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Studying the impact of humidity on the performance of THGEMs

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Abstract: In this study, we investigate the impact of humidity on the performance of a THGEM operated with an Ar-CO_2 gas mixture. The water content is introduced in a range of 0–4000 ppmV. It is observed that the presence of increased humidity does not degrade any of the studied performance criteria. On the contrary, our measurements suggest an improvement in discharge stability with increasing humidity levels at the highest gains and fields. No significant difference is observed at the lower gains, indicating that humidity helps to avoid spurious discharges related to electrode defects or charging-up of the insulating layers. We conclude that adding a small amount of water to the gas mixture may be beneficial for the stable operation of an MPGD.

Keywords: Gaseous detectors; Micropattern gaseous detectors (MSGC, GEM, THGEM, RETHGEM, MHSP, MICROPIC, MICROMEGAS, InGrid, etc)

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Contents

1 Introduction

Despite abundant experience in the production and successful operation of MPGDs [1–3], the effect of water contamination in the gas composition on their performance is still a subject of debate. Previous studies regarding the addition of water vapor to the gas are inconclusive, and no consensus has been reached, especially concerning discharge stability and the influence on streamer development [4–6]. Introducing small amounts of water vapor to the gas could be favorable for detector operation as it prevents glue used for detector components from drying out and supports the detector against aging effects [7]. Hence an adverse effect of humidity in the gas mixture on the detector performance has to be ruled out before its utilization in experiments. The focus of this study is to build a dedicated setup for controlling and introducing humidity, as well as measuring the effect it creates on MPGD performance, with particular attention to discharge stability. We present here preliminary results obtained with a THGEM, being part of a systematic measurement campaign with other MPGD types, such as GEMs and Micromegas.

2 Experimental setup and methods

In order to study the effect of humidity on MPGDs, a dedicated setup has to be built in which a constant amount of water vapor is reliably introduced to the gas, in this case, Ar-CO_2 (90-10). The humidifying process of the gas is presented in figure 1. The initial gas mixture is guided through a pipe system, splitting into two lines. One of the lines incorporates a bubbler filled with distilled water. Gas flowing through this bubbler absorbs humidity without leading to an increase in other contaminants, such as oxygen. By varying the flow through the bubbler via a mass flow meter, a different humidity level is attained, as demonstrated in figure 2. The second line directs the dry gas around the humidifying line until they merge, and the final gas mixture is flushed through the detector chamber. Additionally, a rotameter in the dry gas line controls and monitors the flow. A Rapidox Multigas Analyzer from Cambridge Sensotec [8] is subsequently placed after the detector vessel, recording the oxygen and humidity content of the mixture. The oxygen content is kept at a minimum (< 20 ppm) throughout all measurements. The ambient conditions are tracked with two thermometers and a pressure sensor.

The MPGD used for the purpose of this study is a $11.2 \times 11.2\,\mathrm{cm}^2$ THGEM produced by Eltos S.p.A. The THGEM is 470 µm thick, including a 35 µm thick copper layer on each side. The diameter of the holes and the pitch between them is 400 µm and 800 µm, respectively (see also [9]). For the measurements, an alpha emitter (mixed nuclides ^{239}Pu, ^{241}Am and ^{244}Cm) and

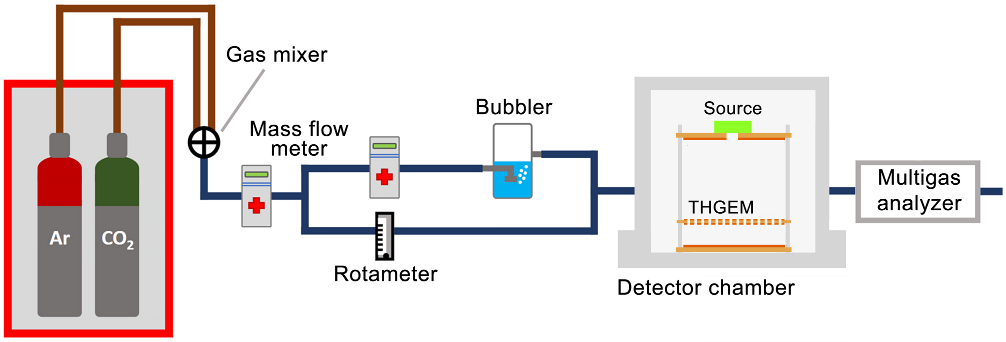

Figure 1. A sketch of the experimental setup used to humidify the gas mixture.

an X-ray source (^{55}Fe) are placed on top of the 1.5 mm thick drift electrode with a source distance of d_{source} = 32 mm and a constant applied drift field of E_{drift} = 400 V cm^{-1}. The measured source rates are ~ 300 Hz and ~ 120 kHz, for the alpha and X-ray emitter, respectively.

