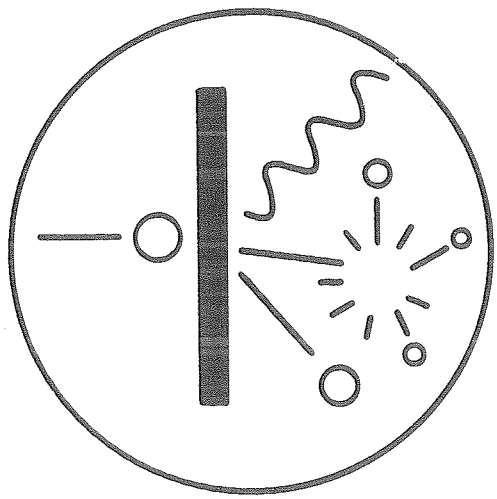
INTERNATIONAL NUCLEAR

TARGET DEVELOPMENT SOCIETY

NEWSLETTER



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Editors Note

Dear Colleagues,

INTDS activity this year centred around the 16th World Conference, which took place in Padova in September. The conference abstracts are presented in this Newsletter and the proceedings will appear, as usual, in Nuclear Instruments and Methods.

The conference host and chairman was Ruggero Pengo who must be congratulated on a successful conference, along with his colleagues Giuseppe Mannenti and Giuseppe Battistello, who organized the visit to the target and physics laboratories.

Great appreciation and admiration is also due to the conference secretary, Marina Stefani, responsible for much behind-the-scenes activity and the smooth administration of the conference together with Roberta Nicole and Sabrina Panariti.

The host organization INFN also played a significant and generous role in providing facilities for the conference and offering financial support to a number of conference participants.

Congratulations must also go to Albert Muggleton, famous old-stager and supporter of the society since the early days who received an INTDS award at the conference dinner, presented by INTDS President Hans Maier, as a recognition of his contribution over many years.

Chris Ingelbrecht
EDITOR

Closing Remarks - 16th INTDS World Conference

Hans J. Maier, President, INTDS

I would like to take this opportunity to thank Ruggero Pengo and his fine staff for hosting a great international conference. 75 participants from 17 countries provided a real international frame for the meeting. It is a great pleasure to state a remarkable increase of the number of attendees from eastern european countries, especially from Russia, as well as from China. On the other hand, it is disappointing that our south american members from Argentina and Brazil were not able to come here. As to the United States, we acknowledge the participation of 13 attendees, which is quite a good rate in view of the difficult financial situation.

During this conference, 45 papers have been presented in 14 sessions. A wide range of topics were covered including

Isotope production and availability
History and progress of target making
Oxide reduction and metallurgical techniques
Target preparation techniques
Target properties
Target assaying techniques
Radioactive targets
Carbon foils
Neutron sources and related phenomena.

I would like to thank all those who have given presentations, making this meeting a great success. And thanks again to Ruggero Pengo and his staff for the perfect organization at the cost of their leisure hours during the period of preparation.

Let me now, before closing, make a few remarks about the society and the general situation of targetry.

This year, INTDS celebrates the 20th anniversary of its first official conference, which took place in October 1972 at the Montreal University in Canada under the auspices of chairman E.H. Woodburn. This is indeed a reason for a proud retrospective. Including that historical meeting, 16 international INTDS conferences and one workshop were held, first in annual, and since 1982 in biennial sequence. More than 400 papers were published in 14 proceedings - many of them in Nuclear Instruments and Methods. They cover nearly every aspect of nuclear targetry. The richness of information and experience contained in these proceedings is tremendous and provides benefits to the whole nuclear physics community.

INTDS provides a platform of cooperation between individuals who do target services for nuclear physics experiments either at scientific institutions or on a commercial basis in private companies. The dominating concern of the society is the accumulation and publication of every information related to targetry. Without INTDS, many target makers would be single fighters against a lack of awareness of their employers with respect to the equipment, the amount of isotopic material and the intricacy required to prepare a specific target. The

accumulated knowledge in the INTDS literature has objectified targetry. The vague cooking recipes of past days, often transmitted orally from physicist to physicist and finally to the targetmaker have been replaced by precisely depicted procedures developed by specialists of many relevant branches of science.

INTDS is a comparatively small society with about 80 members. This makes the exchange of knowledge and experience at the conferences and workshops very effective and facilitates cooperation between individual members beyond the meetings. This situation is very satisfactory and I am sure the coming generation of membership will make every effort to maintain it. As in the past, the INTDS Newsletter will continue to be the center of communication.

Our high level of knowledge and technology is a good starting point to meet the challenges of the future. For instance, highly enriched isotopes will become more and more scarce and expensive. Therefore economical high-tech deposition procedures will have to be further improved to be used as routine tools in daily work of every target laboratory. Equally, recycling of isotopic material may become a necessity soon. Furthermore, new experiments with radioactive beams as well as with radioactive targets will require the cooperation of target specialists, accelerator staff and health physics people.

So, without doubt, the society will keep playing its important part in nuclear science.

Once more, I thank you all for coming. We will meet again in 2 years at the 17th INTDS World Conference at the IUCF in Bloomington, Indiana.

SAMPLES AND TARGETS FOR NUCLEAR MEASUREMENTS DELIVERED BY CBNM DURING 1992*

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1. Samples and Targets for Nuclear Measurements

1.1 Preparations on Request

101 Samples and targets covering 40 different requests have been prepared in support to the CBNM specific programme. They comprise thin deposits, special plastic films and various bulk samples of metals, compounds and alloys (see Table 1).

Moreover 65 samples and targets have been prepared characterized and supplied to external customers in response to 25 orders from six countries. Details are given in Table 2. They concern thin deposits for nuclear physics experiments and bulk samples prepared by various metallurgical methods, including quantitative alloying. Bulk samples include reactor melt-wire temperature monitors prepared from low melting point binary and ternary eutectics, encapsulated in quartz, with melting point determination by differential thermal analysis. Some of these compositions were very brittle and were made by direct casting into wire form.
^{6}Li metal samples required special handling and canning under inert atmospheres to avoid reactions with air.

1.2 Preparation and Characterization of Metallic U-Pu spikes

This work has been carried out to improve the homogeneity and ductility of U and Pu containing metallic spikes required for the IDMS assay of U and Pu in undiluted input samples of reprocessing plants. The work during 1992 was concentrated on the examination of the compositions U-Pu-Ti, U-Pu-Zr-Nb and U-Pu-Nb. Metallography supported by electron microprobe examination,

* Work carried out as part of the European Community Research Programme

Table 1. Supply of thin deposits, films and bulk samples in support of the CBNM programme

Preparation	Number of Samples	Preparation Methods[1]
Thin deposits		
^{10}B	23	VD
carbon	1	FL
hydrogen	5	VD
nitrogen	1	VD
$^{239}PuF_3$	2	VD
$^{244+239}PuO_2$	1	VD
$^{nat}UF_4$	3	VD
$^{238}UO_2$	2	SU
Films		
Polyimide	5	CE
Bulk samples		
Al	1	MA
Al/Ca/Al	1	R-MA-VD
Al.Mg.Cu.Ag	1	M-R-MA
$^{138}BaCO_3$	3	CAN-MA
Ca	4	R-MA
Cd	10	PR-MA
Co	2	MA
Cu	2	MA
Fe	2	MA
Ga As	3	MA
In	8	R-MA
^{6}Li	1	R-MA-CAN
^{6}Li-C_2H_4	1	R-MA-CAN
Ni	2	MA
^{58}Ni	2	M-R-MA
Si	3	MA
Sn	2	R
Ti	2	MA
^{235}U	1	SOL

(1) CAN canning; CE centrifuging; FL flotation; MA machining; M melting; PR pressing; R rolling; SOL solution; SU suspension spraying; VD vacuum deposition

carried out during secondment to the Institute of Transuranium Elements, Karlsruhe, indicated good microhomogeneity of two of the alloys, but with some uranium segregation in the U-Pu-Zr-Nb composition. Homogeneity control by γ-spectrometry using both solid and liquid samples showed that a relative standard deviation in the plutonium concentration of 0.1 to 0.2 % was achieved and this was confirmed by IDMS measurements on samples of the U-Pu-Nb alloy, which is the most attractive candidate spike alloy. The preparation of a production batch of spikes will be carried out during 1993.

