2022; Schaber et al., 2023). Another critical issue is the integrity of the vacuum environment; in the absence of a high-quality vacuum, emitted electrons frequently collide with gas molecules, leading to energy loss, beam scattering, and reduced directionality (Chambers, 2005).

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The stability and reliability of these systems are fundamentally dependent on the precision of the accelerating potential and the thermal equilibrium of the source (Gondol & Tajmar, 2022). Fluctuations in applied voltage can trigger instabilities such as the formation of cathode spots, which disrupt discharge uniformity and can lead to vacuum breakdown (Kazakov et al., 2013). Given these intertwined technical challenges-ranging from thermal fatigue to collisional attenuation-there is a scholarly gap in determining which emission method offers the best balance of longevity and beam quality under practical, non-ideal operating conditions.

The overall aim of this study is to perform a comparative analysis of electron emission mechanisms to evaluate their suitability for practical, high-performance electron sources. Specifically, this research seeks to analyze how thermal stability and vacuum quality impact the consistency of electron emission and beam transport. By evaluating the trade-offs between current density, operational lifetime, and environmental sensitivity, this study intends to identify a method that minimizes energy loss while maximizing beam focus and system reliability.

MATERIALS AND METHODS

Study Design and Setting

This study employed a comparative analytical review design to evaluate the major electron emission mechanisms used in practical electron sources. The analysis focused on five emission approaches: thermionic emission, field emission, photoelectric emission, secondary electron emission, and plasma cathode emission. The study compared these mechanisms based on electron emission stability, current density, energy efficiency, vacuum requirements, thermal stability, beam quality, operational lifetime, and sensitivity to environmental conditions. The research was based entirely on previously published scientific literature and did not involve direct experiments or human or animal participants.

Data Sources and Search Strategy

Relevant scientific literature was identified through structured searches of major academic databases and scholarly search platforms, including Google Scholar, ScienceDirect, Scopus, and Web of Science. Additional relevant publications were identified by screening the reference lists of selected articles. The search strategy combined seven primary keywords related to the objectives of the study: electron emission, thermionic emission, field emission, photoelectric emission, secondary electron emission, plasma cathode, and electron sources. Boolean operators such as AND and OR were used to combine search terms and improve the relevance of retrieved studies.

Eligibility Criteria and Study Selection

Studies were considered eligible when they investigated one or more electron emission mechanisms and provided information relevant to electron-source performance, emission stability, current density, beam quality, vacuum requirements, thermal behavior, operational lifetime, or environmental sensitivity. Experimental studies, theoretical investigations, computational studies, review articles, and relevant technical reports were considered for inclusion. Studies were excluded when they were unrelated to electron emission, lacked sufficient technical information, were duplicate publications, or were non-scientific sources without verifiable supporting evidence. The identified records were screened first by title and abstract, followed by full-text assessment of potentially relevant studies. The final selection was based on the relevance of each study to the objectives of the present comparative analysis.

Data Collection and Extraction

A structured data-extraction framework was used to collect information from the selected studies. The extracted parameters included the type of emission mechanism, cathode material, emission principle, operating temperature, applied electric field or photon energy where applicable, current density, electron energy, vacuum or background-pressure requirements, beam stability, energy loss, thermal effects, electrode degradation, operational lifetime, and major advantages and limitations. Particular attention was given to the effects of residual gas, ion bombardment, surface contamination, thermal deformation, and space-charge effects on electron-beam performance. The extracted information was organized according to the five emission mechanisms to facilitate direct comparison.

Comparative Analytical Method

The selected emission mechanisms were compared using a set of predefined performance criteria. These criteria included emission efficiency, achievable current density, beam stability, energy consumption, thermal stability, vacuum tolerance, cathode lifetime, susceptibility to surface contamination, beam focusing capability, and suitability for practical electron-source applications. Qualitative and, where comparable numerical data were available, quantitative comparisons were performed. Differences between conventional solid cathodes and plasma-based cathodes were particularly evaluated in terms of their ability to maintain stable electron emission under non-ideal vacuum and operating conditions.

