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Proposal of Optical Fiber use in a Portable Spectrometer

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***Abstract*—an optical fiber cable is proposed to be used in a X ray fluorescence device. The main aim is to simplify the detection system making it to reache areas where the traditional device cannot access due to its lack of mobility and external dimensions. It is presented some tests results that demonstrate the efficiency of the system.**

Keywords— NaI(Tl); optical fiber; radiation detection

I. Introduction

Among the nondestructive techniques to materials analysis there are the EDXRF (energy dispersive X ray fluorescence). When solid samples are irradiated with X rays, there is emission of secondary X rays called fluorescence X rays. The “characteristic X rays” emitted have characteristic wavelengths (energies) corresponding to the atomic number of specific elements in the target.

Such technique is very applied to several investigations, for example, for the determination of the nature, structures and components of the works of art [1, 2, 3] and also biological material, as presented for example in [4]. For *in situ* analyzes, it is necessary to have a portable system. The idea of this work was then to construct an innovative device for coupling detector and photomultiplier in such way that both constitute only one body using an optical fiber. Other aim is to eliminate the problem that there is in the adaptation of multiples cylindrical detectors of NaI(Tl) with a variety of sensitive volumes in portable spectrometers.

II. Experimental System

An optical fiber cable has been used in this innovative device, taking advantage of its large passband, small signal attenuation, immunity to electromagnetic interference and lower cost in relation to the electrical cables. The production of optical fibers cables made possible the development of a range of spectroscopic probes for *in situ* analysis [5] performing beyond nondestructive tests, environmental monitoring, security investigation, application in radiotherapy (for dose monitoring, verification and validation).

In the proposed system, an optical fiber cable works as a remote probe being connected in one side to a NaI(Tl) detector and the other side to a photomultiplier valve as it is shown in the Fig. 1. The internal cylinder space is conical and dark painted and each one has an adjustable system of converging lenses that focuses the beam sourced from the detector (fluorescence) on the optical fiber, on which it travels through by total reflection, reaching the other extremity of the probe and being focalized and distributed throughout the surface of the photomultiplier. This innovation simplifies the detection system. This portable probe could bring new solutions for such kind of procedure, once it could reach areas for application that the traditional device cannot access due to its lack of mobility and its external dimensions.

Fig. 1. Proposed remote probe connecting the photomultiplier with the NaI(Tl) detector using an optical fiber.

Two plane-convex converging lenses were specially fabricated with the function of focuses the beam from the detector to the optical fiber and to allow in this way the signal transmission to the photomultiplier. These lenses are designed for infinite conjugate (parallel light) use or simple imaging in non-critical applications and they are ideal for all-purpose focusing elements and then are been used in this work to focusing the light coming from the optical fiber.

It is important mentioning the great versatility and ease to use the remote probe to spectrometry system as with conventional equipment in laboratories, as in portable equipment for outdoor use. Fig. 2 shows the remote probe packaged in a small and safe carrying case (dimensions: 30 x 20 x 10 cm^3) and total weight 2.8 kg, independent and ready for use.

Fig. 2. The remote probe packaged in a small and safe portable case.

III. RESULTS

Initial tests to check the operation of the remote probe were performed irradiating the detector NaI(Tl) with a mobile X ray device type Aquilla Plus-VMI as shown in the Fig. 3. Then, using a simple digital camera, the signal transmitted through the fiber was captured.

Eight cases have been verified according with the characteristics of the Table 1. The detector characteristics used are:

D-I: NaI(Tl) Detector; Optical window area: 5.15 cm^2; Sensitivity Volume: 23.27 cm^3

D-II: NaI(Tl) Detector; Optical window area: 9.68 cm^2; Sensitivity Volume: 225.16 cm^3

As it can be verified in the Fig. 4, there is a small difference in the areas of the images due to the size of the detectors and variations in brightness according with the X-ray energies, demonstrating the proportionality of the signal with type of detector.

Fig. 3. Experimental device showing the X ray above the detector which is connected to the remote probe and finally to the photomultiplier.

TABLE I. LUMINESCENCE EXPERIMENTAL CASES.

Case	Detector	V (kV)	I (mA)	Time (s)	Distance 1* (cm)	Distance 2 ** (cm)
1	D-I	120	100	0,7	40	In Contact
2	D-I	100	100	0,7	40	In Contact
3	D-I	80	100	0,7	40	In Contact
4	D-I	60	100	0,7	40	In Contact
5	D-II	120	100	0,7	40	In Contact
6	D-II	100	100	0,7	40	In Contact
7	D-II	80	100	0,7	40	In Contact
8	D-II	70	100	0,7	40	In Contact

* between focus and detector centre.

** between the camera and the diffusor lens.

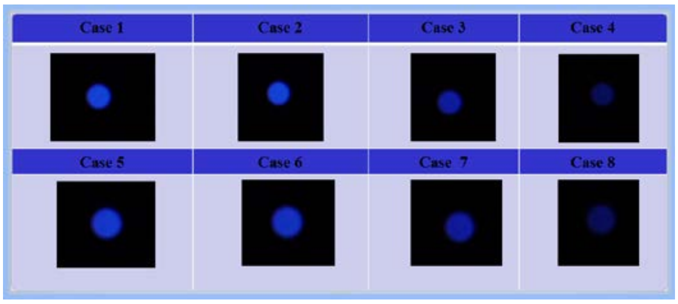

Fig. 4. Photographs of the luminescence signals obtained after crossing the optic fiber.

IV. CONCLUSIONS

It presented in this work, an experimental spectrometry device using an optical fiber cable as innovative remote probe. Several parts of the systems were specially made as the cones for photomultiplier and detector adaption and the lenses for focusing the signal. The first tests were performed to confirm the correct transmission of the luminescence signal and it was demonstrated that it follows a proportional behavior according with the detector conditions. The next step is to perform several experimental with the remote probe for application in the EDXRF technique to demonstrate the capabilities of the system.

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