Ignition Method of Corona Discharge with Modulation of the Field in Ion Source of Ion Mobility spectrometer

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***Abstract* – The new method for the ignition of the corona discharge has been developed, which improves the stability of the ion mobility spectrometer and the resolution of the instrument. The system of forming a corona discharge without additional electrodes, which are used in a number of known structures for the pre-ionization, has been developed. This simplifies the design of the proposed source and an electronic control circuit. IMS technology is widely used in different civil and military fields for vapor-phase detection of explosive, narcotics, chemical warfare agents, biology molecules and so on. There are set of methods whose are used for the ionization of molecules under analysis. They are the following: radioactive ionization, ultraviolet photoionization, laser ionization, electric field ionization, coronaspray ionization, electrospray ionization, roentgen ionization, and surface ionization. All these methods has their own advantages and disadvantages. A comparing of ion mobility spectra of non-polar hydrocarbons for photoionization, corona discharge ionization and 63Ni ionization, had carried in. In our work we have investigated four types of IMS spectrometers whose use different sources for molecules under analysis ionization. They use radioactive ionization, ultraviolet photoionization, laser ionization, and roentgen ionization. The traditional explosives had investigated in experiments. In electricity, a corona discharge is an electrical discharge brought on by the ionization of a fluid surrounding a conductor, which occurs when the potential gradient (the strength of the electric field) exceeds a certain value, but conditions are insufficient to cause complete electrical breakdown or arcing.**

***Key words* – a ion mobility spectrometer, a corona discharge, a ignition of corona, a gate, additional electrodes.**

I. INTRODUCTION

Ion mobility spectrometry (IMS) is an analytical technique [1-3] for gas phase analysis of chemical compounds in laboratory environments; more recently, this method has been used in field applications to rapidly detect chemical warfare agents, explosives, and narcotics. Common structure (Figure 1) of the device includes the ionization region for inlet probe, gate for ion clusters forming, drift region, the detecting unit, data processing system.

The ion mobility spectrometers use radioactive radiation, corona discharge, the laser radiation, ultraviolet or X-rays to ionize air samples. Ionization source is an important part of the system responsible for the stability, resolving and sensitivity of the spectrometer. Sources can operate in continuous or pulsed mode

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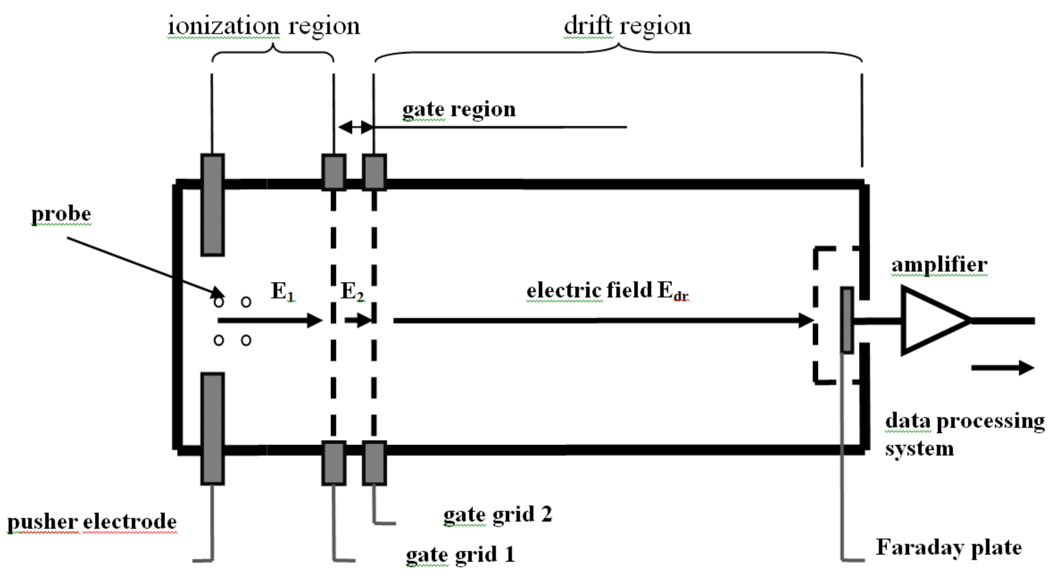

Fig. 1. Common structure of ion mobility spectrometer with electrostatic gates.

The choice of a corona discharge to ionize air samples is connected with the following advantages:

- lack of radioactive materials;
- the possibility of generating both positive and negative ions;
- simplicity and low cost of manufacture;
- low power consumption.

II. CORONA IONIZATION SOURCE

Ionization source by a corona discharge (Figure 2) consists on a conductive substrate, called a pusher electrode with thin sharp electrodes, between which at high voltage corona discharge produced plasma. Limiting (ballast) resistors R are used to align the current burning corona.