Assessment of Practical Suitability

The practical suitability of each emission mechanism was evaluated by considering the balance between electron-emission performance and operational limitations. Thermionic emission was assessed primarily with respect to thermal requirements, cathode lifetime, and beam stability; field emission was evaluated in relation to electric-field requirements, surface condition, and emission stability; photoelectric emission was assessed according to photon-energy requirements and controllability; secondary emission was evaluated based on incident-particle requirements and electron yield; and plasma cathodes were assessed in terms of their ability to operate under relatively higher background pressures, their filamentless operation, and their potential for stable high-current electron production. The final evaluation was based on the overall performance across the selected criteria rather than on a single parameter.

Data Synthesis and Quality Assessment

The findings from the selected studies were synthesized using a comparative qualitative approach. Where studies reported sufficiently comparable numerical parameters, their results were tabulated and compared. Differences in experimental conditions, cathode materials, vacuum levels, operating voltages, and electron energies were considered when interpreting the reported results. Greater emphasis was placed on peer-reviewed studies and publications providing clearly described experimental, theoretical, or computational methods. The consistency of findings across multiple independent studies was also considered when evaluating the relative advantages and limitations of each emission mechanism.

RESULTS

1. Comparative Performance of Plasma and Thermionic Cathodes

The comparative analysis of emission mechanisms demonstrates that plasma cathodes offer a significant advantage in extractable current, capable of delivering maximum current densities of approximately 100 A/cm²- a performance level at least one order of magnitude higher than that of conventional thermionic sources (Oks & Schanin, 1999). This superior efficiency is largely attributed to their "filamentless" or "cold cathode" nature, which allows these systems to operate reliably in fore-vacuum pressure ranges and remain fundamentally immune to damage from back-streaming ions, which is a common failure mode in industrial thermionic guns (Oks & Schanin, 1999; Pal et al., 2012). In contrast, the operation of conventional thermionic cathodes, which typically utilize materials such as Lanthanum Hexaboride (LaB_6) and Barium Oxide (BaO), is strictly governed by the Richardson-Dushman law (Gondol & Tajmar, 2022; Kimball Physics, 2025). This law dictates that the emission current density increases exponentially with temperature; however, to reach significant current levels, these materials must be heated to temperatures often exceeding 1000K (Gondol & Tajmar, 2022). Such high-temperature requirements induce substantial thermal stress, leading to mechanical deformation of the electrodes, which can enlarge the beam spot and degrade focusing precision over time (Zhang et al., 2025). Consequently, while thermionic emission remains standard for many applications due to its simplicity, plasma-based mechanisms provide a more robust and high-intensity alternative for practical electron sources requiring extreme current densities and long-term structural stability (Oks & Schanin, 1999).

Table 1. Comparative Characteristics of Electron Emission Sources (Koivisto, 2013).

Cathode Type	Emission Mechanism	Operating Pressure	Typical Current Density	Observed Stability
Tungsten/LaB_6	Thermionic emission	High vacuum, 10^{-6}Torr	1–10 A/cm²	High, if thermally stable
GaAs/Photocathode	Photoelectric emission	Ultra-high vacuum, 10^{-11}Torr	mA range, continuous-wave (CW) operation	Highly sensitive to residual gas

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Cathode Type	Emission Mechanism	Operating Pressure	Typical Current Density	Observed Stability
Plasma Cathode	Gas discharge	Fore-vacuum, 1–100 Pa	Up to 100 A/cm²	High, filament-less operation
Field Emitter	Cold emission	High vacuum	μA per tip	Sensitive to surface purity

2. Effect of Gas Pressure and Accelerating Voltage on Beam Current

In a single-gap triggered pseudospark discharge device, the peak beam current (I_B) is governed by a complex, non-monotonic relationship with the operating gas pressure (p) and the applied accelerating voltage (U). Experimental observations demonstrate that, for applied voltages of 10 kV and 15 kV, the beam current initially increases with increasing gas pressure but begins to decline after reaching specific turning points at approximately 80 Pa and 90 Pa, respectively. At lower pressures, the beam current is primarily constrained by the low plasma density within the hollow cathode and the accelerating gap. Therefore, increasing the gas pressure enhances ionization and consequently increases the electron-emission current. However, as the pressure increases further, the net beam current decreases because of intensified electron scattering and ion neutralization (Shen et al., 2022).

