International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 9, Issue 2, pp 11-13, February-2025

https://doi.org/10.47001/IRJIET/2025.902003

Sodium-lithium Based Evaporative Ion Getter for Medium to High Vacuum Applications

Maximilian Aaron Jelačić

Research club Nikola Tesla, Catholic school centre St. Joseph, MP Sokolovica 11, 78000 Sarajevo, Bosnia and Herzegovina

***Abstract* - Ion getters play a critical role in maintaining the performance and longevity of vacuum systems used in medium to high-voltage applications, such as electron microscopes, particle accelerators, high-voltage vacuum switches, and various other high-energy devices. These getters are employed to remove residual gases, including reactive and inert species that can compromise the vacuum quality and interfere with the operation of high-voltage equipment. The ion getter technology typically involves the use of materials that ionize gases and subsequently trap them through chemical or physical adsorption, ensuring the preservation of a high-quality vacuum. This paper describes the construction criteria and process for the sodium-lithium based ion getter.**

Keywords: high vacuum, ion getter, vacuum applications.

I. INTRODUCTION

The challenge of creating and maintaining a high-quality vacuum has led to the development of specialized vacuum getters, which are essential for removing unwanted gases that could compromise the integrity of the vacuum in various apparatuses.

When discussing getters, it's important to note that they can differ not only in the types of gases they target but also in the duration of their activity. The "active time" of a getter is crucial in determining its role during the vacuum process [1-4]. This active time depends on when the getter is introduced during the vacuum formation process in a given system.

There are two main types of getters based on their active time:

1. Short-active getters: These getters are active during the evaporation phase and are designed to absorb large quantities of gas quickly. Their purpose is to accelerate the evacuation process or overcome specific limitations in the vacuum system that would otherwise prevent the creation of a sufficiently high vacuum. Short-active getters require external energy, typically in the form of heating, to function. Their active time is brief but critical for achieving an initial low or medium vacuum.
2. Long-active getters: These are used primarily for the maintenance of the vacuum over extended periods. Unlike short-active getters, they do not require external energy for operation. Their gas absorption rate is slower, as they are intended to address the natural, gradual outgassing that occurs in the apparatus over time. These getters are vital for maintaining a stable high vacuum environment.

The choice of getter is largely influenced by the vacuum system in use. In systems designed for lower vacuum levels, short-active getters are favoured, as the immediate formation of a high vacuum takes precedence over longterm maintenance. Conversely, high vacuum systems, which can achieve and sustain more rigorous vacuum levels, rely on long-active getters to ensure that the vacuum remains stable over time.

For devices intended to maintain a vacuum over extended periods, a high vacuum system is essential. However, such systems are often prohibitively expensive and require ongoing maintenance to function optimally. This creates a demand for getters that can operate within lower vacuum systems but still maintain a high vacuum for a longer duration.

While many metals can function as getters with short active times, only a few are reactive enough to also serve as long-active getters. This narrows the selection to primarily alkaline and alkaline-earth metals, which have both the required reactivity and the necessary properties for effective gas absorption over extended periods.

Further criteria for selecting suitable getter materials include evaporability and stability. Evaporability is particularly important, as the getter material must be able to evaporate at temperatures of a few hundred degrees Celsius to work effectively in vacuum systems. Fortunately, most alkali and alkaline-earth metals meet this requirement.

Stability is another critical factor, as it affects both the handling and installation of the getter material. Some metals, such as **cesium (Cs)** and **rubidium (Rb)**, are avoided due to their rarity and the risks associate with handling them in their elemental form. As a result, the most viable candidates for long-active getters are **lithium (Li), sodium (Na),

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potassium (K), calcium (Ca), magnesium (Mg),** and **beryllium (Be)**.

These metals are capable of fulfilling the dual role of efficiently gettering gases in both short and long-term applications, making them ideal materials for use in advanced vacuum systems.

II. GETTER CONSTRUCTION

A getter construction that gives good results is one that allows careful control of the getter material in the short active time period. This means that energy can be applied uniformly. A vapour-ion reflector design was found to provide optimal results.

