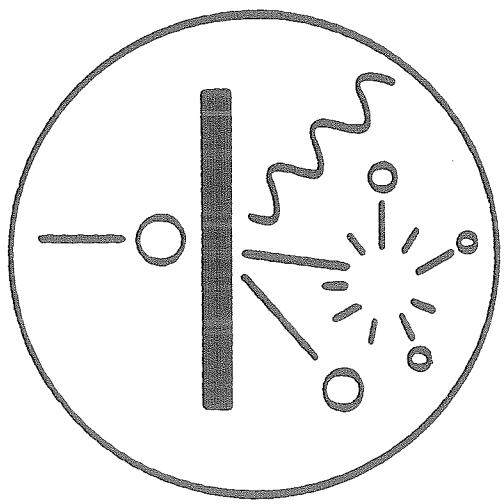
INTERNATIONAL NUCLEAR TARGET DEVELOPMENT SOCIETY

NEWSLETTER



July 1991

Vol. 18 - N°. 1 - July 1991

Published by :

International Nuclear Target Development Society
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Editors Note

Dear Colleagues,

We did not succeed in compiling a Newsletter at the end of 1990 due to complete exhaustion of potential authors following the INTDS conference in Santa Fe last year. However, I am happy to say that we have a healthy collection of contributions for the current Newsletter. Thank you in particular to those (hard working) authors who are regular contributors.

The 15th INTDS World Conference was successful and enjoyable. About 40 papers (now published in Nuclear Instruments and Methods) on evaporation and deposition techniques, isotope enrichment, carbon foils and target characterization were presented to 60 participants. A fascinating visit to LAMPF and the Los Alamos Target Fabrication Facility was arranged. Major credit for a fine conference goes to Pete Gobby for hard work carried out in his enthusiastic and cheerful way. Thanks are also due to Judy Gursky, Harold Adair and Hans Maier for help and advice in planning the technical programme and to Millie Saxman for arranging the social programme.

A special presentation was made to Harold Adair, the retiring INTDS President, in recognition of his support and leadership during his term of office. The composition of the new INTDS board can be found in the minutes of the most recent meeting.

A request was made to INTDS members at the end of last year for information concerning stable isotopes in circulation that may be available for resale. The response was not encouraging and no further action has been taken on this proposal. The problem of non-availability and high prices of stable isotopes, which affect most target makers, remains unresolved.

Chris Ingelbrecht
EDITOR

Recognition for a great presidency

Presentation of the INTDS-Award to Harold Adair at the Santa Fe Conference

Harold Adair's term of office as the president of the INTDS spreaded over the four year's period from fall 1986 to fall 1990. It was one of the most productive presidencies of our society.

Harold received his education at Ogelthorpe University and the University of Tennessee, where he acquired a Physics Master's Degree in 1960 and a MBA Industrial Management Degree in 1975.

Since the early days of nuclear target technology Harold is one of the most outstanding personalities of this science branch. He is a member of the Oak Ridge National Laboratory since 1960. There he was for many years the department head of the renowned Isotope Research Materials Laboratory, where all the significant target preparation procedures were developed, and later the head of the Isotopes Preparation Department. His work on stable isotope targets is acknowledged all over the nuclear physics community, and he is one of the very few world's experts in radioactive targets. He co-authored more than 50 papers and a monography on heavy ion targets. Many of these papers were published under the auspices of the INTDS. Participating regularly at the INTDS World Conferences and co-chairing two of them, he gave particular support to the society.

Harold joined the INTDS in 1975, served in the board since 1983 and became our president in 1986. During his tenure, the bylaws were revised with the result of more continuity and efficiency in the leadership. He also established the guidelines for hosts of INTDS conferences, providing a useful framework to give publicity to target science, which is one of the the main objectives of the INTDS. Under his presidency, the position of the INTDS in the field of nuclear science was substantially consolidated.

On behalf of all INTDS members I wish to appreciate Harold's conspicious merits concerning our society.

Hans J. Maier
President, INTDS

PRODUCING GRAPHITE TARGET FRAMES WITH A DIAMOND CUT-OFF WHEEL

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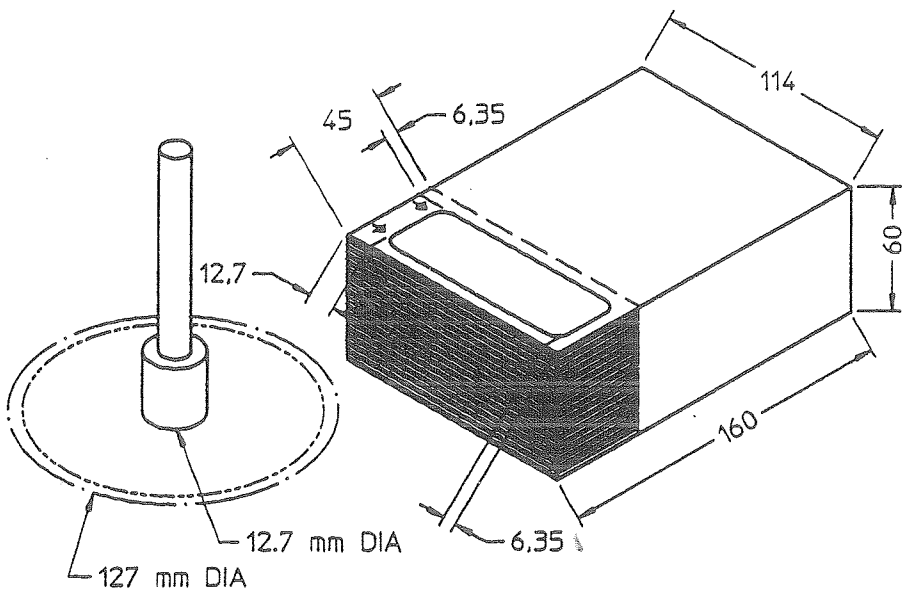
Bloomington, Indiana 47408

