Experiences of using float glass as electrodes for radiation detectors

Sarika Bhide[1], V.M.Datar[2], Satyajit Jena[3], S.D.Kalmani[1], N.K.Mondal[1], G.K.Padmashree[1], B.Satyanarayana[1*], R.R.Shinde[1], P.Verma[1]
[1]*Dept. of High Energy Physics, Tata Institute of Fundamental Research, Mumbai, 400005*
[2]*Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai, 400085*
[3]*Indian Institute of Technology Bombay, Powai, Mumbai, 400076*
[*]*email: bsn@tifr.res.in*

INTRODUCTION

Resistive Plate Chambers [1] (RPCs) are rugged and low-cost gas detectors, which are extensively used in high energy and astroparticle physics experiments for the detection of charged particles. The simplest RPC consists of two parallel float glass plates usually of 2 mm thickness separated by 2 mm using insulators. An electric field (about 50 KV/cm) is applied across the glass plates through a resistive coating on their outer surfaces, while a suitable gas mixture is flown through the detector. A charged particle traversing the gap, initiates an avalanche in the gas volume, resulting in a local discharge of the electrodes. The discharge induces an electrical signal on external pickup strips, which are used to record the position and time of the event.

RPCs will be the active elements in a 50 kTon neutrino detector which is proposed to be built by the India-based Neutrino Observatory (INO) collaboration [2]. The INO detector will need about 27,000 RPCs of dimension 2 m × 2 m and hence will use float glass of about 216,000 m^2 in area.

DEVELOPMENT OF RPCs

We have developed and built a number of RPC detectors, using 2mm thick float glasses procured from local market as electrodes. The bulk resistivity of these glass sheets was found to be about 10^{12} Ω-cm. We have mainly used a gas mixture of Argon, Iso-butane and Freon (R134a) in the ratio of 30:8:62. The detectors were monitored for charge particle detection efficiency, detector currents, and its background counting rates etc. over a period of time. We have obtained results which are consistent with those reported in the literature.

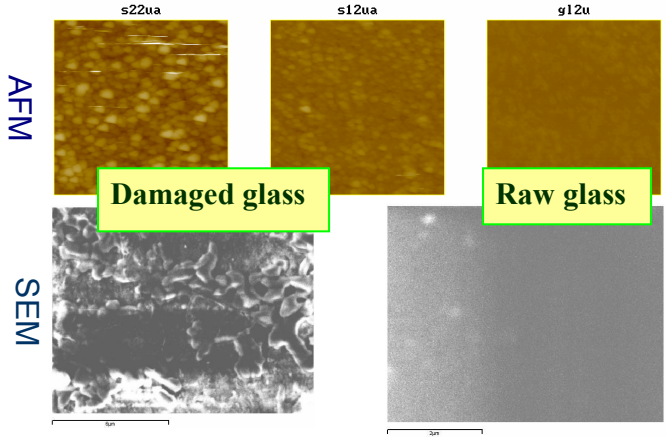

Fig 1: AFM and SEM images of damaged and raw glasses

We would like to acknowledge useful contributions from and fruitful discussions with P.Nagaraj, L.V.Reddy, Mandar Saraf and other INO colleagues. Thanks are due to TIFR colleagues from CMP&MS and CS departments for their help in analysing the glass samples.

DETECTOR AGING

We are however, currently facing a serious problem of sudden aging of detectors after continuous operation [3]. We find that detector efficiency drops suddenly, while its background counting rate and current shoot up. One of the detectors was broke open for examination and the inner surfaces of the electrodes were scanned under Atomic Force Microscope (AFM) and Scanning Electron Microscope (SEM) (Fig. 1). Element analysis (XRD) was also performed both on damaged electrode and raw glass samples, results of which are summarised in Table 1. The structures shown in the AFM and SEM scans were found to be rich in Fluorine, suggesting that Freon (R134a) gas contaminated with moister forms Hydro Fluoride (HF), which actually damages the RPC.

Element	Raw glass	Damaged glass
Oxygen	64.19	28.15
Fluorine	4.17	40.31
Sodium	6.29	11.82
Magnesium	2.11	2.00
Silicon	23.25	17.41

Table 1: Fractional percentages of elements

Even after taking a number of steps towards monitoring and solving the problem of moister in the input gases, the detector aging continued. We have then procured float glass from Japan and fabricated a couple of detectors using these as electrodes. These detectors are now in continuous operation for about a year without showing any signs of aging.

We have then initiated studies to find out the characteristics that distinguish Japanese glass from other local brands, such as Modi, Asahi, and Saint Gobian etc. Results from the studies on glass surface quality, elemental analysis etc., using the above mentioned techniques didn't show any appreciable differences among the samples. Shown in Fig. 2 are results of the light transmittance test for various glass samples. Even though the Japanese glass sample shows marginally better transmittance over the local samples, the results are not conclusive enough.

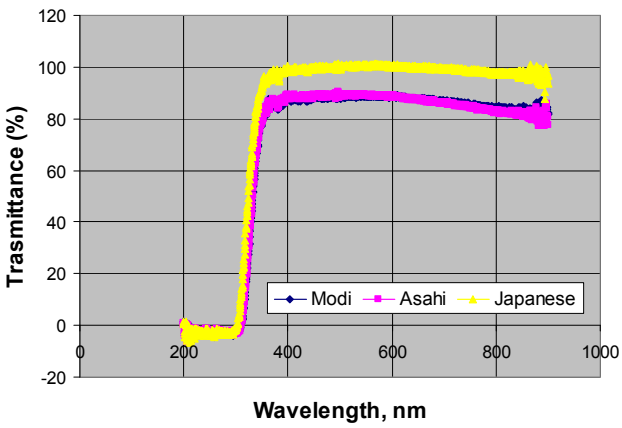

Fig 2: Transmittance test results

FUTURE WORK PLAN

We would like to continue our studies on characterisation and comparison of various local and imported glass samples. This will possibly help us understand the phenomenon of detector aging as well as to find out a suitable glass from local market for our final detector requirement.

REFERENCES

[1] R.Santonico and R.Cardarelli, NIM **187** (1981) 377
[2] INO Collaboration, Project Report, Volume 1, INO/2006/01
[3] S.S.Bhide *et al*, Proc. VIII Workshop on Resistive Plate Chambers and related Detectors, Seoul, October 2005