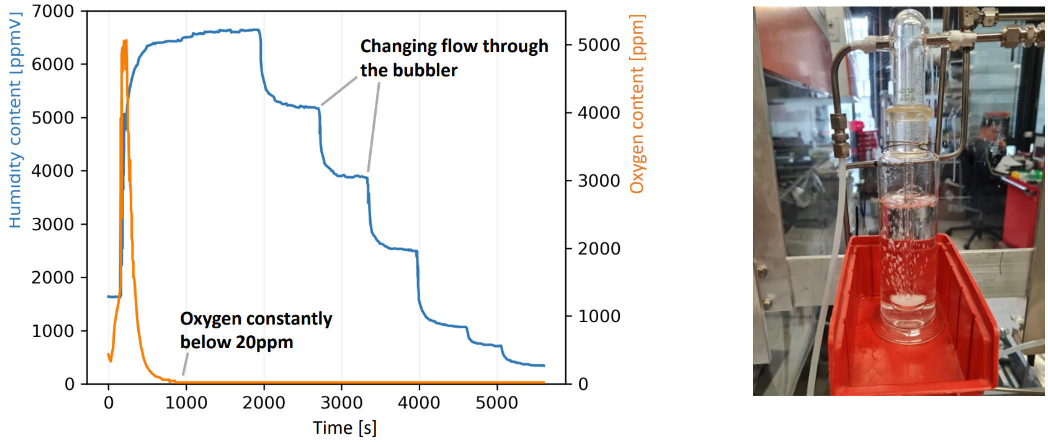

Figure 2. Left: the contamination in the gas mixture was recorded during a test measurement. The initial spike in oxygen corresponds to the activation of the humidifier. It is demonstrated that humidity can be controlled by changing the flow rate through the bubbler. Right: a picture of the bubbler during operation.

For this study, we measure the absolute gain of the THGEM as a function of the amplification voltage while varying the humidity content for each measurement, using a picoamperemeter from PicoLogic [10]. The gain is defined as the ratio of the amplification current measured at the THGEM bottom electrode to the primary current measured in the drift gap. The discharge studies are realized by installing an open cable in the detector chamber that acts as an antenna, detecting the occurring discharges, which are visualized and counted via an oscilloscope to determine the discharge rate and discharge probability.

3 Results

The result of the gain measurements is presented in figure 3, distinguishing between the different humidity contents. The outcome shows that introducing water vapor to the gas mixture does not affect the gain at operational voltages, suggesting that humidity in the given range does not influence

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the Townsend coefficient. The two gain drop regions, observed for the voltages above 1000 V and 1150 V, can be associated with the onset of discharges measured with alpha and iron sources, respectively. This effect, observed previously with THGEM-like structures, is discussed in detail in [9] where it is also shown that the measurements in that region yield the actual absolute gain value. The gain is measured for each point the discharge probability is evaluated.

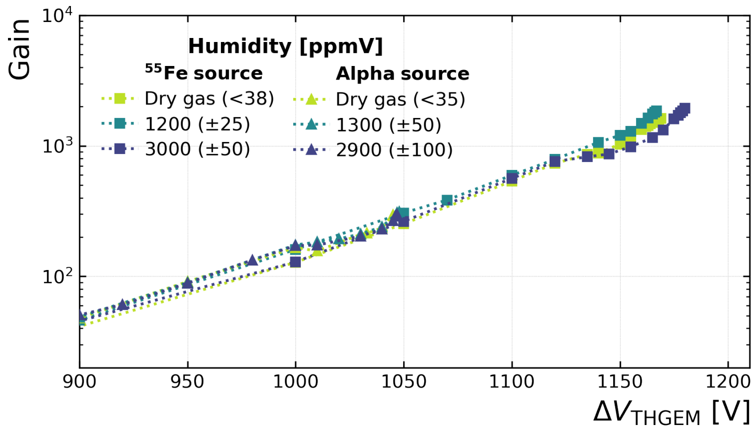

Figure 3. The absolute gain as a function of the amplification voltage for different humidity contents.

The measurements of discharge stability for different humidity contents are presented in figure 4, which shows the discharge rate and probability as a function of amplification voltage and absolute gain. Regarding the effect of humidity on the discharge probability, we observe no deterioration, and a slight improvement is visible for the irradiation with X-rays. Depicted in the discharge rate plot are, in addition, measurements without a radiation source in the detector vessel. In this case, higher humidity in the gas mixture has a significant positive impact on the discharge stability at the highest voltages, reducing spurious discharges which are not related to source irradiation but originate from cosmic rays, field emissions, etc.

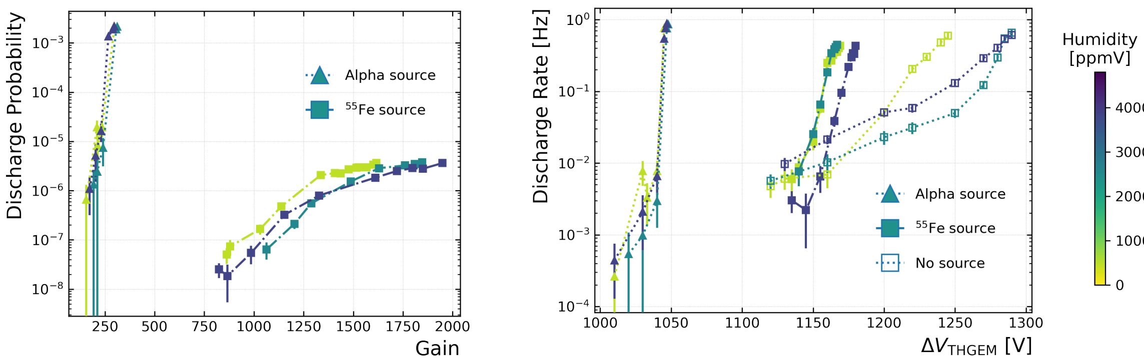

Figure 4. The discharge probability as a function of the gain (left) and the discharge rate as a function of the amplification voltage (right).

We conclude that adding water to the gas mixture increases the discharge stability at the highest voltages. Low humidity levels do not influence the discharge formation process. However, they reduce the rate of spurious discharges related to electrode defects or charging-up of the insulating layers.

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