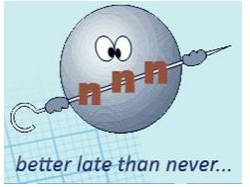
28 International Seminar on Interaction of Neutrons with Nuclei:
«Fundamental Interactions & Neutrons, Nuclear Structure, Ultracold Neutrons, Related Topics»



Ion-beam analysis of thin-multilayer films on the PET, PES polymer substrate

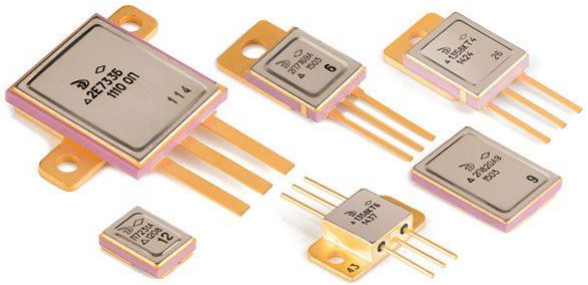
Tuan P.L.[1,2], **Zelenyak T.Yu.[1]**, Phuc T.V.[1,3,4], Khiem L.H.[3,4], Kulik M.[1,5],
Doroshkevich A.C.[1,6], Balasoiu M.[1,7], Stanculescu A.[8]

[1] Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research,Dubna, Russia.
[2] Hanoi Irradiation Center, Vietnam Atomic Energy Institutet, Hanoi, Vietnam.
[3] Graduate University of Science and Technology, Vietnam Academy of Science and Technology, CauGiay, Vietnam.
[4] Institute of Physics, Vietnam Academy of Science and Technology, Ba Dinh, Vietnam.
[5]Institute of Physics, Maria Curie-Skłodowska University, Lublin, Poland.
[6]Donetsk Institute for Physics and Engineering named after O.O. Galkin, Kiev, Ukraine
[7]Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering, Bucharest, Romania.
[8]National Institute for Materials Physics (NIMP), Măgurele, Romania.
e-mail: Tatyana.Zelenyak@nf.jinr.ru

May 24 - 28, 2021

I. Introduction

- The study of the elemental composition and radiation resistance of polymeric functional materials intended for work in a cosmos is an urgent scientific and technological problem. The study of the elemental composition of semiconductor systems on a polymer substrate using the RBS method was the goal of this work.

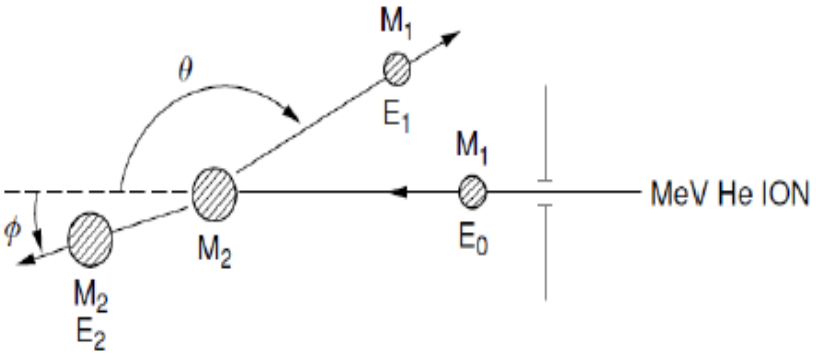


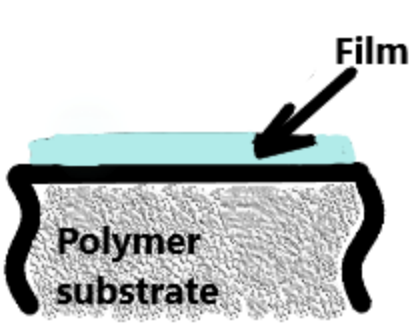
II. Materials and methods

Table 1 . Group of samples:

N⁰	Group of samples		
	Group 1_PET	Group 2_PES	Group 3_PETITO
1	PET 44	PES 39	PET/ITO 45
2	PET/cytosine 4	PES/cytosine 3	PET/ITO/cytosine 26
3	PET/ZnPc 17	PES/ZnPc 8	PET/ITO/ZnPc 31
4	PET/TPyP 24	PES/TPyP 11	PET/ITO/TPyP 35