Low-energy electrons in the 0–0.5 keV energy range have relatively short mean free paths. For example, at 80 Pa, the mean free path of electrons in helium is approximately 12.9 mm. Consequently, these electrons are highly susceptible to collisions and scattering within the drift cavity, which prevents some of them from reaching the collector. At the same time, the increased plasma density at higher pressures facilitates ion neutralization. In this process, positive ions are accelerated toward the Faraday cup and neutralize incoming electrons, thereby reducing the net charge signal recorded by the detector. Conversely, at a given gas pressure, increasing the accelerating voltage (U) consistently results in a higher peak beam current. This monotonic increase is attributed to enhanced electron emission, which is associated with a stronger sheath electric field and reduced sheath thickness at the cathode aperture. In addition, electrons accelerated to higher kinetic energies have longer mean free paths, which reduces the influence of scattering during beam transport (Shen et al., 2022).

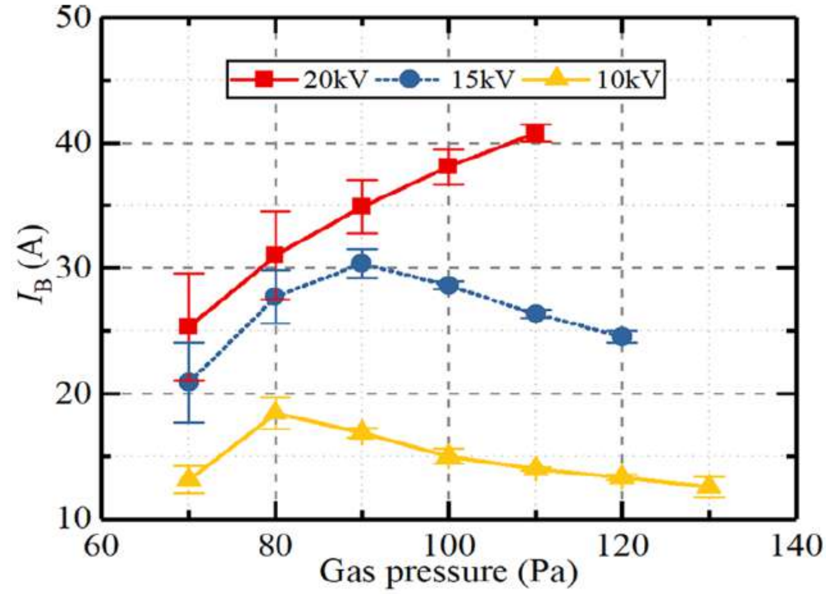

Figure 1. Variation of peak beam current (I_B) with gas pressure at different applied voltages (U) in a single-gap triggered pseudospark discharge (Shen et al., 2022).

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3. Discharge Stability and Mode Transitions

The stability of gas-discharge systems and their operational modes are critical for consistent electron-beam generation. In fore-vacuum plasma sources, a hollow-cathode glow discharge is typically used to generate emission plasma; however, exceeding a specific threshold current trigger the formation of a random cathode spot, initiating a transition to an arc discharge mode (Kazakov et al., 2013). Research by Kazakov et al. (2013) demonstrated that by implementing forced localization of this cathode spot in a limited region distant from the emission surface, the transition from glow to arc discharge maintains highly stable and reproducible pulsed parameters. Under these conditions, with an accelerating voltage of 12 kV and a pulse duration of up to 1ms, the system sustains an emission current of 80 A, achieving a surface-averaged beam energy density of 10 J/cm² with high extraction efficiency (Kazakov et al., 2013).

Conversely, the working gas significantly alters discharge characteristics. In oxygen environments, the discharge operates in an anomalous glow mode, where the discharge voltage increases exponentially with the current, whereas in argon or nitrogen, the voltage remains nearly constant (Burdovitsin et al., 2022). This behavior in oxygen is attributed to the formation of oxide films on electrode surfaces, which increases the sheath thickness between the plasma and the cathode wall. This thickened sheath facilitates avalanche electron multiplication, requiring higher operating voltages to maintain the same current levels compared to inert gases (Burdovitsin et al., 2022). Furthermore, to manage uncontrolled current surges, the introduction of a series negative current feedback (NCF) mechanism—using a specialized niobium electrode within the plasma emitter-has been shown to stabilize the beam amplitude and increase the dielectric strength of the high-voltage accelerating gap (Vorobyov et al., 2022). Experimental data indicate that this NCF method can reduce uncontrollable current surges from 240 A to 140 A, effectively extending the range of stable operation (Vorobyov et al., 2022).

