16th Pisa Meeting on Advanced Detectors - La Biodola, Isola d'Elba, Italy – may 26 - June 1 2024

A goniometric measurement system for reflection, diffusion and transmission characterization in the VUV range

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ABSTRACT

The characterization in the VUV range of reflection, diffusion and transmission of mechanical components plays a crucial role in understanding and optimizing the performance of particle detectors exploiting the scintillation light coming from liquefied noble gases. To this purpose a goniometric measurement system has been realized. The light produced by a deuterium lamp is wavelength selected by means of a diffraction grating with a resolution of few nanometers. The monochromatic light hits the sample under test. A calibrated VUV detector, mounted on a goniometric system, sample at different angles the transmitted and scattered photons. In this presentation, the main technical characteristics and performances of the system are shown together with results coming from preliminary tests on different materials. Tests have been performed in term of reflection and diffusion on polished or sand-blasted steel and aluminum in the VUV range from 115nm to 200nm at various light incidence angle. Measurements on same materials have been carried out more deeply at liquid Argon (LAr) emission wavelength.

Experimental apparatus

The system is based on a vacuum steel chamber optically connected to a VUV monochromator and a deuterium lamp whose spectral distribution ranges approximately from 115nm to 200nm. Light emitted is selected by the monochromator (with a resolution that can be chosen from 0,5nm to 4nm by changing output slit opening) and then collimated to an 8mm diameter beam by means of dedicated VUV collimation optics. An Al+MgF_2 rotating mirror is then used to direct the light spot alternatively on a NIST calibrated reference photodiode (to get the exact number of photons, monitoring also lamp stability) and on the 'Goniometric sample chamber' that houses the sample under test. The whole system works at vacuum conditions down to $3{\cdot}10^{-4}$mbar to prevent VUV light absorption.

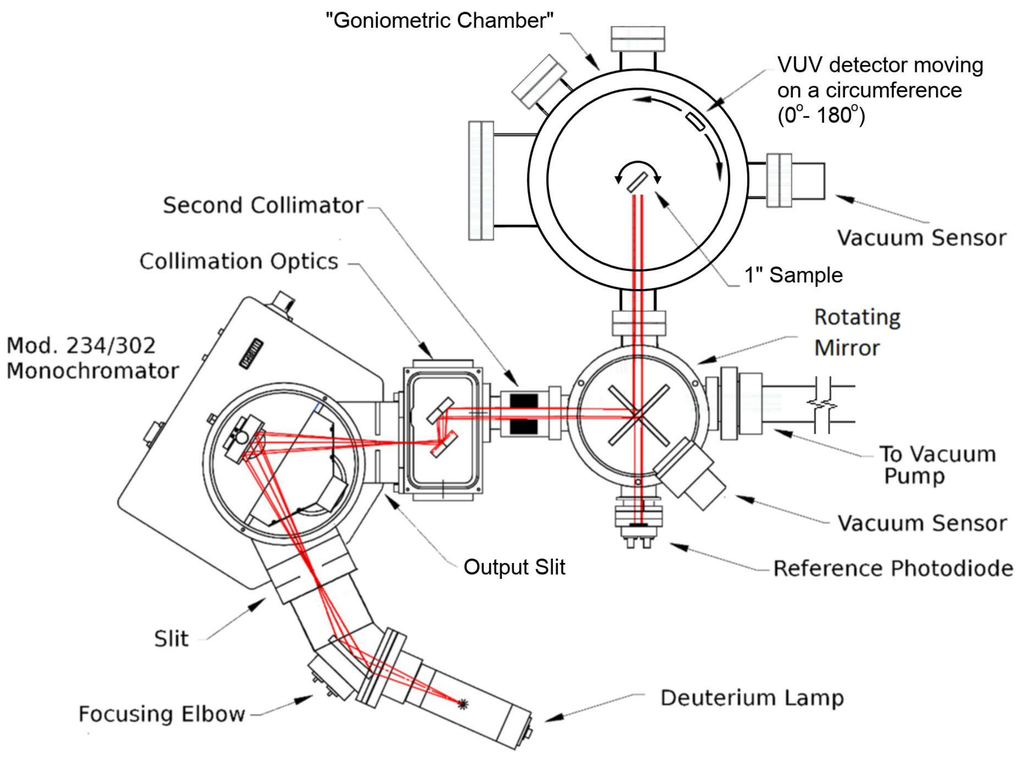
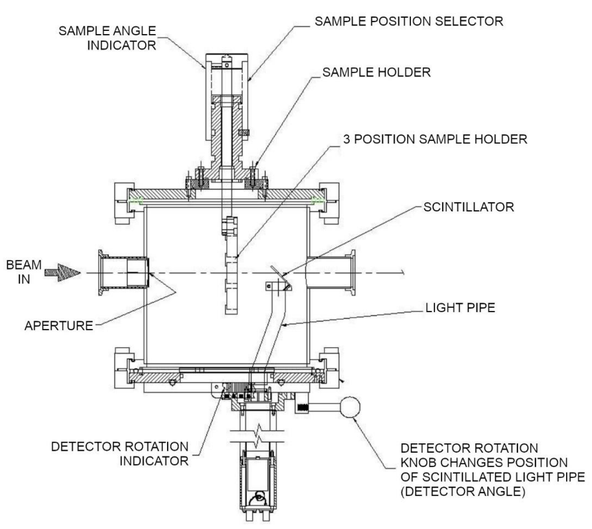