RBS – method (Rutherford backscattering spectrometry)

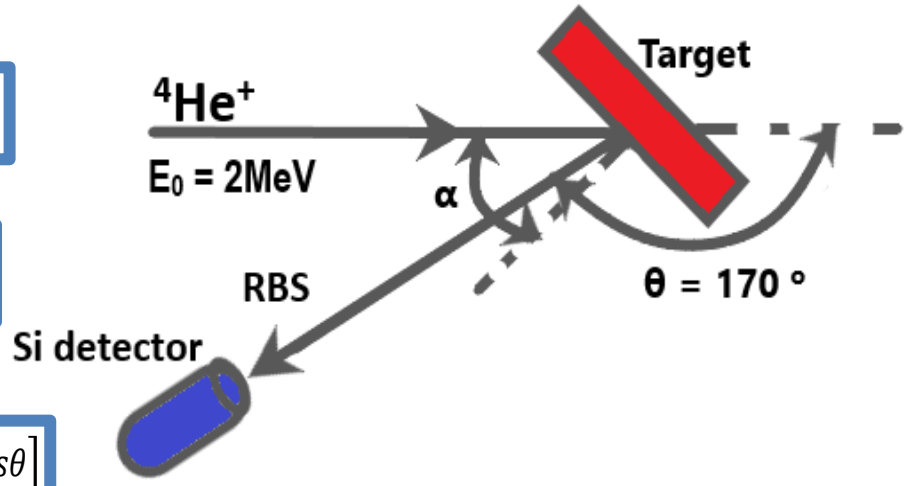




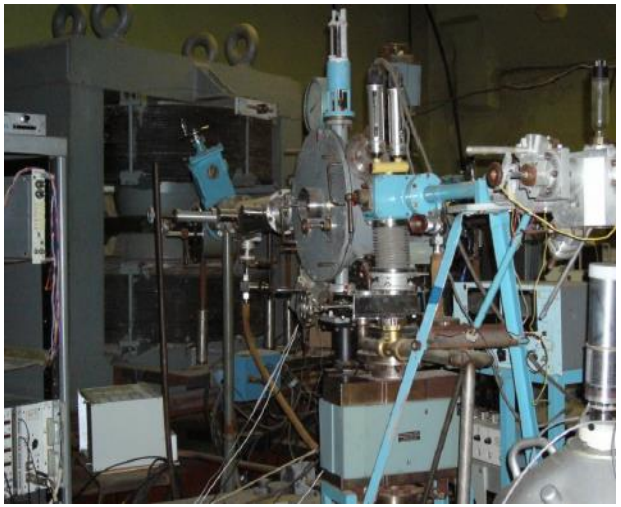
$$\frac{1}{2}M_1v^2 = \frac{1}{2}M_1v_1^2 + \frac{1}{2}M_2v_2^2,$$

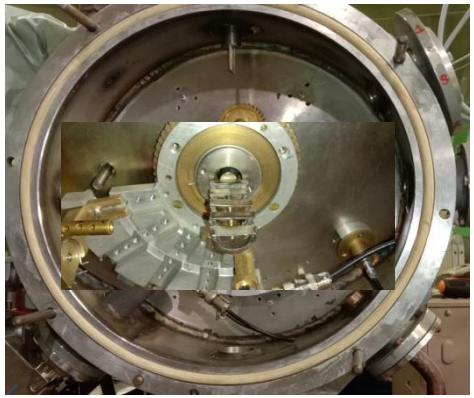
$$M_1\vec{v} = M_1\vec{v}_1 + M_2\vec{v}_2$$

$$\frac{v_1}{v} = \left[\frac{\pm(M_2^2 - M_1^2 sin^2\theta)^{1/2} + M_1 cos\theta}{M_2 + M_1}\right]$$