Table 2. Supply of thin deposits, films and bulk samples to external customers

Preparation	Number of Samples	Preparation Methods[1]
Thin deposits		
Hydrogen	3	VD
^{nat}LiF	2	VD
^{6}LiF	2	VD
$^{239}PuF_3$	1	VD
$^{240}PuF_3$	1	VD
$^{235}UF_4$ or $^{235}U_3O_8$	2	VD, SU
$^{238}UF_4$ or $^{238}U_3O_8$	15	VD, SU
Films		
Polyimide	2	CE
Bulk samples		
Cd.Pb	3	M-MA-CAN
Cd.^{57}Fe	1	M
Gd	1	R
In	4	MA-CAN
^{6}Li	1	R-MA-CAN
Pb	4	MA-CAN
Pb.Ag	4	M-MA-CAN
Pb.Ag.Sn	4	M-MA-CAN
Pb.Cd	4	M-MA-CAN
Pb.In	4	M-MA-CAN
Sb.In	3	M-MA-CAN
Sn.Zn	4	M-MA-CAN

(1) CAN canning; M melting; MA machining; R rolling; SU suspension spraying; VD vacuum deposition

1.3 Preparation and Characterisation of ^{10}B and ^{6}LiF Reference Deposits

In view of an improved redetermination of the lifetime of the free neutron, an agreement for cooperation was signed in 1991 between NIST Gaithersburg and CBNM with the aim to achieve an accuracy close to 0.1 % in neutron counting. In the frame of this agreement an improved vacuum deposition design has been worked out to eliminate border effects and decrease areal density variations in the produced reference deposits. The preparation of improved ^{10}B and ^{6}LiF candidate reference deposits is now completed, and neutron induced particle measurements have been started at BR1 using an upgraded counting facility.

1.4 New Developments

Well-known techniques such as vacuum deposition, electrospraying and spray painting are routinely used at CBNM for the preparation of high quality actinide deposits (1). The increasing demand for homogeneous deposits of rare and expensive enriched isotopes made it necessary to investigate techniques with a potentially high efficiency, and allowing to make deposits with good resolution for fission fragments and/or charged particles.

A preliminary study was carried out in cooperation with the Target Laboratory of the Technical University of Munich (D) to investigate the use of a laser beam as a source for vacuum deposition. In the experiments the material to be evaporated was placed in an air-cooled copper crucible mounted on an x-y-z moveable table in a vacuum chamber at 10^{-5} Pa. The Nd-YAG CW laser beam (60 - 80 Watt, 3 cm diameter) entered the vacuum system through a plano-convex lens. The focussed beam scanned the crucible surface to melt-evaporate the powder. Tests were performed to study the quantitative evaporation of LiF and UO_2, the homogeneity of deposition and the interaction of the laser beam with polyimide substrate films.

Unlike previous attempts, electrodeposition of uranium and/or plutonium in aqueous and organic ("molecular plating") medium was successfully carried out on stainless steel, aluminium and polyimide substrates. New electrolysis cells allowing deposition of actinides on self-supporting thin metallic foils are under investigation.

1.5 Establishment of a Literature Database on Target Preparation

Fifteen INTDS (International Nuclear Target Development Society) Conferences and eighteen years of Newsletters resulted in a collection of more than 530 publications and letters concerning the development, preparation, characterization and/or use of nuclear targets. A computer based database was developed to allow a rapid search of the available information in the field of targetry. Based on Paradox 3.5 (from Borland International), this electronic file is compatible with most of the commercial and public domain spreadsheets and databases; it is available to all INTDS members. This tool has proved to be useful when starting new projects.

(1) J. Pauwels, Nucl. Instr. and Meth. B56/57 (1991) 938

2. Reactor Neutron Dosimetry Reference Materials

CBNM in collaboration with the Euratom Working Group on Reactor Dosimetry (EWGRD) is producing a series of reference materials for neutron metrology and reactor surveillance. These are high purity metals certified for interfering trace impurities, alloys of certified composition and fission dosimeters in the form of oxide microspheres. CBNM is responsible for procurement and distribution, reference material preparation and coordination of the certification.

2.1 Sale and Certification of Reference Materials

Thirteen dosimetry reference materials are currently available and during the last year 118 samples were ordered by customers in seven countries inside and outside the EC.

EC certification of the two metal reference materials EC-NRM 522 (copper) and EC-NRM 524 (iron) was approved by the Nuclear Certification Group during 1992. Complementary certification analyses for CBNM-529 (rhodium) were finished. The iridium mass fraction (26.0 $\pm$ 0.6 mg·kg^{-1}, 95 % C.L.) has now been determined by six laboratories and the platinum mass fraction (< 5 mg·kg^{-1}) has been determined by three laboratories using four methods. The draft of the certification report has been completed.

2.2 Reference Material Preparation

Titanium metal is useful for measuring fast neutron fluence rates primarily via the $^{46}Ti(n,p)^{46}Sc$ reaction for neutron energies above 4.4 MeV and for irradiations of up to about 250 days. In a thermal neutron environment there may be interference from $^{45}Sc(n,\gamma)^{46}Sc$ and it is important that the scandium impurity content is low. Titanium metal with scandium content of about 0.1 mg·kg^{-1} has been partly transformed into foil of 0.1 or 0.5 mm (1 kg of each) and the preparation of 0.5 mm diameter wire has been started. The certification analyses (for scandium content) have been planned and will start early in 1993.

Three Al-Co (0.01, 0.1 and 1.0 % Co) were prepared by spray deposition of powder (Osprey Metals, UK). Two of these alloys are to replace existing stocks

of reference materials and the 0.01 % Co composition will be a new reference material for higher neutron fluence rates. The main use of such alloys is thermal neutron metrology using the reaction $^{59}Co(n,\gamma)^{60}Co$. The cobalt homogeneity on a scale of 20 mg is of great importance and metallography of the spraying ingots shows a fine, homogeneous microstructure. The preparation of foil and wire from the three alloys is underway and certifications analyses (for cobalt content) are planned to commence early in 1993.

Another element of interest for thermal neutron metrology is silver via $^{109}Ag(n,\gamma)^{110m}Ag$. Levitation melted castings of composition Al-0.1 % Ag have been prepared and will be transformed into foil and wire for a candidate reference material.

The preparation of a fission track glass reference material for geological dating is continuing and uranium doped glass powders have been mixed and melted (Institut National du Verre, B) for uranium homogeneity control by the University of Gent.

2.3 Reactor Neutron Dosimetry Samples

A number of special samples and alloys for neutron dosimetry falling outside the dosimetry reference materials programme have been supplied to external customers during 1992. In total 1130 samples have been delivered in response to 12 orders from five countries. Details are given in Table 3.

Many of these preparations were aluminium alloys prepared by levitation melting including Al-Pu discs canned by pressing into aluminium containers without external contamination. In addition, complete flux monitor capsules containing Nb, Ti, Fe and Ni-Co monitor samples were prepared by encapsulation in quartz ampoules and electron beam welding into stainless steel tubes.