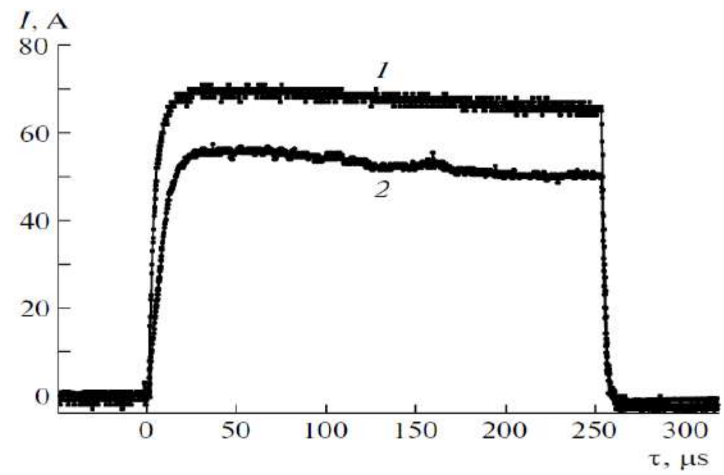

Fig 2. Oscillograms of (1) discharge current pulses and (2) electron emission current pulses at an accelerating voltage of 12 kV and a gas pressure of 8 Pa (Kazakov et al 2013).

4. Thermal Stress and Structural Integrity

Joint electromagnetic and thermal simulations using CST and ANSYS indicate that elevated filament temperatures cause significant mechanical deformation. Radial expansion of the cavity walls was measured at 135 μm, while the cathode nose surface expanded by 30 μm, resulting in a frequency shift of 95 kHz in RF-based electron sources (Tan et al., 2023). This deformation results in an enlargement of the beam spot size and a shift in the axial position of the beam waist, thereby weakening the focusing effect of the electrodes (Zhang et al., 2025).

5. Photocathode Lifetime and Vacuum Sensitivity

The operational lifetime of semiconductor photocathodes, such as GaAs, is strongly dependent on vacuum quality. In DC photoguns, the 1/e lifetime, defined as the time required for the quantum efficiency to decrease to approximately 37% of its initial value, was measured at 550 beam hours at an average current of 100 μA under pressures below 10^{-9} Pa (Hernandez-Garcia et al., 2015). For alkali-antimonide photocathodes (Cs_3Sb), a quantum efficiency of 5% was achieved, with a dark lifetime exceeding one year (Adil et al., 2024).

6. Beam Quality and Emittance

The characterization of beam quality and emittance in photocathode-based DC guns is essential for achieving the high brightness required for advanced accelerator applications (Nishimori et al., 2018). Experimental measurements reveal that the normalized thermal emittance per root mean square (rms) laser spot size is approximately 0.56 ± 0.03 mm-mrad/mm (rms) (Nishimori et al., 2018). Under high-current conditions, such as during the generation of a 50mA electron beam with a laser spot size of 0.2 mm (rms), the system can maintain a normalized emittance of approximately 0.1mm-mrad (Nishimori et al., 2018). For high-energy systems operating at 200 keV, the relativistic Lorentz factor product is approximately $\beta\gamma \approx 1$, allowing the unnormalized emittance to remain nearly equal to the normalized emittance (Nishimori et al., 2018).

Furthermore, assuming a beta function of $\beta y = 0.2$ m at the beam waist, these systems can achieve a highly precise beam diameter of 560 μm, corresponding to a rms beam size (σy) of approximately 0.14 mm (Nishimori et al., 2018). This level of beam precision is possible because emittance growth caused by space-charge effects remains negligible under these operating conditions. Rapid acceleration near the photocathode suppresses the nonlinear beam divergence typically associated with mutual Coulomb repulsion. To ensure the statistical reliability of the measurements, the data acquisition process involves averaging 128 separate measurements using an oscilloscope, thereby reducing measurement noise and variability. This measurement procedure provides an accuracy greater than 95%, supporting a high degree of confidence in the reported beam parameters (Taploo et al., 2023).

