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MATERIAL STUDIES FOR THE RPC MUON DETECTOR OF CMS

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Abstract

The RPC muon detector of the CMS experiment at the CERN Large Hadron Collider uses fluorine-based gases in volumes made by bakelite plates, in high-radiation environment. Studies of radiation damage on bakelite are presented. Bakelite samples were taken from gaps irradiated at the GIF. Preliminary results on an analysis campaign based on SEM-EDS, XRD and chemical analyses performed on a high-statistics sample will be discussed.

1 INTRODUCTION

In the next pages we are going to present analysis and studies about the materials of the RPC muon detector of the CMS experiment at the CERN Large Hadron Collider in Geneva.

We analyzed the detector, sampling three gaps performed at the GIF CERN. The samples analyzed are Bakelite, oiled and fluxed with a gas mix of 96 % $C_2H_2F_4$ 3.5% iso- C_4H_{10} 0.5% SF_6 , and radiated with ^{137}Cs with an intensity of 650GBq.

Then, we did some samples and some analysis using the electronics SEM/EDS microspettrografia. Added to this, we did some maps of the geometric distribution of the defects we noticed and an high statistic analysis concerning the chemical composition.

2 INSTRUMENTS

These analyses are performed at Department of Ingegneria dei Materiali e delle Materie Prime (ICMMPM), Università di Roma “La Sapienza”, using a SEM Hitachi S2500, equipped with a KeveX X-ray Microanalyzer, and at Caratterizzazione dei Materiali Particolati laboratory in Latina using an Oxford Inca Energy 250.

3 ANALYSIS CAMPAIGN

First of all, we checked the chambers to underline the defects or the changes inside them. Firstly we noticed the different internal color of the three chambers: orange (SG196 and SG180) and brown (SG403).

We noticed some superficial dot-like changes in the SG196 chamber. These changes seem to be symmetric in comparison with the two electrodes because there is a copy of the same defects in the same position on both the Bakelite plates. So we can think about some discharge effects between them. Morphologically we can notice these defects in the picture below (Fig.1). We can observe their reconstruction through the stereomicroscope.

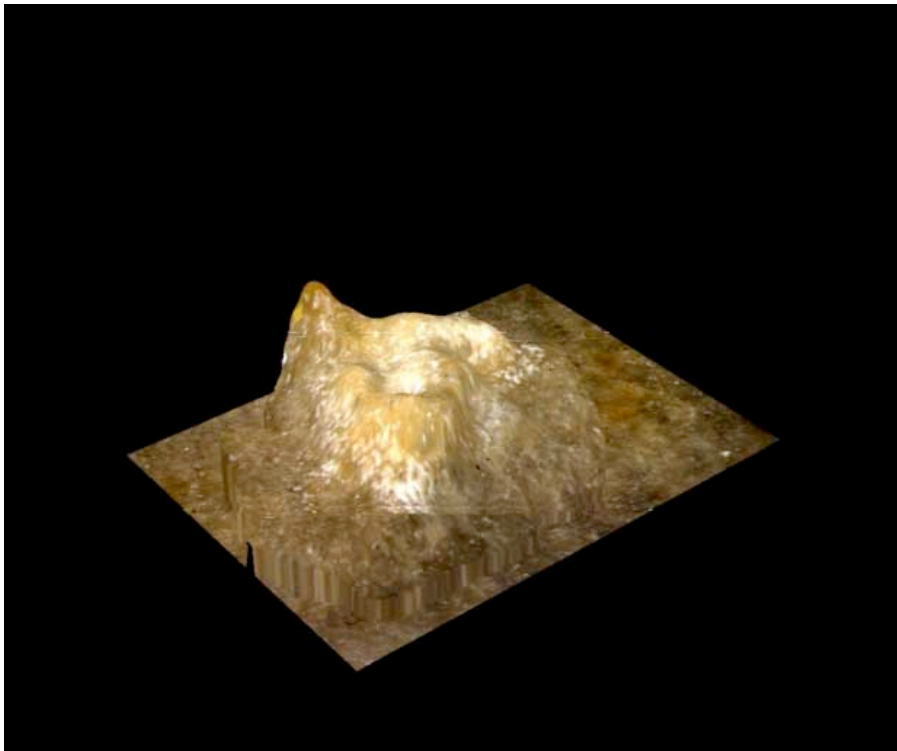


Figure 1 - Tridimensional reconstruction from a real scanning of a generic superficial defect.

They are some little and white protuberances. In a detailed analysis we presupposed, and later confirmed, through a XRD analysis, their crystalline nature.

Following of visual inspection of three gaps we proposed to perform a geometric distribution analysis mapping more interesting defects (Fig.2).

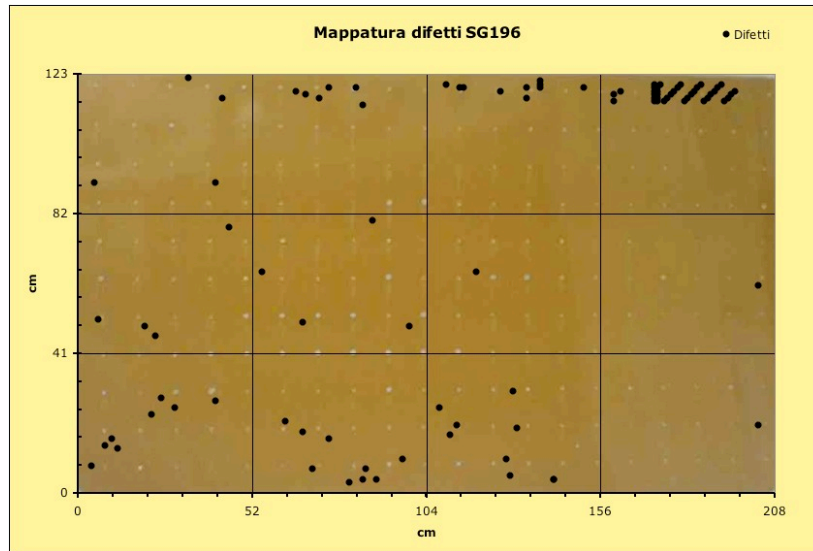


Figure 2 – Mapping.