Fig. 1: The experimental apparatus

The Goniometric Sample Chamber

The Goniometer sample chamber is a cylindrical vacuum box that houses in its center the sample to be tested in terms of reflection, diffusion and transmission; up to three samples, one inch diameter, can be tested by means of a three position sample mount that allows the positioning of one sample at a time on the incoming light beam without breaking vacuum. The sample holder can rotate on chamber center axis so that the angle between the sample and the incoming beam can be adjusted from 0 to 60 degrees. This adjustment is done by hand and the angular scale can be read out in degrees. Sample maximum thickness is 5mm. Usually one of the 3 position is kept empty for reference measurements in order to monitor the total light intensity produced by the light source (absolute measurements). A VUV light detector (that lays in the plane defined by light beam and selected sample center) can goniometrically rotate around the sample from <15 to 180 degrees; this movement is done under vacuum by hand reading directly the angular scale with a resolution better than 1 degree.

The distance of the detector from the sample is 60mm. The detector is made of a 16x16mm^2 scintillator that converts the VUV spectrum into visible emission at 420nm. Visible light is conveyed to an external photomultiplier by means of a light pipe. PMT current is read by a picoAmmeter.



Measurements of reflection and diffusion are carried out by sending a collimated VUV light beam toward the sample and measuring the diffused light at various angles. Transmission measurements are performed by comparing the direct light passing through the empty sample position with the intensity transmitted by the sample; in this case the detector must be at 180 degree on beam line.

Fig. 2: The Goniometric sample chamber

The acquisition system

The acquisition system is based on a personal computer (PC) that controls by means of a LabView program both a Keithley picoAmmeter (model 6487) and the monochromator grating wavelength. PicoAmmeter is connected alternatively to the calibrated photodiode and to the PMT. Once vacuum has been reached, deuterium lamp is turned on and the current from PMT anode can be read. The LabView program records automatically the current from the picoAmmeter for each wavelength selected by the monochromator (wavelength scan). Sample incidence angle and PMT position must be set by hand. The acquisition system is presented in Fig. 3.

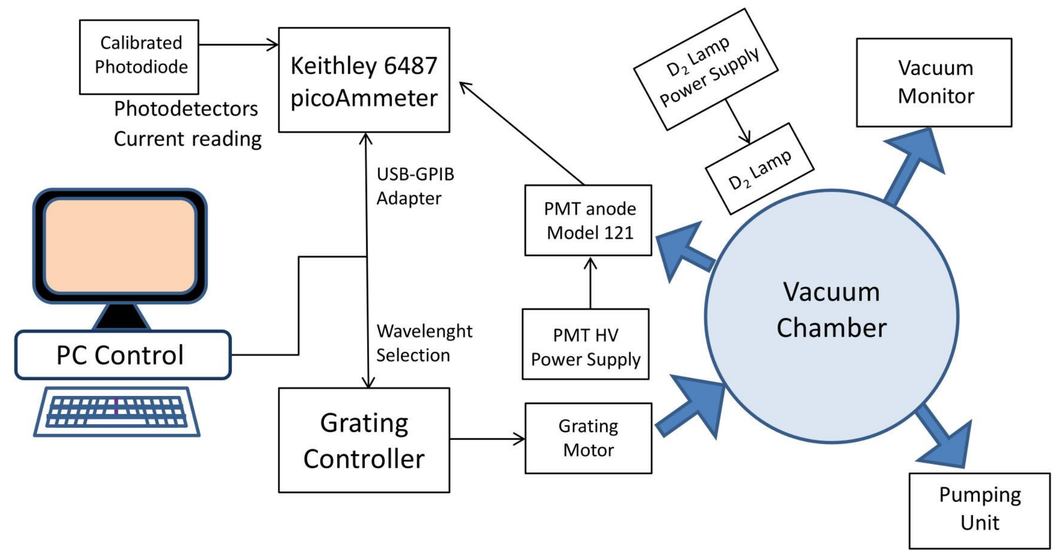


Fig.3: The acquisition system

First samples under test

To validate the system few samples have been produced in INFN-Pavia mechanical workshop: discs, 1 inch diameter, 5mm thick polished by hand or sand-blasted; they are made of aluminum or stainless steel. They have been finally washed in isopropyl alcohol and then inserted in the sample holder. The third position of the holder has been left free as reference. Finally the sample holder has been inserted in the vacuum chamber. Measurements have been carried out once reached 10^{-4} mbar.