DISCUSSION

The results of this comparative analysis demonstrate a significant performance hierarchy among electron emission mechanisms, particularly highlighting the robust advantages of plasma-based sources over traditional thermionic systems. While thermionic cathodes are governed by the Richardson-Dushman law, requiring temperatures exceeding 1000 K to achieve modest current densities (1-10 A/cm²), plasma cathodes achieve densities of approximately 100 A/cm² without the need for a heated filament. This interpretation aligns with the literature provided by Oks & Schanin (1999), which emphasizes that "filamentless" operation eliminates common failure modes such as ion back-bombardment and thermal fatigue. The simulations by Zhang et al. (2025) further contextualize these results, showing that thermal stress in solid emitters leads to substantial mechanical deformation, such as a 135 μm radial expansion, which undermines beam focusing precision.

A comparison across the evaluated mechanisms reveals distinct trade-offs between environmental tolerance and beam performance. Photocathodes (GaAs) offer exceptional beam quality and emittance (0.56 mm-mrad/mm), which is essential for high-energy accelerators; yet they are restricted by extreme vacuum sensitivity, requiring pressures below 10^{-9} Pa to maintain a 550-hour lifetime. In contrast, plasma cathodes excel in non-ideal fore-vacuum environments (1-100 Pa), where traditional solid cathodes would be vulnerable to residual gas contamination. Field emitters provide high brightness but are limited to microampere ranges and are highly sensitive to surface purity, whereas thermionic sources provide stable operation if thermal equilibrium is maintained, albeit at lower intensities.

These findings advance the field by quantifying the complex, non-monotonic relationship between gas pressure and beam current in pseudospark discharges. The identification of turning points at 80 Pa and 90 Pa for 10 kV and 15 kV, respectively, clarifies the transition where electron scattering and ion neutralization begin to outweigh the gains from increased plasma density. Furthermore, the study highlights the efficacy of forced localization of cathode spots as a method for maintaining stable pulsed parameters during the transition from glow to arc discharge, as established by Kazakov et al. (2013).

A primary strength of this study is its integrated approach, combining joint electromagnetic-thermal simulations with experimental vacuum-sensitivity data to provide a holistic view of cathode longevity. However, a limitation remains in the practical implementation of high-current semiconductor photocathodes. Despite achieving a 5% quantum efficiency, observations indicate that exposure to even 1 Pa of air can result in permanent degradation, requiring complete wafer replacement. Additionally, while plasma sources are robust, managing uncontrolled current surges requires complex feedback mechanisms.

The implications of this research are particularly relevant to the development of high-brightness light sources and industrial irradiation processing. The successful implementation of series negative current feedback (NCF) using niobium electrodes suggests a viable approach for stabilizing high-voltage gaps and reducing current surges from 240 A to 140 A. Future research should focus on optimizing superconducting radio-frequency (SRF) solutions to manage the heat generated during continuous-wave (CW) operation and investigating new materials for alkali-antimonide photocathodes to extend their operational dark lifetime beyond the currently achieved one year.

CONCLUSION

This comparative analytical review demonstrates that the performance of electron emission mechanisms is strongly influenced by current density, beam quality, vacuum requirements, thermal stability, and operational lifetime. Among the evaluated mechanisms, plasma cathodes showed the greatest potential for high-current electron sources, with current densities of approximately 100 A/cm² and reliable operation under fore-vacuum conditions. Their filamentless operation also reduces the limitations associated with thermal stress and ion back-bombardment in conventional cathodes. Thermionic cathodes remain useful because of their established and stable operation; however, their requirement for high temperatures can cause thermal stress, mechanical deformation, and degradation of beam focusing. Photocathodes, particularly GaAs-based sources, provide high beam quality and low emittance, making them suitable for high-brightness accelerator applications, but their performance and lifetime are strongly dependent on ultra-high-vacuum conditions. The results further indicate that plasma-cathode beam current is highly dependent on gas pressure and accelerating voltage. An optimum pressure range is required because increasing pressure initially enhances plasma density and beam current, whereas excessive pressure increases electron scattering and ion neutralization. Discharge-control techniques, including forced cathode-spot localization and negative current feedback, can improve the stability of high-current plasma sources. Overall, plasma cathodes appear particularly suitable for high-current electron sources operating under non-ideal vacuum conditions, while photocathodes are more advantageous when high beam brightness and low emittance are the primary requirements. Therefore, the selection of an electron emission mechanism should be based on the specific operating conditions and performance requirements of the intended application.