Then we performed a SEM/EDS analysis.

We used some samples from gaps performed at Gamma Irradiation Facilities (GIF) of the CERN. All of Bakelite were previously oiled and fluxed into Closed-Loop mode.

Below we can see the list of the number of samples tested and their characteristics:

- n° 10 SG196, Orange Defects
- n° 2 SG196, Orange No Defects
- n° 1 SG180, Orange No Defects
- n° 1 SG403, Brown No Defects

Total 14 samples.

4 RESULTS

In the ten defected samples, we noticed the presence of fluorine, sulfur and sodium. (Fig.3a/b/c)

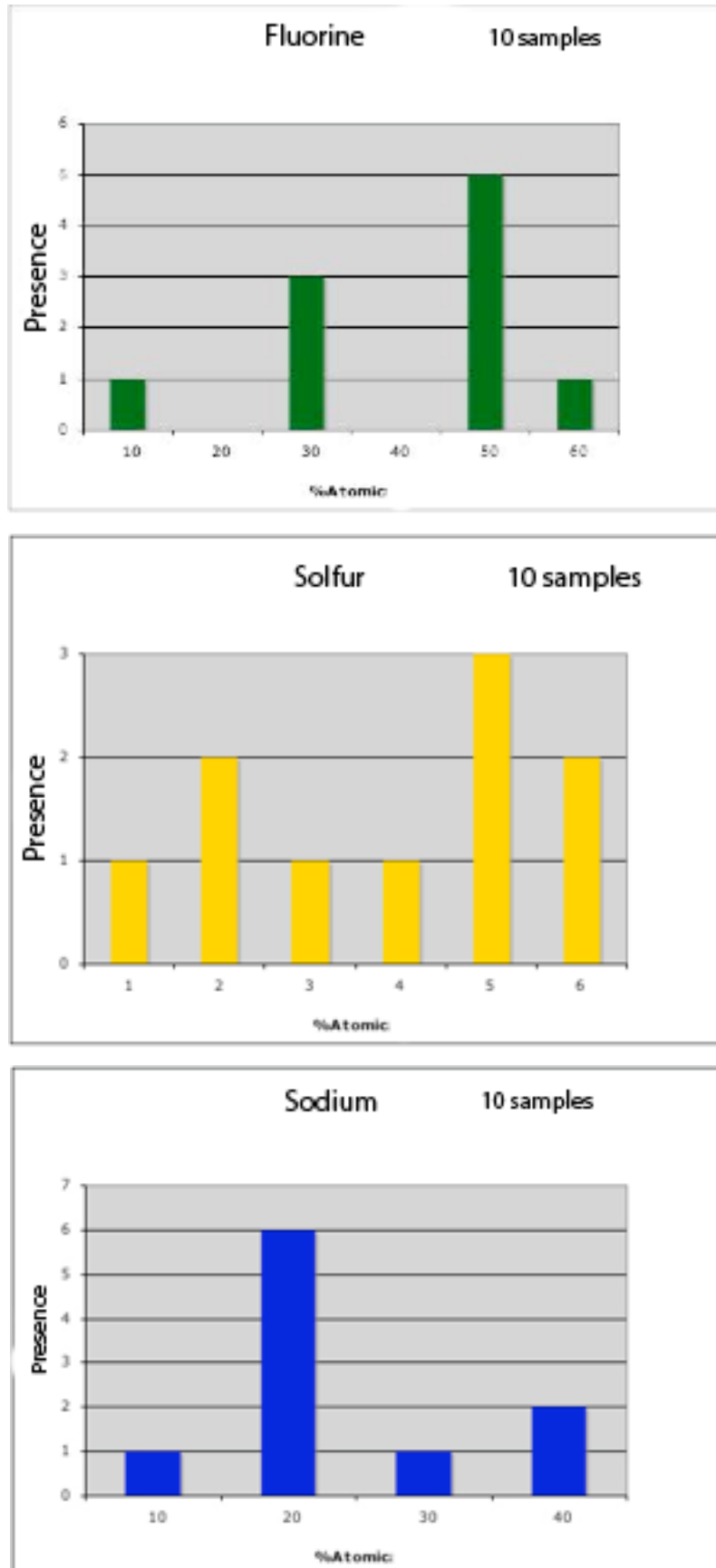


Figure 3 - Presence of elements.

Table 1 - Atomic Elements percentage.

	% Atomic
Fluorine	35 ± 5
Sodium	19 ± 3
Sulfur	$3,5 \pm 0,6$

Instead we note the complete absence of sodium in the no-defected samples.

5 CONCLUSIONS AND FUTURE DEVELOPMENTS

After XRD analysis we confirm that the superficial defects are NaF nature. The sodium comes from the catalyst used in the manufacture of Bakelite. Crystal (NaF) Growth mechanism it hasn't been known yet, but it has been studying.

The high-statistic analysis confirm the presence of Sodium in defected samples only.

The lack of homogeneity surface, probably due to the polymerization of linen oil.

The distribution of defects is preferred in the external areas of the gaps, these results will be soon confronted with fluid dynamics analysis.

We are planning to perform other SEM / EDS, X-ray, and high-statistic analysis about new gaps. Currently there is an ongoing program at ISR and GIF in Geneva.

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