We have made 45 large graphite frames (drawing below) from a block of 1.81 g/cm^3 graphite (Poco Graphite Inc., Decatur, TX 76234; grade AXF-5Q). The method to be described requires a shop machinist's end-milling machine, end mills, a diamond-impregnated brass cut-off wheel (Struers no. RS-70308 from VWR Scientific), and an arbor with a 25-mm diameter shoulder to hold the cut-off wheel in a collet of the milling machine. The wheel (127-mm diameter x 0.41-mm thick) was used to slice the graphite into frames quickly, with minimal kerf loss of the valuable graphite block. Adequate cooling for the saw blade was provided by room air drawn across the blade and into a vacuum cleaner nozzle positioned near the blade. The maximum spindle speed of the milling machine (2720 rpm), not the temperature of the blade, limited the speed the graphite could be cut with the saw. At the fastest feed rate found to maintain the desired plane of the cut, the blade was only slightly warm to the touch.

The quickest way to produce the frames was accomplished by: (i) orienting them within the block as shown, and (ii) leaving one side of the 114-mm dimension as the final cut to free all of the frames. The former consideration allowed the center volume of 34 frames to be removed rapidly by through-cutting with an extended-length 12.5-mm diameter end mill cutter. The latter permitted the graphite to be simply and securely clamped to the table of the end-milling machine during all of the machining operations.

To remove the center volume of the frames, a starting hole of 12.5-mm diameter was drilled near the perimeter, completely through the 60-mm thick graphite. Plunge cuts with a 72-mm length end mill cutter were then used to remove the graphite along the perimeter, advancing the cutter 0.6 mm per cut. Although over 400 plunge cuts were required, the center volume was removed within 30 minutes.

Slicing the graphite into 1.27-mm thick cantilevered pieces was accomplished by advancing the graphite into the diamond cut-off blade (rotating at 2720 rpm) at a table-feed rate of 23.8 mm/min. The 45-mm deep cuts were made in one pass, requiring ~8 minutes per cut. Two 30-mm deep cuts (front and back) were made at the same feed rate to free the frames from the remaining graphite block.



CUTTING GRAPHITE FRAMES 1.27 mm THICK

SAMPLES AND TARGETS FOR NUCLEAR MEASUREMENTS DELIVERED BY CBNM DURING 1990

J. Pauwels and C. Ingelbrecht

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1. PREPARATION OF SAMPLES AND TARGETS ON REQUEST

104 samples and targets corresponding to 42 orders have been prepared, characterised and supplied to 12 customers in Belgium, France, The Netherlands, Austria, Sweden and the United States. Moreover, 158 samples and targets covering 33 requests were supplied in support of the CBNM specific programme. They consist of thin deposits of actinides (^{232}Th, ^{233}U, ^{235}U, ^{236}U, ^{238}U, ^{239}Pu, ^{241}Pu) or stable nuclides (^{10}B, ^{152}Gd, ^{157}Gd, ^{177}Hf, ^{149}Sm, ^{171}Yb), thin plastic films (polyimide, polystyrene), bulk samples (^{6}Li, ^{7}Li, ^{53}Cr, ^{58}Ni, ^{238}U, Al, Au, Fe, Mn, Si, Ti, $C_3H_6N_6$) or alloys, generally prepared by high frequency levitation melting (Al-Ag, Al-Au, Al-Lu, Al-Mn, Al-Ni, Al-U, Au-Fe, Ni-Al, Ni-Co, Ni-Fe, Ni-In, Ni-In-Nb, Ni-Pd, Ni-Rh, Ni-Si, Ni-Ta).

2. PREPARATION OF HYDROGEN REFERENCE DEPOSITS

As elastic scattering on hydrogen H(n,n)H is an important standard reaction in neutron metrology, the effort to prepare homogeneous, stable and well characterised reference deposits was continued. Last year, several long-chain hydrocarbons, alcohols and carboxylic acids were evaporated onto several substrate materials. Mainly on the basis of electron microscopy studies, octacosanol was chosen as the most promising compound. This year, several evaporations of this compound were carried out on highly polished tantalum. Targets of thickness in the range 300 to 1000 $\mu g \cdot cm^{-2}$ are being investigated.

3. CHARACTERISATION OF ^{10}B AND ^{6}LIF REFERENCE DEPOSITS

The characterisation of ^{10}B and ^{6}LiF reference deposits prepared last year was completed. ^{10}B IDMS determinations including a chemical purification step carried out by CBNM's Mass Spectrometry Group confirmed last year's results. Finally, ^{10}B and ^{6}LiF surface densities could be certified with accuracies down to 0.30 % and 0.35 %, respectively. An intercomparison of the ^{10}B and ^{6}Li calibrations showed their consistency at < 0.1 %.

One of the ^{10}B deposits was used in the frame of University of Sussex - NIST - SURRC - CBNM measurements at I.L.L. to redetermine the lifetime of the free neutron. An improved neutron lifetime value τ_n = 893.6 ± 5.3 s was determined (1).

4. PREPARATION OF U-PU METALLIC SPIKES

Alloys of ^{235}U-^{239}Pu are required as metallic spikes for the accurate assay by IDMS of U and Pu in undiluted input samples of reprocessing plants. However, problems exist with both homogeneity and workability of these alloys and a systematic study of the parameters of importance for their preparation is being carried out.

A metallographic facility for α-active alloys consisting of two glove boxes for mounting/polishing and microscopy are being installed and a box for encapsulation under inert atmosphere is being prepared. Binary and ternary alloys of uranium with molybdenum, zirconium or niobium additions of 2 - 12% have been prepared in order to stabilise the γ-phase and improve the ductility of the uranium matrix. Some success has been achieved and wires have been prepared by swaging. A study of the error propagation of IDMS indicates an optimum ^{239}Pu content of 10% in 100 mg spikes. This is not compatible with good ductility in the alloy and some compromise in composition will have to be reached.