Table 3. Supply of special dosimetry preparations to external customers

Preparation	Number of samples	Preparation Methods(1)
Al-^{235}U	800	LM, R, MA, CAN
Al-^{239}Pu	301	LM, R, MA, CAN
Al-Lu	1	LM, R
Al-^{232}Th	1	LM, R
Nb, Ti, Fe, Co monitors	11	MA, CAN
$^{235}UO_2$	10	CAN
Nb	2	R, MA
V	2	R, MA
Zr	2	R, MA
$^{238}UO_2$	1	CAN
Al-Au	1	LM, R

(1) CAN canning; LM levitation melting; M melting; MA machining; R rolling

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The 4 th Natinal Symposium of NTSC

Xu Guo ji

The 4 th national symposium of Nuclear Target sub-society of China, NTSC, was held at Enstitute of Nuclear Phtsics and Chemistry, Chengdu, 16-18 June, 1992. Fifty six participants from 12 institutes and universities attended the meeting. Thirty nine papers have been presented in five sessions which covered topics including:

1. fabrication and determination of Laser Fusio Targets
2. trium targets
3. carbon foils
4. rolling
5. determination of thickness and uniformity of targets
6. clectro-beam-gun evaporator and
7. centrifugal precipitation

The next symposium of the NTSC well be held in Beijing in 1995.

16th WORLD CONFERENCE OF THE INTERNATIONAL NUCLEAR TARGET DEVELOPMENT SOCIETY

SEPTEMBER 21-25, 1992

International Nuclear Target Development Society

ISTITUTO NAZIONALE DI FISICA NUCLEARE
LABORATORI NAZIONALI DI LEGNARO
PADOVA, ITALY

ABSTRACTS

Specification of Beryllium Targets for Neutron Production

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Before their utilization in a Be(α,n)C differential cross section measurement at the PTB neutron time-of-flight spectrometer, four Be targets, consisting of a thin Be layer (150 $\mu g/cm^2$) on a 0.5 mm thick tantalum backing (38 mm diam.), were investigated to evaluate the uncertainty contribution resulting from the sample thickness. The total Be mass, evaporated onto a well-defined area of the backing, was determined by differential weighing of the target before and after the evaporation process at a PTB standard laboratory. Although the mass ratio between the backing and the Be layer was about 10^4, the averaged areal mass density of Be was determined with an uncertainty of less than 1.5% . In order to check the homogeneity of the sample area, a non-destructive test method was applied. The targets were irradiated at several spots (3 mm diam.) with the pulsed alpha beam (E_α = 12 MeV) from the CV28 cyclotron, the total neutron yield being measured with four large-area NE213 scintillation detectors of the spectrometer. In another arrangement with a wobbling target the radial dependence of the layer thickness was investigated. The results presented clearly show that randomly distributed inhomogeneities, different in magnitude for the investigated targets, have to be taken into account for the uncertainty consideration, resulting in a value of 2.5% for the total uncertainty of the sample's thickness in the central area of the target.

RECOMMENDED TARGET MATERIALS FOR D-D NEUTRON SOURCES

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Abstract:

Systematic investigations were carried out on the properties of gas cell, aperture and beam stop materials to increase the signal-to-background (S/B) ratio of $^{2}H(d,n)^{3}He$ neutron sources. The self-target buildup has been determined for different target materials by the detection of tritons and protons from the $^{2}H(d,p)^{3}H$ reaction with a SB-Si detector in the 100 keV deuteron energy range. Contaminations of the D-D neutron spectra caused by the target construction materials have also been studied in the 4-10 MeV range of incident deuterons. Angular dependence of background neutrons as a function of bombarding energy for different targets are also given. Gas cell window, aperture and beam stop materials to obtain high S/B values are recommended. Results were compared with model calculations.

"Mass Assay and Uniformity Tests of Boron Targets by Neutron Beam Methods"

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Several sets of enriched boron and lithium targets on silicon wafer backings were prepared by vacuum evaporation at the Central Bureau for Nuclear Measurements (CBNM) in Geel, Belgium. The radial density variations of these deposits were previously reported based on spectrophotometric measurements at CBNM of stainless-steel-backed targets, which were prepared during the same evaporations as the silicon-backed targets. Now these very small variations over the 19 mm radius of the targets have also been measured by scans with an intense, 3 mm diameter neutron beam at the NIST Research Reactor. The neutron measurements agree with the spectrophotometric results within the experimental uncertainties, and no pattern of uniformity variation except that small radial dependence has been found.

In a separate series of measurements at NIST, the boron mass ratios of a number of these deposits were determined using a new double ionization chamber. The new double chamber is a enlarged model of the NIST Double Fission Chamber, which has been employed at NIST for mass comparisons of targets of fissionable isotopes. Two targets to be compared are placed back-to-back at the central plane of the double ionization chamber, and the reaction rates from the two targets are observed separately but simultaneously as the neutron beam is allowed to pass through both targets. Repeating the measurement with the target positions reversed with respect to the beam direction removes the biases due to transmission losses and certain other systematic effects. The new device offers some advantages over previously employed methods of neutron beam comparisons of target masses. The new double ionization chamber permits a comparison of two targets directly without a beam monitor and without sensitivity to the exact placement of the samples. The new device requires a relatively simpler data acquisition system and less neutron beam intensity than the previously-employed system with its array of five surface barrier detectors. For comparison of targets of nearly equal masses prepared on identical substrates, the new device can serve a very useful complementary role in carrying out the deposit comparisons that must precede destructive analysis of a part of a new set of deposits.

ALLOY PREPARATION BY LEVITATION MELTING

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Abstract

The levitation melting technique is ideal for the preparation of small quantities of alloys for nuclear applications. The method avoids contamination of the melt, and high superheat and eddy current stirring ensure complete dissolution in the molten state. Melting time is typically less than 1 min. and evaporation losses under inert atmosphere are usually minimal, allowing close control of alloy composition. Very dilute alloys (ppm levels) are prepared using several dilution steps chosen to minimize weighing errors. Casting into water-cooled copper moulds gives cooling rates of at least 100 $K \cdot s^{-1}$ for ingot thicknesses of 5 - 10 mm and much finer microstructures than conventional ingot metallurgy.

Different techniques of levitation melting for sample masses of 10 to 400 g are discussed and recent experiences of alloy preparation, including alloys containing actinides, are described and homogeneity data are given. A brief review of some theoretical aspects is also made including the influence of current frequency, coil shape and surface tension on the mass of sample that can be levitated and the effect of volatility, atmosphere and chemical activity of the liquid metal on alloy composition.

This work was carried out as part of the EC research and development programme

Preparation of self supporting, metallic Hf targets from isotopically enriched HfO_2

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Abstract

Bomb reduction of HfF_4 with Na results in Hf metal sufficiently pure to prepare self supporting Hf targets of 100-350 $\mu g\ cm^{-2}$ thickness by high vacuum sputter deposition. A necessary condition for the success of the procedure is the capability to convert HfO_2, the standard chemical inventory form of enriched Hf isotopes, into HfF_4, which is free from oxyfluoride admixtures. This is also described in some detail. Targets of the isotopes ^{176}Hf, ^{177}Hf, ^{178}Hf, ^{179}Hf, and ^{180}Hf have been made by this method.

