A GAS FEED SYSTEM WITH PIEZOELECTRIC VALVES

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1. Introduction

Fine control of the gas flow rate is indispensable for efficient operation of a cold-cathode PIG ion source in addition to a wide dynamic range of the flow rate extending from 0.1 to 10 cm^3/min. Conventional gas-feed system with a motor-driven needle valve is insufficient from this point of view.

A new gas-feed system controlled by piezoelectric valves has been installed for the ion source of the INS SF cyclotron. The piezoelectric valves driven by electronic pulses have characteristics suitable for heavy ion sources; a quick responce, fine controlability and a wide dynamic range of the flow rate. The system is equipped with two gas-feed lines to provide a mixture of two different gasses. Each line has a piezoelectric valve in it. The second line was designed to feed a support gas to strike an arc easily or a subsidiary gas to increase the beam intensity.

At the same time the ^{3}He gas recovery system with a charcoal trap in a liquid nitrogen bath for purification, has been replaced with an evacuated bottle of ^{3}He gas storage. This method eliminated the use of liquid nitrogen during the ^{3}He beam time.

2. Gas Feed System

A block diagram of the gas-feed system is shown in Fig. 1. This system is similar to the one used at the Texas A & M cyclotron[1]. Each line has a low-pressure regulator and a piezoelectric valve. The regulator commercially available for propane gas, was modified to be vacuum tight for the present purpose. It is operated with a spring and it keeps the output pressure at a level

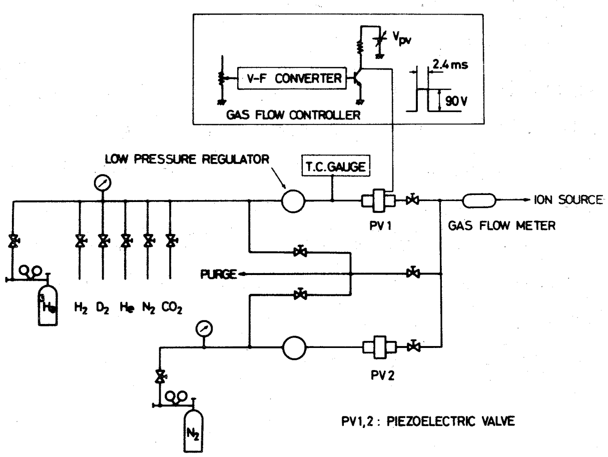

Fig. 1

Block diagram of the gas-feed system

higher than the atmospheric pressure by 0.03 kg/cm^2 for the input pressure range of 0.1 - 3.0 kg/cm^2 (above the atmospheric pressure). The piezoelectric valves are also commercially available from Veeco, U. S. A.. It uses the displacement of a piezoelectric crystal and can be opened either by a pulse voltage or a DC voltage. In the case of DC operation, the stability of the flow rate is very poor. In pulse operation, the flow rate can be controlled either by the frequency of the pulses or by the height. We usually use a frequency mode of operation with a constant pulse voltage of 90 V and the pulse length of 2.4 ms.

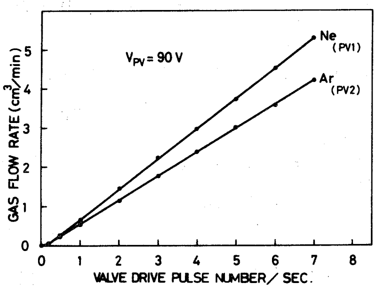

Fig. 2

Gas flow rate vs valve-drive pulse rate. In the case of Ne, the first line was used and for AR the second was used.

Fig. 2 shows the results measured for two different gasses. It should be noted that the flow rate is linear to the pulse number per second. More important is the fact that the flow rate can be reduced to zero. This allows us to compare the effects of mixed gas on the beam intensity with those of pure gas.

The system employs 12 electromagnetic valves, which are actuated by a sequence controller (OMRON SCY-PO), thus avoiding the use of bulky electromagnetic relays. The main line is connected to six gas inlets which can be selected by a remote control.

3. Gas Mixing Experimant

It is reported[2,3] that the beam intensity of some kinds of ions can be increased by adding nother kind of gas to the PIG arc. By using this gas-feed system we tried to observe this effect. An example is shown in Fig.3, in which a large increase of the 115-MeV $^{20}Ne^{6+}$ beam was observed by adding nitrogen gas. However, the intensity was not so much increased by an optimum addition of 0.3 cm^3/min argon gas. Finer tuning of the arc and the cyclotron is needed to get a more definite conclusion.

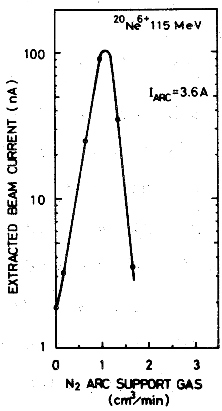

Fig. 3

The extracted beam current of the 115-MeV Ne beam as a function of the flow rate of nitrogen support gas

1. Y. Sakurada et al., Nucl. Instr. Meth. 164 (1979)196
2. E. D. Hudson et al., IEEE Trans. Nucl. Sci. NS-24(1977)1950
3. Y. Sakurada et al., IEEE Trans. Nucl. Sci. NS-26(1979)2175