5. REACTOR NEUTRON DOSIMETRY

CBNM is collaborating with the Euratom Working Group on Reactor Dosimetry to prepare a series of dosimetry reference materials. There are currently 12 RM's available, either activation dosimeters (Rh, Ni, Al, Fe, Cu, Nb, Al-Co or Al-Au) or fission dosimeters UO_2 and NpO_2). In the past year 50 samples have been supplied to 11 customers and encapsulation in quartz or vanadium tube has been carried out. Four reference materials were certified during 1990 : EC-NRM 525 Nb (19.6 ± 1.8 ppm Ta), EC-NRM 526 Nb (0.30 ± 0.09 ppm Ta), EC-NRM 523 Al (< 0.1 ppm Na) and CBNM-530 Al - 0.100 ± 0.002 % Au.

(1) J. Byrne et al., Physical Review Letters 65, 289 (1990)

PROGRESS REPORT ON NUCLEAR TARGETS DEVELOPMENT WORK

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ABSTRACT - The development of nuclear targets and stripper foils carried out in the target laboratory of the Pelletron Accelerator during the last two years is described.

Most of the targets are prepared by vacuum evaporation - sublimation of chemically pure material onto polished glass plates previously recovered by some adequate parting agent. The targets are then fished on appropriate frames.

On the table 1 a summary of the relevant parameters used for each target is given. Some comments are given subsequently.

TABLE 1 - NUCLEAR TARGETS AND THE MAIN CHARACTERISTICS IN EVAPORATION PROCESS

No.	Element	Thickness $\mu g/cm^2$	Backing	Method	Crucible or boat	Power (e.b.) current(J.h.)	Parting agent	Obs.
1	^{24}Mg	20 to 30	carbon + bismuth	e.b.[a)]	Ta	50 to 60W	RBS[b)]	
2	^{27}Al	30	S.S.[c)]	J.h.[d)]	W	2 to 2.5A	RBS	filament
3	^{27}Al	84	mylar	J.h	W	2 to 2.5A	-	filament

No.	Element	Thickness $\mu g/cm^2$	Backing	Method	Crucible or boat	Power (e.b.) current(J.h)	Parting agent	Obs.
4	^{27}Al	750 to 1400	S.S.	rolling	-	-	-	
5	Si	300	C	e.b.	C	100 to 120W	-	
6	Si	300	S.S.	e.b.	C	100 to 120W	betain	
7	TiO_2	20	C	e.b.	Ta	80W	-	
8	Ni	200 to 1000	S.S.	J.h.	W	3 to 4A	RBS	
9	Ni	1600	C $20\mu g/cm^2$	J.h.	W	3 to 4A	-	
10	Cu	500	mylar	J.h.	W	4 to 5A	-	
11	Cu	500 to 1000	S.S.	J.h.	W	4 to 5A	RBS	
12	^{66}ZnO	30	C $\approx 10\mu g/cm^2$	e.b.	C	60 to 100W	betain	
13	Ag	20	Carbon $10\mu g/cm^2$	e.b.	W	15W	RBS	filament
14	Ag	400	mylar	J.h.	Mo	$\approx$2A	-	
15	In	20	carbon	e.b.	W	10 to 15W	-	
16	^{114}SnO	30 to 50	carbon $10\mu g/cm^2$	e.b.	Ta	40W	RBS or betain	
17	Sn	280	mylar	J.h.	Ta	2 to 3A	-	
18	SnO_2	150 to 600	Au ($1,5mg/cm^2$)	e.b.	Ta	150W	-	
19	Sb	$\approx$1000	Ni	e.b.		10 to 15W		

No.	Ele-ment	Thickness $\mu g/cm^2$	Backing	Method	Crucible or boat	Power (e.b.) current(J.h.)	Parting agent	Obs.
20	Sb	≈1000	Ni+Cu	e.b.		10 to 15W		
21	Sb	700 to 1200	Au (1 to 1,5mg/cm^2)	e.b.	Ta			
22	Au	50 to	S.S. 2000					
23	Pb	1050	mylar					
24	Pb	≈2000	Cd (1,8mg/cm^2)			2.5A		–
25	Bi	200 to 500	Au					

a) e.b. - electron bombardment

b) RBS - detergent

c) S.S. - self supporting

d) J.h. - Joule heating

COMMENTS:

The ^{24}Mg target was made using enriched MgO. A carbon layer of about 10 to 20$\mu g/cm^2$ was first evaporated onto a thin RBS film. Over the carbon film a layer of 3 to 5$\mu g/cm^2$ of Bi was evaporated by electron bombardment to get better adherence of Mg. The MgO powder was mixed with some droplets of water to provide that the MgO was in contact with the Ta crucible, where the reduction takes place. The heating was done very slowly to get a better efficiency in the reduction.

The 4th target on the table was made by rolling of ^{27}Al to a thickness of 1,6mg/cm^2. A chemical attack with NaOH solution was performed to clean the surface and to get the desired thickness.

Both Si targets were very difficult to fabricate because during the floating process the film rolls up.

The storage of the TiO_2 targets is possible only for a period of two to three months. They tear up.

The Ni targets are easily made on thin (~10μg/cm^2) C backing.

The ZnO was evaporated on several parting agents as usually done and betain gave the best results. When enriched material was used, the distance between the crucible and the substrate was maintained at 6cm. The heating was carried out very slowly to avoid jumping of the material.

The ^{114}Sn targets were made on C backing mounted on target frames, which were in thermal contact with a water refrigerated copper arm. A better adhesion was verified.

The $^{120}SnO_2$ and $^{124}SnO_2$ targets were requested with 1mg/cm^2 thickness. Although a thick (~1mg/cm^2) Au water refrigerated backing was used the heating had to be performed very slowly, because of the ~3cm distance between crucible and backing. The gold layer would be otherwise damaged. A maximum thickness of 500μg/cm^2 was obtained.