VAPOR DEPOSITION OF THIN SEMICONDUCTING LAYERS ON POLYESTER FOILS FOR DETECTOR APPLICATIONS

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The vapor deposition of thin semiconducting layers on a 2 μm polyester foil for application in the "Huygensvat" Central Trigger Detector is described. This detector has been designed for the measurement of light and intermediate-heavy charged particles. The foils are used as entrance foils for the plastic scintillator-detectors to assure light-tightness and optimum specular reflection. Further demands are a low energy loss of the particles passing the foils, resulting in thin semiconducting layers, homogeneity within narrow limits and low conductivity because of the applied high voltage (6 kV) surrounding the detector.

Preparation of natural and synthetic diamond targets for specialized nuclear and atomic physics experiments

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Interest in diamond has expanded rapidly in recent years. There have been dramatic improvements in the stable growth of high quality single crystal synthetics and also, more especially, in the novel metastable production techniques of thin films. The exploitation of the extreme physical, chemical and electrical properties of diamond for scientific, commercial and industrial purposes now has wider application as well as a much increased potential. Addressing these new opportunities in the context of accelerator based studies and applications has required a sophistication of techniques relevant to the preparation of diamond as a "target".

This paper will deal briefly with the historic research on diamond cleaning for high vacuum beam-conditions. The preparation of diamond surfaces with minimal crystallographic disorder has advanced and will be assessed.

Recently large single crystal high quality synthetic diamonds have been grown in high T - high P equipment. We show that these diamonds satisfy the requirement of very low mosaic spread and demonstrate their use in multi-hundred GeV electron and positron channeling experiments.

Many in beam studies require oriented targets of large nett surface area and an highly accurate semi-automatic rapid orientation system which can handle compound targets has been developed.

The need for thin (few micron) diamonds for transmission electron and ion-beam research remains urgent, and recent work that achieves this objective will be presented.

New developments in the strain free mounting of thin diamond targets (both natural and thin "CVD" films) and also of compound targets will be discussed. In particular, a matrix of oriented rare synthetic diamonds highly enriched in ^{13}C used in polarised muon beam experiments will be presented.

Finally, a number of other applications of diamond where preparation methods relevant to target making have been developed, will be presented.

Target Thinning Using a Saddle Field Ion Source*

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The Saddle Field Ion Source has been used quite successfully to produce thin films from small amounts of source material. The unit has proved to be quite stable and reliable. There is a need for self supported targets which are too thin to be produced by rolling and too thick to be made by the evaporation technique. Producing this type target has been achieved by first rolling or by some other method making one much thicker and then thinning it with the saddle field ion source using an ion milling technique.

The method used, the beam profile and characteristics of the various targets thinned are discussed.

*Work supported by the U.S. Department of Energy, Nuclear Physics Division, under contract W-31-109-ENG-38.

RADIOACTIVE TARGET AND SOURCE DEVELOPMENT AT ARGONNE NATIONAL LABORATORY*

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Because of an increased demand for low-level radioactive targets, a laboratory was assembled dedicated to the production of these foils. A description is given of this radioactive target and source development work being performed at the Physics Division target facility of Argonne National Laboratory. The ability to produce these targets represents an important new capability for the target lab. Highlights include equipment used and the techniques employed. In addition, some recent examples are given as well as work currently in progress.

*Work supported by the U.S. Department of Energy, Nuclear Physics Division, under contract W-31-109-ENG-38.

Isotopic Targets Preparation With Rotating Substrate Method

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ABSTRACT

Isotopically enriched accerelator targets were prepared with rotating substrate method in a vacuum chamber with a resistant heating crucible.Due to the low source to substrate distance (13----25mm) high collection efficiency (0.048--0.019mg cm^{-2}/mg) could be achieved while preserving good homogeneity. Backing and self-supporting targets of elements with evaporation points up to 2000° C could be fabricated with the method.

Organization and Radiation Protection Conceptions of the University of Munich Hot-Lab Facility

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Abstract

The preparation of radioactive targets requires extensive precautions to protect the laboratory staff as well as the environment from radiation damage and contamination. In the new hot-lab facility of the University of Munich, which is currently under construction, the technical equipment for target production will be integrated in a health physics system which meets these conditions in a very satisfactory way. Some details of the lay-out and the organization of the laboratory are given.

THE PREPARATION OF ISOTOPIC MOLYBDENUM TARGETS

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ABSTRACT

The simple method of production of ss molibdenum foils is discussed. The electron gun is used in two steps procedure. The Mo powder undergoes reduction-sintering and melting-solidifying steps leading to creation of a piece of metal suitable for further cold rolling or vacuum deposition.

URANIUM-PLUTONIUM SPIKES FOR I.D.M.S. ACCOUNTABILITY MEASUREMENTS: PREPARATION AND CHARACTERIZATION.

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Abstract

Uranium-Plutonium alloys are required for use as metallic spikes for I.D.M.S. determination of Uranium and Plutonium to improve accuracy of Safeguards measurements. These alloys have to meet specific workability, dissolution and homogeneity requirements. After a systematic study of the parameters of importance for their preparation, several ternary alloys have been prepared by quantitative crucible-less induction melting. A method for fast homogeneity control by γ-spectrometry has been developed and allows their quality control. The alloys are also characterized by metallography. Results on both methods are discussed.

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This work was carried out as part of the EC research and development programme.

Preparation of actinide targets for laser resonance ionization spectroscopy

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Trace amounts of actinides can be detected by resonance ionization mass spectroscopy (RIMS). Stepwise excitation and ionization of the actinide atoms with resonant laser light followed by mass analysis leads to high selectivity and high sensivity [1,2]. The system for photoionization consists of three tunable dye lasers, which are pumped simultaneously by two copper vapor lasers. For mass determination a time-of-flight mass spectrometer with a mass resolution of about 1500 is used.

Atomic beams of the actinides are produced by evaporation from a rhenium filament with a special sandwich arrangement. For this, the actinides are deposited by electrolysis in form of the hydroxides as a 2 mm spot on a rhenium foil of 25 μm thickness and covered electrolytically with a thin rhenium layer of a few micrometers [3]. Evaporation of the atoms occurs by heating the filaments to 1700-2000°C. Diffusing through the rhenium layer, the actinides are reduced to the metallic state and evaporated from the surface as atoms. At temperatures of $\sim$ 2000°C surface ionization of contaminants in the rhenium layer and of the rhenium itself, leading to a higher background, cannot be excluded. Therefore rhenium filaments overplated with platinum are tested, in order to decrease the evaporating temperature [4].

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State of the art of high vacuum sputter deposition of nuclear accelarator targets

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Abstract

During a two years period of experience high vacuum sputter deposition has proved as a reliable, economical procedure to prepare isotopically enriched targets. The present paper gives a survey of remarkable samples so far prepared and in some detail concerns with impurities related to the procedure and their possible elimination.

ELECTROMAGNETIC SEPARATION OF STABLE ISOTOPES AT CHINA INSTITUTE OF ATOMIC ENERGY

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ABSTRACT

Electromagnetic separation of stable isotopes at China Institute of Atomic Energy(CIAE) is discribed. In last 30 years, the improvement of a 180° production separator with linear shims was carried out, a 255° double focusing separator and a new 180° shimming field separator were made, a computer aided inspection system for improving quality of products and reducing labour intensity was designed for the 180° separators. More than 130 isotopes of about 30 elements have been separated since 1962 mainly with two 180° production separators, and enriched isotope samples have been used in many fields of scientific research and industry.

Key words stable isotopes, separator, computer aided system.