Results

A scan of wavelength from 115 nm to 200 nm has been performed measuring the percentage of light reflected by the sample for various light incidence angle: for each sample, first the a scan of the direct light produced by the lamp has been registered with the sample holder in the free position and in front of the incoming beam; then scans has been carried out for 4 incidence angles (30°, 40°, 50°, 60°) with the detector at the reflection angle (two times the incidence angle).

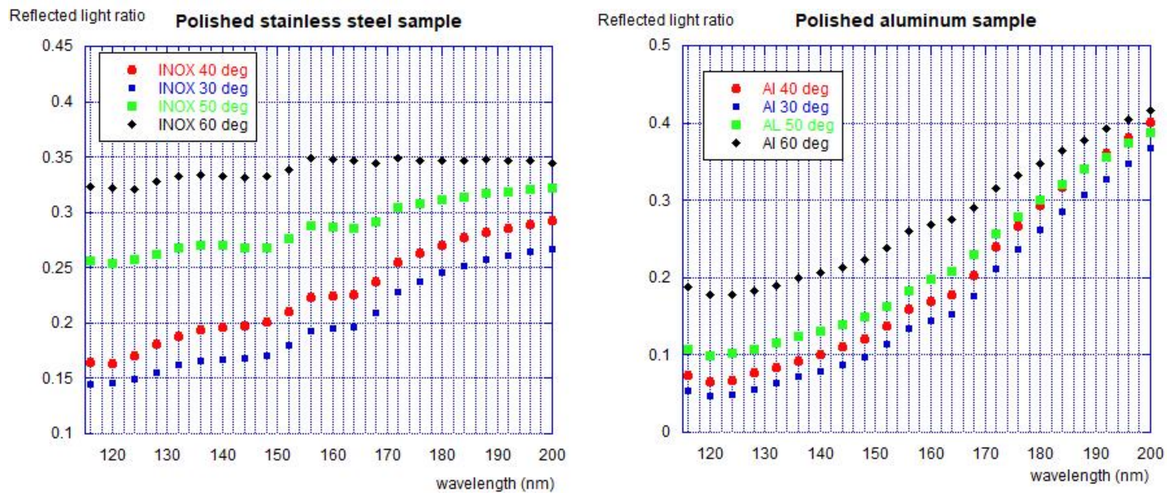


Fig. 4: Percentage of reflected light for various incidence angle from 115 to 200nm wavelength scan, left polished stainless steel sample, right polished aluminum sample

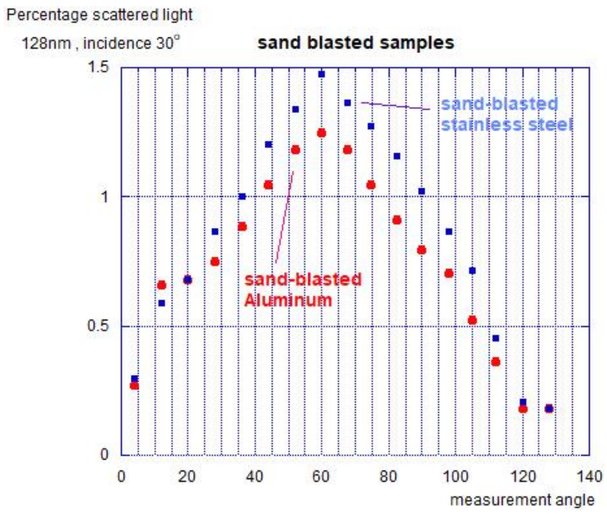


Fig. 5: Diffused light for sand-blasted samples at 128nm, incidence angle 30°

Another kind of measurements is the characterization of samples in term of diffused light: for a specified wavelength and a fixed incidence angle on the sample, the light diffused is detected "around" the reflectance angle. For example in Fig.5 it is shown the diffused light at 128nm of the stainless steel sample at 30° incidence angle.
The intensity of measured light is very low because of sand-blasted diffusive effect and the relatively small solid angle of the detector.

Conclusions

The system has shown good performances in measuring VUV diffused and reflected light on few tested materials and different types of surface treatment.