Natural Sb targets were obtained by evaporation of Sb on Ni or on Cu (when Ni+Cu backing was used). The water refrigerated holder was used. The backing foils were previously cleaned using trichloracetic acid. The best efficiency was obtained using 20mg of material to get one target of $1mg/cm^2$ with an area of $1cm^2$, although many test runs were performed. To get the Sb targets evaporated on Au, a Ta crucible was used.

The evaporation of Pb on Gd was performed in three steps starting from 146mg of Pb to get a $2mg/cm^2$ of Pb. In this case the Pb was the stopper and the Gd the nuclear target.

To study air pollution by the PIXE method a multilayer target of Zr, Cu, Ti and Al was requested. A thick layer of Zr was obtained by electron bombardment using C crucible, the Cu and the Ti layers with a Ta crucible and finally the Al layer with a W filament.

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue, Argonne, Illinois 60439

May 3, 1991

C. Ingelbrecht
Editor, INTDS Newsletter
CBNM
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Belgium

Dear Chris,

Here is my Physics Division annual report for our lab.

PHYSICS DIVISION
ANNUAL REPORT OF RESEARCH ACTIVITIES

Name: John P. Greene & George E. Thomas

Period being reported on: April 1990 through March 1991

Achievements:

During the period being reported on, ATLAS experienced a curtailment of research activities in favor of safety concerns and is thus reflected in the production of nuclear targets. This time however, was devoted to above mentioned safety concerns and entailed the development, administration and documentation of electrical safety training at ATLAS and, indeed, throughout the Physics Division as well. While ATLAS has since come back on-line and target demand is on the increase, these activities are continuing, although at a reduced level.

In the past year, numerous targets were fabricated either as self-supporting films or on various substrates, as rolled foils, as stretched films, and as "sandwiched" foils. Targets produced included Al_2O_3, Al, Au laser mirrors, ^{10}B, B_2O_3, ^{12}C, C detector windows, ^{54}Fe, $^{154,160}Gd$, ^{7}LiF, LiH, L-Valine, $^{24,26}Mg$, ^{24}MgO, $^{92,98}Mo$, $^{146,148}Nd$, ^{208}Pb, ^{152}Sm, $^{122,124}Sn$, ThF_4 and ^{176}Yb.

Numerous carbon stripper foils were prepared for various experimental requirements ranging from 0.6 ug/cm^2 to 300 ug/cm^2. Manufacture of carbon foils in-house using the E-gun was necessary in some instances. Some new stripper foil applications (Pos. #4, PII, etc.) required large aperture frames of a more demanding nature. This work is still in progress.

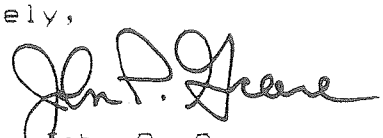
PHYSICS DIVISION
ANNUAL REPORT OF RESEARCH ACTIVITIES (cont.)

Inventories of gold and carbon foil targets on standard ATLAS frames have now been established for a variety of the most common thicknesses requested and are available for immediate use.

During the ATLAS shutdown, time was available for continued upgrade of the target lab equipment as well as improving of deposition techniques. Work progressing includes acquisition of a sweep control circuit for the E-gun system and installation of a new 4000 watt quartz lamp. Installation is continuing on the vibration isolator coupling for the cryopump on the VEECO system. A water-cooled target holder was fabricated for the vertical E-gun and work on alternate reducing agents for the rare-earth isotopes is currently in progress.

Recent software applications for the PC-XT computer included acquisition of a Turbo-C compiler and dBASE III. Energy loss calculations for determining target thickness using alpha particles were rewritten from FORTRAN into C and now resides on the PC itself. A number of thickness and efficiency calculations written in BASIC were developed over the summer by a student intern. Hardware upgrades included a math co-processor chip for faster calculations.

Sincerely,



John P. Greene
George E. Thomas

Physics Division - ANL

THE TARGET AND THIN FILM PREPARATION LABORATORY

Daresbury Laboratory, Warrington WA4 4AD, UK
Tel 0925.603432 Fax 0925 603196

Targets, Foils and Thin Films

The Target Preparation Laboratory is set up at Daresbury to provide special research forms of elements throughout the periodic table, including enriched isotopes required for the preparation of targets used in experiments in the nuclear structure physics experimental programme. It is well - equipped and staffed by experts with many years experience. Due to a lessening of demand from the nuclear physics research programme some of the resources of the target laboratory are now available for commercial use.

High purity thin films for use as targets, coatings and foils are essential for many applications in physics. Over the past forty years techniques have evolved to meet the needs of the experimental community actively engaged in research. These include : vacuum deposition, electrodeposition, rolling, sputtering, ion plating, compacting and spraying. Equipment, facilities and expertise also exists for preparing and storing reactive targets and radioactive materials.

The laboratory can also make carbon foils for ion beam stripping and as supports for other targets. A number of methods are available for this including the preparation of diamond-like carbon films using the glow discharge technique originally developed by this laboratory in 1979. The range of sizes of carbon foils that can be prepared is shown below.

It may be that some of the techniques and processes used at Daresbury could be suitable to prepare materials for your specialised application.

A unique opportunity exists for you to acquire materials which are not normally available commercially. The Laboratory is willing to discuss the feasibility of producing materials to meet your specific requirements.

Should you require any further information please contact Liz Mason of Daresbury Research Services (DRS) as above. DRS can provide quotations for consultancy, target preparation and the supply of materials.

D W L Tolfree
DRS

CARBON FILMS AND FOILS

Carbon films can be supplied on coated microscope slides or as self supporting foils.
The following representative sizes have been prepared and could available on request.

	Thickness (microgram/sq.cm)	Area (sq.cm)
1) on coated slides of metal substrates	2 - 100	100
2) as 1) but also as self supporting	10 - 100	100
3) self - supporting	up to 10000	100

The laboratory has experience in making films for use as stripper foils, windows and coatings for electrodes in detectors and optical filters.

DRS would be pleased to quote for any specialist application.