STABLE ISOTOPES PRODUCTION IN RUSSIA
/electromagnetic separation technique/

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Regular stable isotopes separation on the industrial separation facility SU-20 (an electromagnetic separator having 20 tanks) began from the middle of 1955 and is going on till now. By 1990 there were obtained 200 isotopes of 44 elements; the isotopes of gases, radioactive elements, ruthenium, palladium and iridium don't belong here. The electromagnetically enriched isotopes form the State's Isotope Inventory created in 1960 to meet the home needs and coordinate export deliveries. All in all during the period of the separator's exploitation there have been produced and sent to the State's Inventory some 300 kg of isotopes with masses from magnesium to lead range.

All 20 separation tanks are joined by a common electromagnet. Each separation tank can accomodate three ion sources and the same number of ion receivers. To produce ions in versatile ion sources arc charge is utilized burning in the vapours of different elements in the longitudinal magnetic field. Slightly changed the ion sources can be used to obtain ions of different elements having solid, liquid and gaseous form. The ion sources design allows to trap simultaniously all isotopes of an element. More often receiving pockets are made of copper and graphite.

The extraction of isotopes from receiving pockets and their purification from admixtures are carried out by applying different chemical techniques. To purify isotopes are applied such techniques as: extractional, electrochemical, ion-exchange techniques, sublimation, distillation, co-precipitation, etc.

Control operations accompany all the main stages of isotopes production. The final products are subjected to control as to the contents of admixtures of 10...17 elements. The contents of separate admixtures do not exceed very often some thousandth parts of a percent.

To meet reqirements of medicine the isotopes of Thallium, Zink, Cadmium, Nickel and Ytterbium have been more frequently separated during the past ten years. Average enrichment data of the most popular isotopes of these elements are shown in the Table 1.

Table 1.

Isotope	Enrichment, %
Thallium-203	97 - 98
Zink-68	98 - 99
Cadmium-112	97 - 98
Nickel-58	99,7-99,9
Ytterbium-168	30 - 40

STABLE ISOTOPE ENRICHMENT - CURRENT AND FUTURE POTENTIAL

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ABSTRACT

Oak Ridge National Laboratory (ORNL) operates the Isotope Enrichment Facility for the purpose of providing enriched stable isotopes, selected radioactive isotopes (including the actinides), and isotope-related materials and services for use in a wide variety of research applications. ORNL is responsible for isotope enrichment and the distribution of approximately 225 nongaseous stable isotopes from 50 multi-isotopic elements. Many enriched isotope products are of prime importance in the fabrication of nuclear targets and the subsequent production of special radionuclides. State-of-the-art techniques to achieve special isotopic, chemical, and physical requirements are carried out. Status and capabilities of the Isotope Enrichment Facility and the Isotope Research Materials Laboratory (IRML) are described, and future potential advancements in enrichment capabilities are emphasized.

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Enrichment of tellurium isotopes for pure iodine-123 prodaction using gas ultra-centrifuges.

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One of the major efforts in cyclotron production of medically important radioisotopes consisists of development of a suitable targets for irradiations.The targets have to be highly enriched by the valuable stable isotope.The abundance of impurity nuclei, which would generate disturbing radioisotope in the nuclear reaction, must be reduced to a present limit depending among others on the reaction cross-sections, half-lives and decay modes of the isotopes in question.

The Kurchatov Institute of Atomic Energy is engaged in production of stable isotopes for about thirty years.Work is constantly in progress on several procedures:electromagnetic separation, laser separation of isotopes in atomic and molecular beams, plasma techniques and separation of isotopes in centrifugal cascades.The enrichment of ^{123}Te has been carried out in a laboratory-type rectangular cascade of gas centrifuges where the separation of gaseous TeF_6 took place.As a result enriched ^{123}Te hexafluoride with extreme high enrichment was produced in gramm quantities.Using this new TeO_2 target the optimum irradiation conditions have been investigated for the production of ^{123}I by using small cyclotron (E_p<15 Mev) at Institute of Nuclear Research,Hungarian Academy of Sciences.Using this target the ^{123}I yields and relative impurities of ^{121}I, ^{124}I and ^{130}I at 12, 15 and 18 Mev proton energiers.

A specialized centrifugal cascade for separation of tellurium isotopes was desigred and it is in operation now.

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ELECTROMAGNETIC SEPARATION OF URANIUM AND TRANSURANIUM ISOTOPES AND TARGET PREPARATION FOR NUCLEAR DATE MEASUREMENTS

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A B S T R A C T

The paper describes the problems and capabilities of the highly enriched actinide isotopes production by electromagnetic separation on the mass-separator S-2 of VNIIEF.

Isotope enrichment characteristics for uranium, plutonium, americium and curium isotopes, used in different nuclear physic experiments, and isotope contaminations for single and double separations are presented.

The capabilities of highly enriched ^{244}Pu and ^{243}Cm production for nuclear accelerator experiments and other applications as well as methods of fabrication of special preparates and targets and layers out of highly enriched isotopes on various substrates are described.

The conditions of delivery and transport kit constructions for isotope production are discussed.

A Personal Computer Data Base on INTDS Publications

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Abstract

Fifteen INTDS conferences and eighteen years of Newsletters resulted in a collection of more than 530 publications and letters concerning the development, preparation, characterisation and/or use of nuclear targets.

In order to permit to all INTDS members (new comers and veterans) to have an easy way to find their "vital" references, we decided to continue the examplary work performed by Judith Gursky and Marjorie Peacock (Report LA-UR-2097, 1984). All the conference proceedings and Newsletter contributions have been introduced in the INTDS computer Data Base, allowing a rapid search of the relevant keywords. This new tool is at the disposal of all INTDS members.

We intend to present our project, to know if our effort is supported by the interest of many of the collegues. A minimal "keyword" indexing will be used to demonstrate this easy and powerfull database. This indexing may then be extended to all the INTDS publications.

We would like to welcome all comments, suggestions (and corrections), that may result in the establishment of a usefull working tool, that may be then distributed as an ASCII file, compatible with most commercial database softwares.

Laser plasma ablation of carbon

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A new plant for fabricating carbon stripper foils by laser plasma ablation-deposition has been installed. The adaptation of the preparation process to the ultrahigh vacuum process and the pulsed (≈10 ns pulse width) Nd:YAG laser with a repitition rate of 50 Hz is described.

Carbon deposition rates were measured as a function of laser power density, polar angle ϑ and azimuth angle φ, where the central laser beam defines the polar axis.

The crystal structure of the ≈4 μg/cm^2 thick carbon foils was analyzed in dependence of laser power density and polar angle ϑ. In addition the density and resistivity of such carbon foils were measured in relation to the laser power density for carbon films mounted during deposition at ϑ=14°.

New development in target preparation at CBNM: laser evaporation-condensation and electrodeposition

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Abstract

Nuclear target preparation is a traditional activity at the Central Bureau for Nuclear Measurements, conceived as a public service for neutron physicists from nuclear centers, universities and industries. Well known techniques, such as vacuum deposition, electrospraying and spraypainting are standard techniques used at CBNM to prepare high quality actinide deposits [1]. The increasing demand of homogeneous deposits of rare and expensive isotopes (deposits with good resolution for fission fragments and/or charged particles), forced us to look for other "high efficiency" techniques.

A preliminary study was carried out (in collaboration with the Target Laboratory of the Technical University of Munich), using the laser evaporation technique [2]. Tests were performed for: - the quantitative evaporation of lithium fluoride and uranium oxide; - the homogeneity of the deposits on stainless steel backings and polyimide foils; - the interaction of the plastic films with the laser beam. This experimental technique may be included in the near future, in our production facility.

Unlike previous attempts, we succeeded to perform uranium and plutonium electrodeposition in aqueous and/or organic (cf. molecular plating) phases. A few of the promissing results obtained with this simple, fast and efficient technique will be presented.