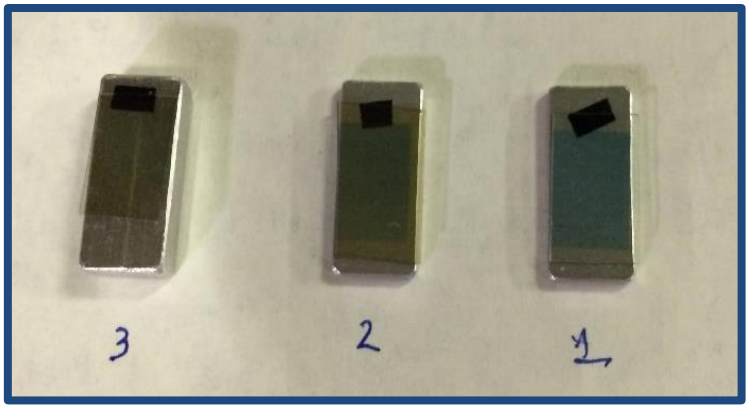
several photos related to the RBS method and JINR in Dubna EG-5



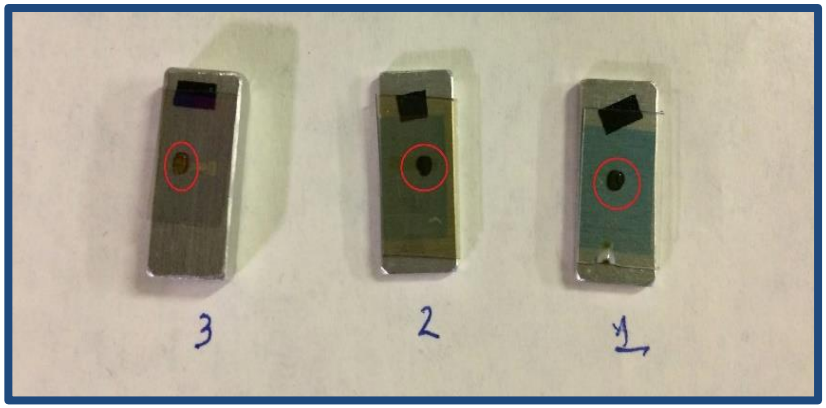


III. Results and Discussion

- Experimental samples before and after interaction with the ion beam during RBS experiment (The alpha particles with energy 2MeV was used). We can see some destroy of surface layer occurred in all samples



Before experiments



After experiments

III. Results and Discussion

- **The samples were measured by RBS methods under the following experimental conditions:**
- **Energy of α particles $^4He^+$: 2.0 MeV.**
- **Incident angle of ion beam with IBM geometry: 10^0 and 40^0.**
- **Scattering angle: 170^0.**
- **Calibration sample: Si/SiO_2 substrate**

Substrate: Polymers like poly(ether sulfones)/**PES** polyethylene terephthalate/**PET**

Polemers films: phthalocyanine (zinc phthalocyanine/**ZnPc**) non-metallic phorphyrine 95,10,15,20-tetra(4-pyrydil)21H,23H-porphyne /**TPyP)** nucleic acid base (**cytosine/C**)