Heater /Cathode

The heater/cathode consists of a thin spirally wound tungsten filament. The getter material is placed inside of this spiral prior to connecting the getter to the vacuum apparatus (Figure 1).

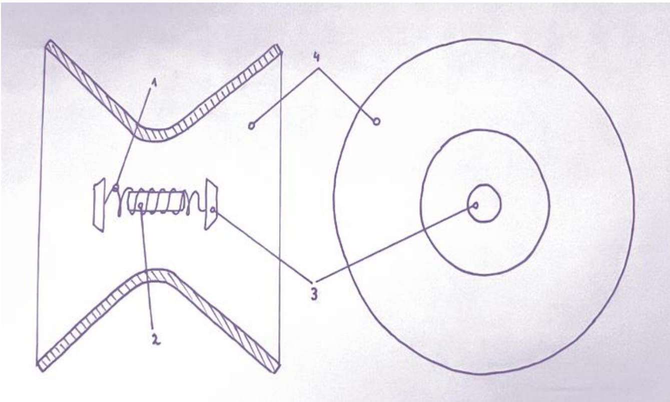

Figure 1: Advantages of iron

In Figure 1the following parts have been indicated:

1 – heater/cathode filament

2 – getter material

3 – heater end-caps

4 – reflector anode

Anode reflector

The anode reflector consists of metal plates shaped as cones that are attached back to back forming an hour-glass shaped that is concentric with the heater spiral.

Activation and operation

Once a low-vacuum is formed by an external vacuum pump, the heater filament is flashed by applying a voltage across its ends. This causes the getter material to evaporate.

III. SEVERAL GETTER STAGES

The getter undergoes several fazes once the low-vacuum is formed by an external vacuum pump.

Faze 1 – Evaporation

The apparatus is disconnected from the vacuum pump and the heater filament is flashed by applying a voltage across the ends. The getter material evaporates. A small portion of the heated getter vapour reacts with oxygen molecules present in the vacuum, while the remainder of the vapours condenses on the colder anode reflector.

Faze 2 – Ionisation

Once the getter has cooled down from faze 1, the filament is heated once more. This time it is heated to the point of thermionic emission. A current limited DC voltage of a couple of hundred volts is placed between the cathode filament and the anode reflector.

Initial arc is formed by the present nitrogen in the vacuum. Maintaining a current flow of a couple of milliamps will heat the anode reflector, causing the getter material to revaporize and ionize in the formed plasma.

The formed alkaline plasma will react with the present nitrogen and be sputtered out of the reflector where it will condense on a cold surface.

Faze 3

The condensed getter material will still have a lot of unreacted material that will continue to absorb loose gasses in the vacuum.

IV. EXPERIMENTAL DISCUSSION AND CONCLUSION

Through experimentation it was found that sodium was best suited for use as the primary constituent of the getter material. Its low melting point and high reactivity make it easy to vaporize and ionize.

Lithium is used as an additive to sodium in this process. Its chemical properties are similar to these of sodium with the advantage that lithium is much more prone to react and thus absorb remaining nitrogen in the 3rd faze of the getter operation.

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REFERENCES

[1] K. A. Alhassen et al., "Evaluation of the Gettering Efficiency of Evaporative Ion Getters," Journal of Vacuum Science & Technology A, Vol. 25, Issue 6, 2007.
[2] "Ion Pumps and Getters," Handbook of Vacuum Science and Technology (1998), ed. by James M. Lafferty.
[3] "Principles of Vacuum Technology" by John F. O'Hanlon.
[4] "Vacuum Technology and Applications" by David J. Hucknall (Chapter on Ion Getters).

AUTHOR'S BIOGRAPHY

Maximilian Aaron Jelačić is a high-school student who has several awards in science, physics and mathematics. He won several gold medals in International Science Project Olympiad, is national champion in physics and science. His hobbies are electronics and chemistry.

Citation of this Article:

Maximilian Aaron Jelačić. (2025). Sodium-lithium Based Evaporative Ion Getter for Medium to High Vacuum Applications. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(2), 11-13. Article DOI https://doi.org/10.47001/IRJIET/2025.902003

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