Status of the plant for laser plasma ablation-deposition for carbon stripper foils

P. Maier-Komor, G. Dollinger, E. Hammann and Maria Katharina Nacke
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Introduction

The aim to develop irradiation resistant carbon stripper foils for swift heavy ions was achieved with the new technique of laser plasma ablation-deposition of carbon, in which a pulsed Nd:YAG laser induces a hot carbon plasma for deposition on parting agent coated substrates in high vacuum [1,2]. The essential feature of this technique is the ablation of monoatomic carbon with an average charge state of 4+ and a broad spectrum of energies up to 1 keV of the monomers. These conditions influence the nucleation and growth of a carbon film in such a way that a nearly isotropic orientation of the nanocrystals in the condensed film is achieved [3]. These new foils (lpa-foils) show, as postulated [4], a much better strength against irradiation damage caused by heavy ions, compared to all other types of stripper foils [5,6].

In order to supply the Munich tandem accelerator with such lpa-stripper foils after the upgrading, intensive studies were done to determine the relevant parameters necessary for a routine preparation. In addition many other accelerator laboratories around the world show their interest in using these new foils for stripper purposes. The method, however, is still too complicated and an investment of more than US$ 200.000 is necessary for a complete plant. That is why no commercial supplier will take the risk with such a hightech method on a basis of the limited amount of accelerator customers. For this reason we have decided to provide all interested accelerator laboratories with lpa-films on a basis of colaboration.

Design of the plant

A new vacuum apparatus with a more powerful Nd: YAG laser system was designed to prepare the new lpa-foils in series production. A better vacuum of about 10^{-6} Pa working pressure and a higher repitition rate of the laser are required to enlarge the distance between substrate and carbon source from 10 cm to about 30 cm and simultaneously reduce interactions of the depositing carbon and the residual gas on the substrates.

In the meantime a suitable laser, the SL-801 Spectron laser was funded by the Deutsche Forschungsgemeinschaft. It was delivered in the first quarter of 1991. Specifications of this laser in comparison to our 2660-1R Holobeam laser and to the DCR-11 laser from Spectra Physics are summerized in table 1. The Holobeam laser, which is used for isotopic target materials for evaporation condensation processes, emits only a power density of $\approx 10^{8}$ W/cm^2, which is not sufficient to create a hot carbon plasma. That is why the DCR-11 laser was borrowed from the ion source group of our tandem accelerator for the development of the lpa-foils and was also used to determine specifications for the proposal of the new laser system.

Table 1
Parameters of used Nd:YAG lasers:

Laser model Manufacturer		2660-1R Holobeam	DCR-11 Spectra Physics	SL-801 Spectron Laser
cw-power	[W]	100	---	---
energy per pulse	[mJ]	12	300	>400
pulse width, FWHM	[ns]	120	<10	<10
max. peak pulse power	[MW]	0.1	30	>40
max. repetition rate (with max. energy per pulse)	[Hz]	4000	10	50
average power	[W]	50	3	>20
laser beam diameter	[mm]	6.35	6.35	6.35
half angle divergence	[rad]	2.5×10^{-3}	2.5×10^{-4}	4×10^{-4}
optimum upcollimator for plano-convex lens (f = 400 mm)		6 : 1	3.4 : 1	3.8 : 1
theoretical power density	[W/cm^2]	8×10^{7}	7×10^{11}	5×10^{11}
power density (focus 0.1 mm^2)	[W/cm^2]	2×10^{7}	3×10^{10}	4×10^{10}
power density (focus 1 mm^2)	[W/cm^2]	10^{7}	3×10^{9}	4×10^{9}
optimum upcollimator for plano-convex lens (f = 800 mm)		(10.2 : 1)	5.7 : 1	6.4 : 1
theoretical power density	[W/cm^2]	6×10^{7}	6×10^{11}	4×10^{11}

Fig. 1 shows schematically the design of the new ultrahigh vacuum apparatus for the laser plasma ablation deposition of carbon. It is completely metal sealed with the exception of the viton sealed main glass door. The refrigerator cryopump offers a pumping speed of ≈4000 l/s for N_2 and should guarantee a working pressure of 10^{-6} Pa. In order not to ruin the ablation-deposition properties due to outgassing of the carbon source material this graphite disc can be heated up to 1300 K by means of electron bombardment. For this purpose the substrates are protected by a shutter, which is turned above the graphite during the outgassing cycle. The laser is mounted above the vacuum vessel, its light beam with a diameter of about 6 mm is expanded by an upcollimator. A dielectric mirror, used to reflect the horizontal laser beam into its vertical direction, can be wobbled and thus computerized scanned horizontally on the graphite disc. The laser beam enters the vacuum chamber through a convex plano lens (f = 80 cm, both sides with anti-reflection coating) and is focused on the graphite sample. The substrates, which are rotated for better thickness uniformity, experience the scanning procedure as deposition from an area source. In this way the uniformity of one deposition charge should be excellent. The distance between the entrance lens and the sample can be varied by means of the bellows sealed manipulator. Not included in this drawing is a glass pane which is mounted slightly tilted directly under

the lens, to protect it against carbon deposition. This glass pane can be slided horizontally by means of a magnetic push-pull feedthrough to present the laser beam a clean uncoated glass area, whenever necessary.