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IMPROVED CARBON MICRO-RIBBON TARGETS AND STRIPPER FOILS FOR THE IUCF COOLER RING*

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ABSTRACT

Carbon micro-ribbons have been made which are stronger and a factor of three thinner than any previously made at IUCF. Ribbons of 4-$\mu g/cm^2$ areal density and 6-μm width were mounted to span 32-mm lengths. Also, open-edged (32-mm) stripper foils of 4-$\mu g/cm^2$ carbon have been prepared with significantly reduced curling at the open edge. For both the foils and ribbons, the progress is the result of efforts to produce uniform, densely distributed microscopically-sized features on the surface of glass substrates.

Along with the grinding technique currently used to texture the substrates, a method to make wire-grill evaporation masks with more closely regulated spacing of the wires will be described. Furthermore, our initial experience with coating the micro-ribbons with ultra-thin deposits of several desired cooler target materials is reported. The micro-ribbons are thought to have considerable potential as backings for cooler targets.

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Thickness Measurements of Carbon Stripper Foils Using Optical Transmitance+

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ABSTRACT

A very simple system was built consisting of an incandescent lamp and photodiode mounted on each side of a box, where stripper foils can be easily inserted. The optical transmitance of a foil is properly related to its thickness, for each different preparation method. The absolute thickness were obtained by the yield measurements in a Rutherford scattering experiment using sub-barrier ^{16}O ion beam. In the figure below it is shown the calibration curve for one type of stripper foil made by arc evaporation on glass slides with CsI parting agent. Extrapolation of this straight line to thicker foils is not appropriate as shown by a comparison made between results obtained with differing methods.

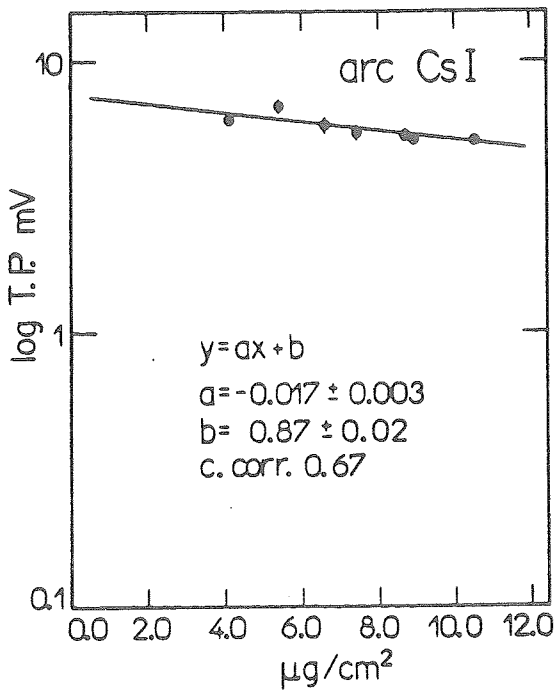

Fig. 1 - Calibration of the transmitance in log scale related to the thickness of carbon foils made by arc evaporation.

+This work has financial support from FAPESP, CNPq and FINEP
*FAPESP

ABSTRACT

Acoustic Measurement of the Surface Densities of Unsupported Thin Foils

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A new method for measuring the surface densities of unsupported thin foils has been developed. This method involves measurement of the additional time delay of an acoustic wave transmitted through air from source to receiver when a foil is introduced into the path. The method is in principle independent of the foil's composition and is capable of absolute calibration in terms of the density of air, the absolute temperature, and fundamental constants. The theory of the method is well known but does not seem to have been applied to this application previously. In practice the method has been used to measure foils' surface densities in the range from five micrograms per square centimeter to several thousand micrograms per square centimeter. Different measurement ranges may be obtained by using different frequencies of acoustic waves. Examples of the application of this method and some of its practical limitations are presented.

Developments of ^{208}Pb and ^{209}Bi targetwheels in the synthesis of $_{107}Ns$, $_{108}Hs$ and $_{109}Mt$

H. Folger, W. Hartmann, F.P. Hessberger, J. Klemm, S. Hofmann, G. Münzenberg, V. Ninov, K.-H. Schmidt and W. Thalheimer

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Abstract

The development of rotating target-wheels at GSI is reviewed under the special aspect of their application in heavy-ion bombardments at the GSI SHIP in the production of the heaviest elements. The new wheels are developed for both evaporation-condensations of target materials and bombardments with pulsed beams of heavy-ions. The centers of the evaporator or accelerator beams are focused at a wheel radius of 155 mm to specially shaped frames, covering up to ~98% of the circumference of 973.89 mm with target areas.

The targets have to be sandwiched between carbon layers, so the used preparation of the carbon backings is described briefly at first. ^{208}Pb and ^{209}Bi are evaporated from resistance-heated tantalum crucibles to rotating target wheels carrying the frames with the carbon backing. At a source-to-substrate distance of 12 mm a high uniformity of ~3% is achieved for all targets of one run, and the deposition yields vary between 35-50%, depending on the target geometry. The new target layers are coated with ~8 $\mu g/cm^2$ of carbon.

The applications of the target systems in heavy-ion bombardments at the UNILAC with beams of ^{54}Cr and ^{58}Fe at Coulomb energies and intensities of 10^{11}-10^{12} particles/s are described. Especially the target parameters for the production runs of $_{107}Ns$, $_{108}Hs$ and $_{109}Mt$ are mentioned.

THE INFLUENCE OF TARGET BACKING ON IN-BEAM ELECTRON SPECTRA

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Abstract

Several different aspects of the influence of the target backing on in-beam electron spectra following compound nuclear reactions induced by accelerated ions at Tandem energies irradiating backed targets are discussed in detail. This discussion is illustrated by a few typical examples, like $^{12}_{6}C^{5+}$ and $^{31}_{15}P^{10+}$ beams at 4 MeV/u bombarding Sn(+ Be), Sn(+ Au), Pb(+ C) backed targets. Moreover, the relative influence of electron backscattering, electron Doppler shift and Doppler broadening as well as δ-electron emission on the low energy electron spectra ($E_e \leq$ 100 keV) obtained under such conditions are investigated and the experimental data are compared to the theoretical predictions.

Progress in the preparation of targets for the GSI Fragment Separator

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Abstract

At the Fragment Separator of GSI energy straggling has been measured in various targets for fully stripped heavy-ion beams from oxygen to bismuth in the energy range of 100 to 1000 A·MeV. The data, so far, exceed theoretical predictions by 20 to 100%, resulting probably from thickness nonuniformities. Therefore, surfaces of targets were investigated using opto-electrical thickness gauges and a SEM, where structures with large roughness values up to ± 0.04 mm could be identified.

In order to obtain homogeneous, finely polished targets of diameters of 20 mm an improved industrial diamond-cutting machine and an automatic polishing apparatus have been set up. The best operational parameters for nearly all metallic targets ranging in thicknesses from about 0.2 to 20 g/cm^2 will have to be elaborated. First opto-electrical scans and SEM fotographs can be presented for prepared targets of Al, Ti, Cu, Zr, Mo, Ag, Ta, and Pb with roughnesses of as small as ± 0.0001 mm.

In future experiments at the GSI Fragment Separator these targets of highly uniform thicknesses will suppress the influence on energy straggling significantly. It will lead to an easier interpretation of experimental and theoretical values.

Automatic measurement of thickness and uniformity of thin films by a computer aided device.