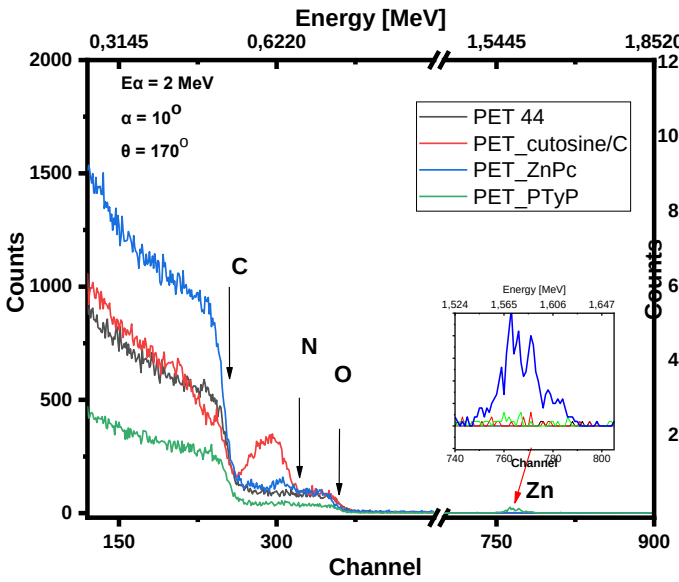


Fig. 1: RBS spectra of Group 1_PET samples

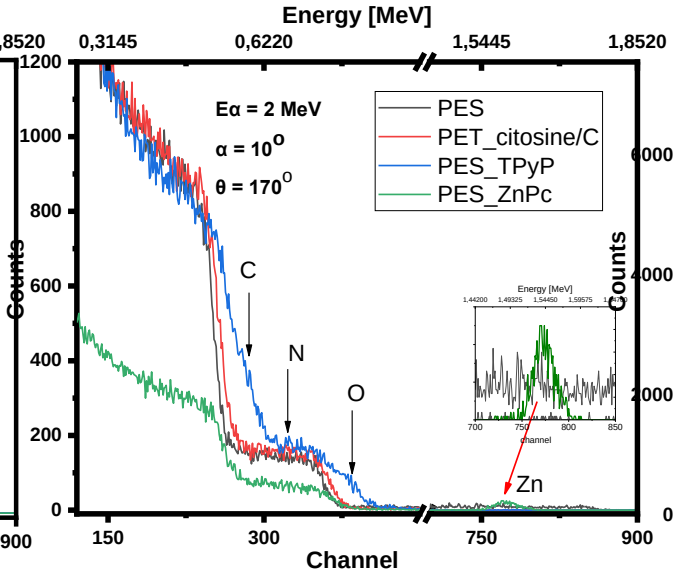


Fig. 2: RBS spectra of Group 2_PES samples

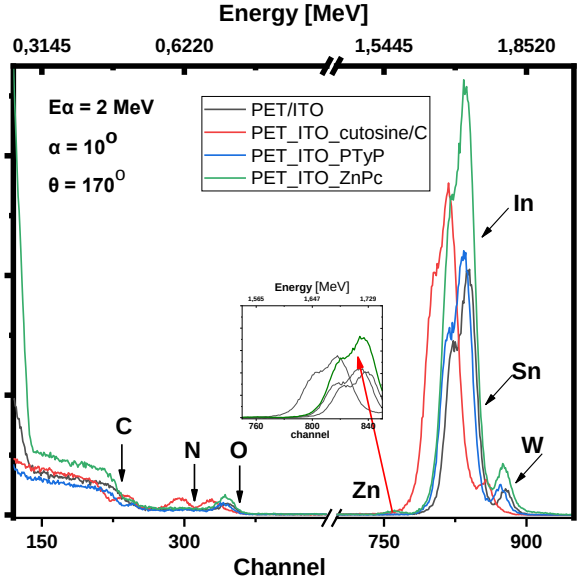


Fig. 3: RBS spectra of Group 3_PETITO samples

1. D. Benzeggouta, I. Vickridge (2011). " Handbook on best practice for minimising beam induced damage during IBA" Universitede Pierre et Marie Curie. P. 1-54.
2. Namavar, F. and J. I. Budnick (1986). "Beam-induced compositional changes in RBS analysis of polymers." Nuclear Instruments & Methods in Physics Research Section B-Beam Interactions with Materials and Atoms 15(1-6): 285-287.

IV. Concluding

1. It was showed that the RBS method can investigate polymer structures, in particular - provide quantitative information about the composition of the sample. This method allows to make a detail analysis of light elements, such as C, N, O. It was found that the ion beam destroyed a polymer materials which can lead to changing of an elemental composition of the sample surface layer.
2. It was found that the ion beam destroyed a polymer materials which is lead to changing of an elemental composition of the sample surface layer.
3. Based on the analysis of literature data, it is shown that there is a way to avoid this problem. **The following activities must be performed**

1. It is necessary to have a low current ~ 2 nA / mm^2, for a minimum heating of the target by the beam.

2. It is necessary to set a sliding angle from 4^o.

3. Minimize the shooting time of the experiment.

1. D. Benzeggouta, I. Vickridge (2011). " Handbook on best practice for minimising beam induced damage during IBA" Universitede Pierre et Marie Curie. P. 1-54.
2. Composto, R. J., Walters, R. M., & Genzer, J. (2002). *Application of ion scattering techniques to characterize polymer surfaces and interfaces. Materials Science and Engineering: R: Reports, 38(3-4), 107–180.* doi:10.1016/s0927-796x(02)00009-8
3. Musket, R. G., & Felter, T. E. (2004). *Extending RBS analysis to very fragile, nanometer-thick foils. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 219-220, 379–383.* doi:10.1016/j.nimb.2004.01.086

The study was performed in the scope of the Poland- JINR and RO-JINR Projects within the framework of themes FLNP JINR 03-4-1128-2017/2022.

Thanks for your attention!