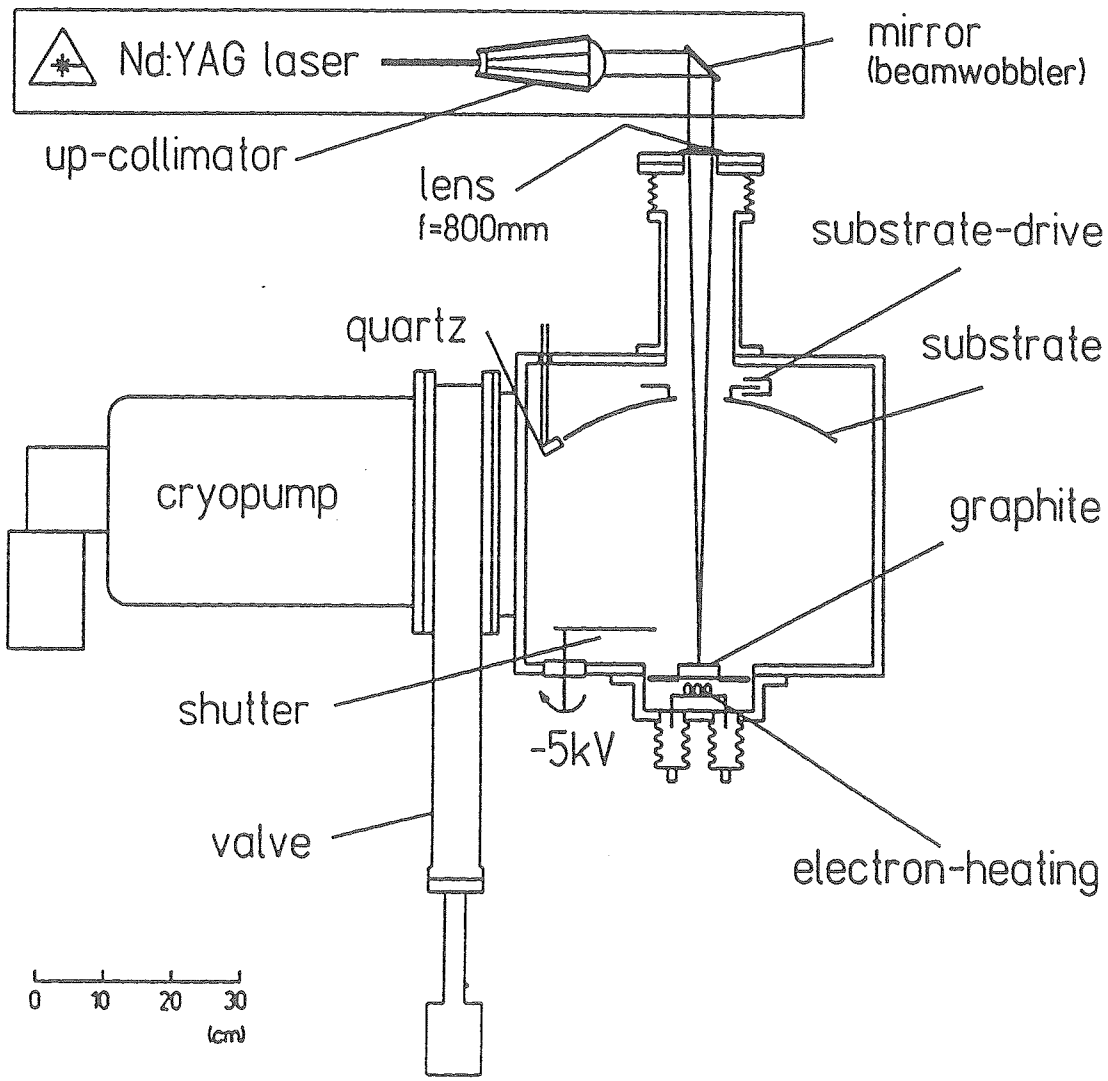

Fig. 1. Schematic drawing of the new ultrahigh vacuum apparatus for laser plasma ablation-deposition of carbon.

[1] G. Dollinger, Ph.D. thesis, TU München, 1990.
[2] G. Dollinger and P. Maier-Komor, Proc. 15th World Conf. of the INTDS, Santa Fe, N.M.,1990, to be published in Nucl. Instr. and Meth. A.
[3] G. Dollinger, P. Maier-Komor and A. Mitwalsky, ref. [2].
[4] G. Dollinger and P. Maier-Komor, Nucl. Instr. and Meth. A 282 (1989) 223.
[5] G. Dollinger and P. Maier-Komor, Proc. SNEAP 1989, Oak Ridge (World Scientific,New Jersey, 1990) p. 138.
[6] G. Dollinger and P. Maier-Komor, Nucl. Instr. and Meth. B 53 (1991) 352.

Future Availability of Radioactive Targets

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For more than 15 years the University of Munich target group has supplied radioactive targets for numerous nuclear accelerator experiments in Europe and the USA. These targets were prepared in a "Hot Lab" facility, which has been described in some detail in a previous publication [1]. Recently, this facility has been shut down for reconstruction purposes. The present contribution provides a prospect on the future possibilities basing on the new technological equipment which is currently being installed.

The new laboratory under construction will not only provide improved radiation protection for the target personnel, but also contemporary technological equipment for radiochemical work as well as for thin film preparation by physical and physico-chemical methods. The installation of a lead shielded hot cell with master slave manipulators will give rise to the most important extension of our technical capabilities. Operations with up to 1 Ci of activity will be possible. Procedures will primarily aim towards ion exchange purifications of isotopic material, including the separation of short lived daughters, and subsequent preparation of small quantities of chemical compounds suitable for further processing by physical vapor deposition.

Emphasis will be not only on actinides or heavy α-emitters. As a matter of fact, targets of any isotope will be available regardless of their radiation type, as long as their activity can be tolerated in the beam line of the accelerator. The activity of a target is a function of the isotopic half life and the target mass. For a quick evaluation of this number it is convenient to write the radioactive disintegration law in the form

$$A = 0.358/\tau \ [\mathrm{Ci}/\mu\mathrm{mol}].$$

Here, τ is the half life of the isotope in question, expressed in years, and A its activity, expressed in Ci/μmol. This unit tells directly the radioactivity of a kind of standard target containing 1 μmol of radioactive material. For a ^{239}Pu target, for instance, 1 μmol corresponds to 239 μg, which is a reasonable figure for a nuclear accelerator target. A graph of the relation is shown in fig. 1. For illustration, a number of relevant target isotopes have been marked explicitely.