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In experimental physics it happens that a large number of thin films need to be measured with the highest possible accuracy, as in the case of stripping foils for accelerators or catcher foils in recoil range measurements. In order to avoid the need of the continuous presence of an operator and to eliminate any possible error which could be made through inattention, we have designed, built and tested CASTM a Computer Aided System for Thickness Measurement of up to 44 thin films, controlled by an IBM PS/2 Model 30 personal computer and a smart card, the servo-motor controller Galil DMC 220. The CASTM set-up consists of:

1) a measuring chamber, with its own vacuum system, having internal moving parts driven by motors, each of ones with the associated electronic h/w, including the servo-motor Galil DMC 220

2) a well collimated α-source and a surface barrier silicon detector with its associated electronics (preamplifier, amplifier, power supply)

3) a multichannel analyser, with its own high quality ADC, to collect α-energy spectra with high sensitivity

4) a personal computer providing the automatic operation of the system and the storing and manipulation of α-spectra and the result printing.

The samples to be measured are situated on a rotable disk with a movable arm, supporting α-source and detector. The combined movements of the disk and the arm allow the α-source +detector to reach every sample.

So the thickness of each film with its error can be computed by measuring the energy lost by α-particles passing through them, with a few percent error, by exploiting the kwown energy-loss relation. The great advantage of this apparatus, beside its precision, is the possibility of measuring the thickness of the film in different points, so giving also informations about uniformity.

Depth microscopy for thin film analysis

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Depth microscopy with swift heavy ions was recently developed, which is an elastic recoil detection technique with high depth resolution, performed at the Munich tandem accelerator and its Q3D magnetic spectrograph. The method gives the possibility to analyze elemental and isotopic concentration profiles in thin films and foils with high accuracy up to single layer depth resolution near the surface.

This technique was applied to examine surface and bulk concentrations of hydrogen in thin carbon foils and $^{11}B/^{12}C$ multilayer systems. In addition mixing zones were investigated between silicon substrates and carbon films deposited by the ablation of carbon with a Nd:YAG laser at different light intensities. The width of the mixing zone strongly depends on the light intensity for laser ablation and varies from 0.4 $\mu g/cm^2$ for a power density of 2 GW/cm^2 to 2 $\mu g/cm^2$ for 20 GW/cm^2.

A Small Volume Tritium Monitor and Fill System

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and
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ABSTRACT

Environmental concerns demand that all tritium releases be minimized. In particular an experiment recently fielded at Los Alamos National Laboratory required a four cubic millimeter volume to be dynamically filled to a pressure of 1000 psi, while keeping the total tritium content (and potential release) below 20 Ci. We describe the system which was designed and built for this purpose, complete with a low volume fiberoptic tritium monitor and pressure transducers.

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Targets of magnetic properties

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Guest from Heavy Ion Laboratory of Warsaw University, Warsaw, Poland

Various multilayer targets with ferromagnetic matter as a middle layer for TF (transient magnetic field) measurements were prepared using rolling and vacuum evaporation-condensation techniques.

The compatibility of different backing materials with the condensed ferromagnetic layers was investigated. The influence of the substrate temperature on the magnetic properties was analyzed as well.

Ferromagnetic Fe-layers consisting of magnetically separated segments of domain size were prepared by vacuum evaporation-condensation through suitable mesh masks.

For NMR-ON (nuclear magnetic resonance on oriented nuclei) experiments rolled foils of highly diluted ferromagnetic alloys were needed. Such impurity systems had to be melted together in a water cooled copper crucibles of an electron beam source. The diluting process strongly depends on the relative vapor pressures of the impurity metal and the ferromagnetic host.

Purity investigations of several types of nuclear targets

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ABSTRACT

The purity of several types of self supporting targets usually prepared by evaporation on soluble Cu substrates has been studied in order to obtain information on the mechanism of targets deposition. Targets have been analysed by Rutherford backscattering (RBS) and instrumental neutron activation analysis (INAA). Because of the high percentage of Cu observed in some Si targets, further measurements, including transmission electron microscopy (TEM) have been performed on Si targets deposited onto various substrates by e-gun bombardment and ion beam sputtering.

Thin Film Stoichiometry and Impurity Concentration Analysis Studied by Nuclear Techniques.

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I.N.F.N.-Laboratori Nazionali di Legnaro.

Abstract

Rutherford and non-Rutherford Backscattering Spectrometry with He-ions and protons beams of few MeV/nucleon energy is a suitable technique for studing the stoichiometry ratios of the elements in the surface of materials, with the exception both of the lighter elements and of the heaviest ones.
Specific Nuclear Reaction using low energy deuteron beams are used for the analysis of the most important surface contaminants like oxigen, carbon and nitrogen.
Moreover the presence of hidrogen isotopes can be studied both by means of nuclear reactions and forward elastic scattering.
A brief review of the basic principles will be presented together with peculiar experimental analysis.

Historical Development and State of the Art of Nuclear Targetry in the United Kingdom and Australia.

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Abstract:-The development and state of the art of nuclear targetry in the United Kingdom and Australia, since the earliest days of nuclear physics research, is briefly described. A more detailed account is given of the author's experience in nuclear target laboratories both in the United Kingdom and Australia.

Characterization of targets

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The uniformity of the targets and impurities in the target are crucial parameters in the nuclear physics experiments. The impurities have been determined by elastic recoil detection analysis (ERDA). A self supporting carbon foil of thickness ~ 100 $\mu g/cm^2$ prepared by electron bombardment was examined by ERDA technique at an angle of 30 degree using 100 MeV ^{127}I ions. The impurities of N, O, Na, Si and Cl were observed as 0.07 %, 1.77 %, 0.40 %, 4.11 % and 0.40 % respectively in comparision to ^{12}C. The thickness variation within a foil was found to be within 2.8 % for the targets prepared by the electron gun and upto 10.5% for the targets prepared by rolling and centrifuge technique. It has been shown that light impurities of the constituents of paraffin introduced in preparation of targets by rolling and centrifuge can be reduced by baking the target at a temperature of 300^0 C in vacuum.

Production of thin metallized plastic films

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We describe a method for the production of thin plastic films in the thickness range 3–5$\mu g/cm^2$ for use as a replacement for the carbon foils widely used in micro channel plate (mcp) heavy ion timing detectors. In these detectors, electrons emitted as the heavy ion passes through a thin foil are transported to an mcp for amplification to provide a fast timing signal.

The equipment developed for casting films consists of a perspex water bath and a stainless steel spreader, mounted on a carriage which is rail driven by a small servomotor. 1ml of Lexan solution dispensed into the stainless steel spreader trough is lowered beneath the water surface and drawn along the entire length of the bath, leaving on the water surface a uniform film. The film is recovered onto a metal supporting frame with a 8cm diameter open mesh and a coating of 10–15 $\mu gm/cm^2$ indium evaporated on them. The resulting foil has a mirror finish and is to some degree bonded to the support grid, making it mechanically quite robust. Detailed tests of the performance of these foils in heavy ion detectors are being made. The time resolution of detectors employing them is at least as good as that observed using carbon foils.

THE PREPARATION OF NUCLEAR TARGETS AT IMP

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ABSTRACT

It is described that the investigation and development of the preparations of nuclear targets have been used for nuclear physics experiments at IMP since 1975. The targets of more than forty elements which include natural elements enriched isotopes, lathanide and actinide have been produced and the preparing methods, such as electroplating, focused heavy-ion beam sputtering, centrifugal precipitation, rolling, electron bombardment, resistance heating, have been set up.

The analysis of target films contaminated by oil vapor and the equipment for preparing thin metal self-supporting target without oil contamination are also related.