REFERENCES

1. Adil, H. M., Abbas, S. F., Kadhim, S. A., Mohmmed, A. H., & Sharad, A. H. (2024). Radiation therapy systems using linear accelerator, importance of its components and their development. GSC Advanced Research and Reviews, 20(3), 22–29. https://doi.org/10.30574/gscarr.2024.20.3.0315
2. Burdovitsin, V., Bakeev, I., Karpov, K., Ngon A. Kiki, L., Oks, E., & Vizir, A. (2022). Characteristics of a source for oxide coating deposition by the electron-beam evaporation of dielectric materials. Plasma, 5(2), 258–264. https://doi.org/10.3390/plasma5020020
3. Chambers, A. (2005). Modern vacuum physics. CRC Press.
4. Forbes, R. G. (2016). Field electron emission theory (October 2016) (arXiv:1801.0825, v2). University of Surrey. https://doi.org/10.13140/RG.2.2.25426.15047
5. Gondol, N., & Tajmar, M. (2023). A volume-averaged plasma model for heaterless C12A7 electride hollow cathodes. CEAS Space Journal, 15, 431–450. https://doi.org/10.1007/s12567-022-00449-w
6. Hernandez-Garcia, C., et al. (2015). Status of the high voltage DC photoemission gun for the Jefferson Lab FEL.
7. Kazakov, A. V., Burdovitsin, V. A., Medovnik, A. V., & Oks, E. M. (2013). A forevacuum pulse arc-discharge-based plasma electron source. Instruments and Experimental Techniques, 56(6), 680–683.
8. Kimball Physics. (2025). Electron gun tutorial resource 2025_0420. Kimball Physics.
9. Koivisto, H. (2013, March 4). Particle sources part I: Electron sources [Lecture notes]. University of Jyväskylä.
10. Kutsaev, S. V. (2021). Electron bunchers for industrial RF linear accelerators: Theory and design guide. The European Physical Journal Plus, 136(4), 446. https://doi.org/10.1140/epjp/s13360-021-01312-3
11. Nishimori, N., et al. (2018). Stable operation of a 50 mA GaAs photocathode DC gun. Particles, 1(1), 178–185.
12. Oks, E. M., & Schanin, P. M. (1999). Plasma sources of electron beams. Physics-Uspekhi, 42(12), 1271.
13. Pal, U. N., Kumar, N., Verma, D. K., Prajapati, J., Kumar, M., Srivastava, V., Dwivedi, H. K., & Prakash, R. (2012). Development of low-pressure high-current plasma cathode electron gun and use of associated techniques. Journal of Theoretical and Applied Physics, 6, 36. https://doi.org/10.1186/2251-7235-6-36

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IJCSRR @ 2026
www.ijcsrr.org

14. Schaber, J., Xiang, R., & Gaponik, N. (2023). Review of photocathodes for electron beam sources in particle accelerators. Journal of Materials Chemistry C, 11(9), 3162–3180. https://doi.org/10.1039/d2tc03729g
15. Shen, S., Sun, G., Wang, X., Yan, J., Shang, T., & Ding, W. (2022). Influence of gas pressure and accelerating voltage on beam current in a pseudospark discharge based plasma cathode electron source. Physics of Plasmas, 29(1), 013503.
16. Taploo, A., Lin, L., & Keidar, M. (2023). [Study on electric propulsion]. Journal of Electric Propulsion, 2(21). https://doi.org/10.1007/s44205-023-00058-7
17. Valković, V. (2022). Low energy particle accelerator-based technologies and their applications (1st ed.). CRC Press. https://doi.org/10.1201/9781003033684
18. Vorobyov, M. S., et al. (2022). Negative current feedback in the accelerating gap in electron sources with a plasma cathode. Technical Physics, 67(6), 752.
19. Zhang, Z., Huang, J., Fan, M., Yu, T., & Li, H. (2025). Thermal stress analysis and structural optimization of electron guns for electron beam irradiation processing (IAEA-CN-332/489). ICARST-2025.
20. Zheng, L., et al. (2023). Design, fabrication, and beam commissioning of a 216.667 MHz continuous-wave photocathode very-high-frequency electron gun. Physical Review Accelerators and Beams, 26, 023501.

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 *Corresponding Author: Mohammad Bilal Hilal