Two up-to-date-stainless steel vacuum chambers, each enclosed in a glove box, will be available for thin film deposition. From our experience, diffusion pumps are still unique with respect to reliability. Consequently, the routine work will be performed in a classical, diffusion pumped system equipped for electron beam as well as for hot crucible evaporation. High speed pumps and a titanium sublimation booster will provide a working pressure of 10^{-5} Pa. The second chamber will be cryopumped and set up for ion beam sputtering at residual gas pressures of less than 10^{-6} Pa. High purity metal films and stoichiometric actinide oxide films are accessible by this technique [2], which, due to its low material consumption, is very appropriate for the processing of radioactive isotopes. Sputtering also provides an approach to prepare elemental ^{14}C-targets of so far unknown quality, replacing the very inconvenient CVD procedure described in [3], which results in brittle foils of limited thickness and size.

Each vacuum chamber will be enclosed in a glove box not only for reasons of radiation protection. Optionally, there will be the possibility to work in a purified argon atmosphere if

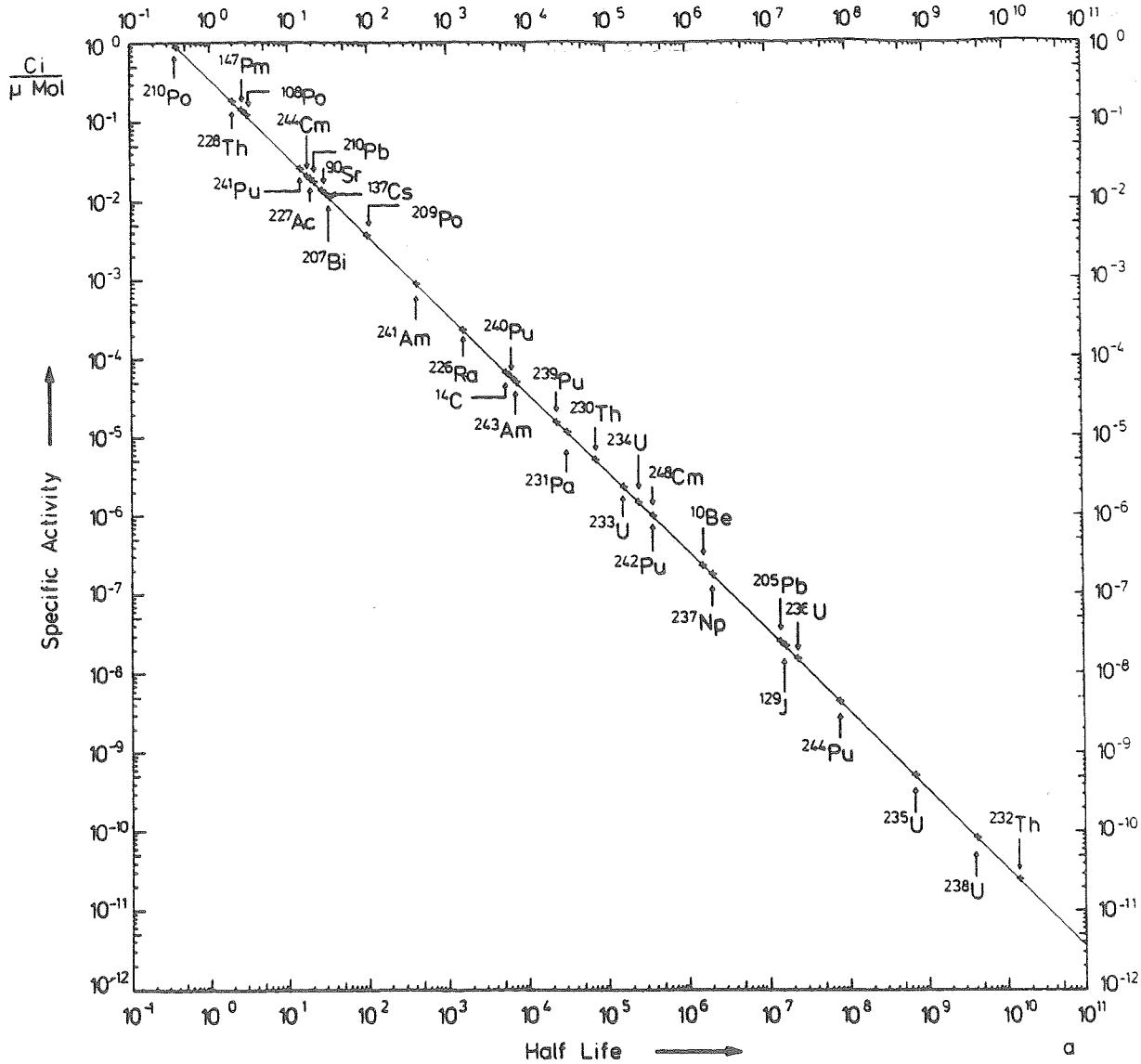

Fig. 1: Molar activity as a function of half life.

targets of reactive metals like uranium, plutonium or radium have to be handled. A third glove box will be equipped with a small rolling mill, a pellet press and a set of microbalances.

Elaborate interlock systems for the safe transfer of the radioactive targets from an individual glove box to the scattering chamber at the accelerator are under construction, too.

The facility is expected to be on service before July 1992.

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ACTIVITY AT NSC TARGET LABORATORY

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Centrifuge machine and heavy ion sputtering set up are quite useful for the preparation of target foils of expensive materials available in small quantities. Therefore it was decided to set up facilities for these two techniques.

Heavy ion sputtering unit has been assembled and tested. Saddle field ion source B11W is used as a source of positive ions to sputter the target material. The sputtered material is collected on glass slides on a close geometry. The source is mounted on a SS plate. The substrate holding arrangement as well as crucible for target material are also attached to the same plate with a tripod. A thickness monitor is mounted inside the belljar at about 45 degree to the ion beam direction facing the target material. Ni and Ag target were made as test cases. The ion current during the process was 100 μa with 7 keV energy and it took about 8 hrs. to get 63 $\mu g/cm^2$ Ni deposit on glass slides at a distance of about 50 mm from the source of sputtering.