TARGET PREPARATION FOR TRACE ELEMENT DETERMINATION OF BIOLOGICAL MATERIALS USING NUCLEAR TECHNIQUES

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During last two decades, a great deal of developments have been made in trace element determination of biological materials using nuclear techniques. Among them, the most prominent ones are total reflection X-ray fluorescence, widen available synchrotron X-ray and charged particle beams, and microprobes constructed from these beam lines. As biological materials are often presented in a variety of forms (e.g. soft tissue and bones), shapes, sizes and quantities, one has to select an optimum procedure for target preparation depending on the objectives of study and the available experimental conditions. Target preparation is of paramount importance to perform a good analysis, especially when the elements of interest exist in samples at trace and ultra-trace concentrations. In this paper, a brief review on target preparation is presented together with some examples from synchrotron radiation total reflection X-ray fluorescence (SR-TXRF), proton induced X-ray emission (PIXE), and microprobe proton induced X-ray emission (μPIXE).

A Filter for X-Ray Astronomy CCD's

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Abstract

We have developed a prototype X-Ray bandpass filter within the EOBB (Electro-Optical-BreadBord) phase of ESA's X-ray Multi-Mirror satellite mission (XMM), to be launched at the end of this decade. The observatory will be equipped with CCD's as detectors in the focal plane of the telescopes.
CCD's have a broad spectral response ranging from the X-Ray to the very near infrared range. For X-ray observations therefore a filter transparent to radiation at energies above 0.1 keV and suppressing radiation below this value at more than 6 orders of magnitude must be located in front of the detector.
The unsupported filter has a size of 3 cm x 1cm and is composed of multilayered thin films of parylene N, carbon and aluminium with mass densities of 25, 25, and 30 $\mu g/cm^2$ respectively.
We describe the technique of manufacturing , the measurements of the spectral transmission characteristics and the testing of their resistance to environmental stresses.
The performance data is presented.
The final flight model filters require an effective filter size of 60 mm in diameter. The concept for a large area filter is reported.

THE Sr-82 CYCLOTRON PRODACTION FOR MEDICAL APPLICATION. METHOD.EXPERIMENTAL RESALTS.

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Rubidium-82 is one of the perspective positron emission radionuclides, which can be used at the positron tomography method. The short half-life of the ^{82}Rb (75 sec) allow significantly to reduce radiation dose to patients and hospital personnel. Rubidium-82 is obtained from a generator system through its 25-day half-life parent ^{82}Sr. This report is devoted to problem of the ^{82}Sr cyclotron production for the ^{82}Sr-^{82}Rb generator. The ^{82}Sr was received into RbCl(99% ^{85}Rb) target with help of the ^{85}Rb (p,4n) reaction, using 70 Mev protons of inner cyclotron bunch at the current up to 75 μA.

Chemical processing included chromotographic isolation of Sr with help of ion exchange column.

The target construction, experimental method and results are presented in this report.

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ABSTRACTS

HD1 Modern Aspects of Nuclear Accelerator Target Preparation
H. J. MAIER, *Sektion Physik, Universität München, 8046 Garching, Germany* (20 min.)

Target preparation for nuclear accelerator experiments requires the application of a variety of physical techniques like vacuum evaporation condensation, ion beam sputter deposition and cold rolling. Up to date equipment like cryopumped vacuum chambers, deflection gun type electron beam heating systems, xenon operated ion guns, quartz crystal thickness and rate control monitors and dry box rolling facilities are indispensable to prepare targets of high purity and well defined thickness. Since enriched isotopic material is offered mostly in the oxide form, the mastery of chemical operations like oxide reduction and metal purification is a necessary condition for the operation of a target facility. The high price and limited availability of enriched isotopes demands the development of procedures getting along with small quantities of material at a high degree of efficiency and, in extreme cases, recycling of wasted material. The access to analytical services is vital for quality control of the prepared targets.

HD2 Nuclear Target Analysis with Heavy Ion Beams
W. ASSMANN, Universität München, Germany (20 min.)

Targets for nuclear accelerator experiments have been analysed using heavy ion beams from a 14 MV Tandem accelerator in two different measuring geometries: either detecting the elastically backscattered projectiles (RBS) or the recoiled target atoms (ERD). The Rutherford scattering analysis is a comparatively fast and simple method offering the well known advantage of an absolute and quantitative determination of the target composition and impurity concentration. For RBS we used typically 25 MeV ^{16}O beams and a cheep PIN diode as detector. With these projectiles and the corresponding increased mass resolution of RBS heavy element impurities could be detected even in targets with heavy components. Light element components, e.g. H, C, O, in thin target foils were measured in ERD geometry using heavy ion beams of 120 MeV ^{127}I and PIN diodes. Direct scattering of this projectil is kinematically excluded for angles larger than 30^0 and target elements up to Cu, therefore an absorber foil in front of the detector can be avoided. For heavier elements analysis and thicker targets Z-identification of the recoils is necessary. We have detected the recoiled target atoms in this case with a position sensitive gas ionization counter and measured impurity concentrations depending on the target preparation process and the parting agent used. As a first result of this systematic study an Al contamination of high vacuum sputter deposited targets, originating from the sputter source, could be reduced by two orders of magnitude .

HD3 Carbon Foils for Nuclear Accelerator Experiments.
P. MAIER-KOMOR, *Physik-Department, Technische Universität, W-8046 Garching, Germany.*
(20 min.)

Carbon foils are the mostly used targets and backings in nearly all experiments on nuclear physics and related subjects performed at ion accelerators. Due to their good tensile strengths carbon foils can be prepared even with a thickness below 1 $\mu g/cm^2$ and are therefore exclusivly used as backings whenever a low Z element is tolerable. There are several methods available to prepare carbon foils with different properties. A review is presented about these methods and the application of special techniques in order to achieve specific foil properties. The characterization and exact thickness determination of carbon foils are described in detail.

HD4 Solid-Target Technology at the Indiana University Cyclotron Facility[a]
W. R. Lozowski, *Indiana University Cyclotron Facility, Bloomington, IN 47408* (20 min.)

The capabilities of the IUCF solid-target lab have evolved to provide nuclear targets in a thickness range of approximately 5-$\mu g/cm^2$ to 200-mg/cm^2 areal density. Adaptations of lab equipment and techniques used to obtain specific targets will be discussed. Extensive use is made of procedures developed to prepare pressed-powder pellets of materials in thicknesses perhaps not accessible with other methods. Carbon micro-ribbons for the IUCF Cooler are among the targets made by vacuum evaporation/condensation. Isotopically enriched lead and tin are rolled to thicknesses of 4 mg/cm^2 and 2 mg/cm^2 resp by using an outer pack of stainless steel and an inner one of the same element (unenriched).

[a] Supported by the National Science Foundation and Indiana University

HD5 Potential Advancement in Isotope Enrichment Capabilities at ORNL.
J. G. TRACY, Oak Ridge National Laboratory, Oak Ridge, Tennessee. (20 min.)

The plasma separation process (PSP) is based on the mass dependence of the ion cyclotron resonance of a charged particle in a uniform magnetic field. By tuning the frequency of an applied electric field to match the natural cyclotron frequency of the plasma ions, ions of any given mass can be made to absorb energy from the electric field and move in trajectories with large orbit sizes. The PSP exploits this simple principle for isotope separation. A production prototype module PSP utilizing a 2.0-tesla superconducting magnet, helically wound excitation coils, and electron cyclotron resonance heating for forming the plasma was built and tested for uranium-235 enrichment and is currently available for stable isotope separations. This machine, the separation process, enrichment capabilities, and the proposed location in the calutron facility are depicted. The PSP can be employed as a stand-alone process to produce large quantities of moderately enriched isotopes or for producing feed material for the calutrons. When used in tandem with the calutrons, isotopes low in natural abundance can be made available in quantities and enrichments never before attainable.