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A corona is a process by which a current, perhaps sustained, develops from an electrode with a high potential in a neutral fluid, usually air, by ionizing that fluid so as to create a plasma around the electrode. The ions generated eventually pass charge to nearby areas of lower potential, or recombine to form neutral gas molecules. When the potential gradient is large enough at a point in the fluid, the fluid at that point ionizes and it becomes conductive. If a charged object has a sharp point, the air around that point will be at a much higher gradient than elsewhere. Air near the electrode can become ionized (partially conductive), while regions more distant do not. When the air near the point becomes conductive, it has the effect of increasing the apparent

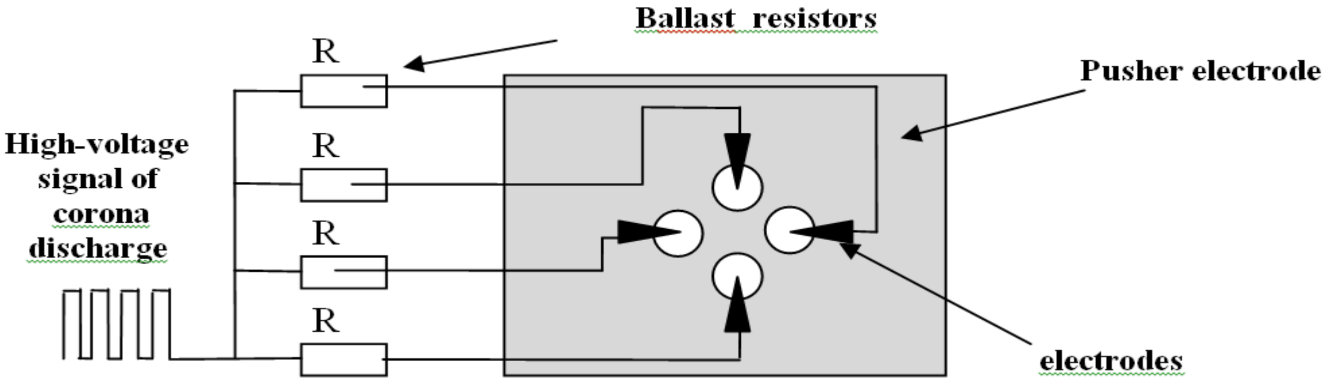

Fig. 2. The ionization source by a corona discharg

size of the conductor. Since the new conductive region is less sharp, the ionization may not extend past this local region. Outside of this region of ionization and conductivity, the charged particles slowly find their way to an oppositely charged object and are neutralized.

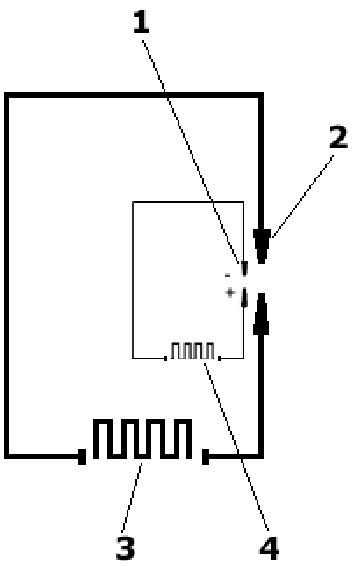

Fig. 3. The ionization source with two additional firing electrodes (1 – the additional electrodes, 2 – the main electrodes, 3 – the pulse generator for ignition corona discharge between the main electrodes, 4 – the pulse generator for ignition corona discharge between the additional electrodes).

If the geometry and gradient are such that the ionized region continues to grow instead of stopping at a certain radius, a completely conductive path may be formed, resulting in a momentary spark, or a continuous arc.

Corona discharge usually involves two asymmetric electrodes; one highly curved (such as the tip of a needle, or a small diameter wire) and one of low curvature (such as a plate, or the ground). The high curvature ensures a high potential gradient around one electrode, for the generation of a plasma.

Typically, ionization chamber design is such that the ignition electrodes locate in a region of high electric field, so that the generated ions are carried out from the ionization region to the gate. In this case ions of natural origin continuously carried out from the area between the electrode tips of the corona source, this complicates ignition of the corona. This leads to the instability of the discharge and the need to increase the duration and amplitude of the voltage pulse ignition. One of solution ways is proposed in American patent № 6407382 [5], which suggests the use of corona ionization source with additional firing electrode (Figure 3). First additional electrodes are initiated to following provide with ions the main electrodes.

In this work the corona discharge ignition system is proposed, in which the ignition is divided on two phases: preliminary and basic. During the preliminary phase an electric field in the ion source set to zero, and the generating "initiating" ions remain near the fire electrodes after end of the discharge. To the moment of a start of basic ionization phase the field in the ion source is restored to the nominal level, with the "initiating" ions do not have time to leave the region of ignition due to the low mobility. This ensures the stability of ignition of a corona discharge due to the presence of ions in the discharge gap staying since the preliminary phase of discharge. The proposed system provides manufacturability and preserves the ionization source dimensions without resorting to the use of the additional electrodes.

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