Arrangements are made to make thick targets of thickness 1 mg/cm^2 or above on Mylar or any other backing using a centrifuge with 7 000 RPM. Mechanical fittings were made for centrifuge tube. Foils with thickness of few mg/cm^2 of ZrO_2 and Sb were made as test cases.

Report on Nuclear Target Activities at LANSCE

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The astrophysical neutron measurement group at LANSCE in Los Alamos National Laboratory has been making targets for neutron capture and (n,p) reactions for a number of years. A recent addition to the techniques used by the group has included the implemetation of a radioactive vacuum evaporator system. This technique was used to make targets for three different types of experiments on the same nucleus, 36Cl.

The evaporated material was Na36Cl, enriched in 36Cl at the 50% level, which was purchased as a solution from the Amersham Corporation. This solution was placed in an Al2O3 crucible and evaporated from a Tungsten basket. Both crucible and basket were purchased from the R. D. Mathis Company. The evaporation was done under a filtered hood in the radiation chemistry wing at LAMPF.

Two of these targets have been used in a (p,gamma) experiment at the California Institute of Technology. Two targets were produced for use in upcomming (n,p) reactions at LANSCE and one was produced for use at the 30 KeV Maxwellian source at Karlsruhe. The target instabilities characteristic of proton bombardment on NaCl proved to be a problem for the (p,gamma) measurement. The other targets will be used in the near future.

The targets contained either 5 or 10 microcuries of 36Cl on a spot of either 1 or 2.5 cm diameter. This is approximately the diameter of the opening of the crucibles. The evaporation was made with a mask in order to define the target size precisely. This was very important for the (n,p) measurements at LANSCE due to the solid angle of the Surface Barrier Detector used in these measurements.

All the targets seemed reasonably uniform, most important for the proton measurements, and were mechanically durable. They were all placed in Al and plexiglass containers for shipment. This shielding was sufficeint for the nucleus involved.

It is anticipated that radioactive evaporation techniques will become more important as our studies are extended to (n,gamma) measurements. Thus it is hoped that the apparatus will be used often in the future.

THE PREPARATION OF NUCLEAR TARGETS AT IMP

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ABSTRACT

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

The analysis of target film contamination by oil vapor and the equipment for preparing thin metal, self-supporting targets without oil contamination are also described.

1. Introduction

There are five high-vacuum evaporators in our laboratory. Two of them have been used for preparing carbon films and for evaporating material of lower melting point.

An electron bombardment apparatus and two focused heavy-ion beam sputterers have been used for preparing targets of high melting point materials. The laboratory also has a rolling mill for preparing various metallic, self-supporting films and an installation for preparing thin metal, self-supporting targets without oil vapor contamination. Examples of target preparation and investigation are as follows.

2.3 Focused Ion-beam Sputtering Method

A system shown in Fig. 2 similar to that described by Sletten [1] and Gu An Shouren[2] has been set up in the last year. In order to obtain better uniformity, our target support not only can rotate around the center of the crucible but also can move 1 cm up or down. This equipment was used in the preparation of many accelerator targets[3]. It is suitable for preparing targets of enriched stable isotopes with high melting points, such as W, Ta and Mo. Targets of tungsten have been deposited on 20 ug/cm^2 carbon backings. The working parameters are: arc current 2A, filament current 50A, filament diameter ϕ 1 mm, anode current ~ 1A, acceleration voltage -7.2 kV, Ar ion beam about 2 mA, beam spot ϕ 2 - ϕ 3 mm.

2.4 Electron Bombardment Method[4]

This is also a film preparation method(4) for high melting point material. Our setup is shown in Fig. 3. It is suitable for preparing films with a small amount of starting material. The thickness is about 100 ug/cm^2 - 400 ug/cm^2.

3. Electroplating

3.1 Electrolytic Reduction

In our laboratory, some enriched stable isotope targets have been prepared by this method, because most isotopes we have are small in amount and in the form of compounds.

The equipment for electroplating is shown in Fig. 4. The advantages of the method are a short cycle of preparation, ease of operation and high deposition efficiency. Targets were made of ^{63,65}Cu, $^{58, 60, 62, 64}$Ni, $^{118 - 124}$Sn, $^{107, 109}$Ag, ^{54}Cr, ^{64}Zn, and ^{54}Fe. Self-supporting targets were

obtained by dissolving the backing chemically or separating physically. The thickness range is 400 ug/cm^2 - 3mg/cm^2. The deposition efficiency can be up to 80 - 90%. Properties of the films are satisfactory.

3.2 Molecular Plating

For preparing targets of rare earth oxides or $UO_2(NO_3)_2$, we used the molecular plating method. The films can be prepared quantitatively. We used isopropyl alcohol solution. Many rare earth oxide targets have been made, such as Nd_2O_3, Sm_2O_3, Gd_2O_3, Dy_2O_3, Ho_2O_3, Yb_2O_3, Tm_2O_3, Lu_2O_3, and Tb_2O_3. Radioactive uranium targets on backings of thin aluminum have been made. The uniformity and adhesion are good; efficiency of deposition can be up to 99%. The thickness range is 100-300 ug/cm^2.

4. Rolling

This is also one of the basic methods in our lab. We bought a B85/120 rolling mill from West Germany in 1984. Stainless steel 0.5 mm thick or 1 mm thick teflon were used as packing plates. We have rolled self-supporting Ta, Mo, V, Nb, Ni, Au, Ag, Cu, Sn, Zn, Ta, Cd, Y, Al, Fe, and In foils and alloys of Au + Ag, Au + Cu, Au + Fe, Au + Sn, Au + Fe + Cu, and Au + Fe + Cu + Ag. The purity of the targets is high.

5. Centrifugal Precipitation

This method is used to prepare various powder-material targets on backings of aluminum. Advantages of the method are high yield, good uniformity and wide range in thickness. The equipment has been set up recently. Sm_2O_3 and Yb_2O_3 films on backings of thin aluminum were made. Collodion is used as an adherent agent. The thickness was from 50 μg/cm^2-

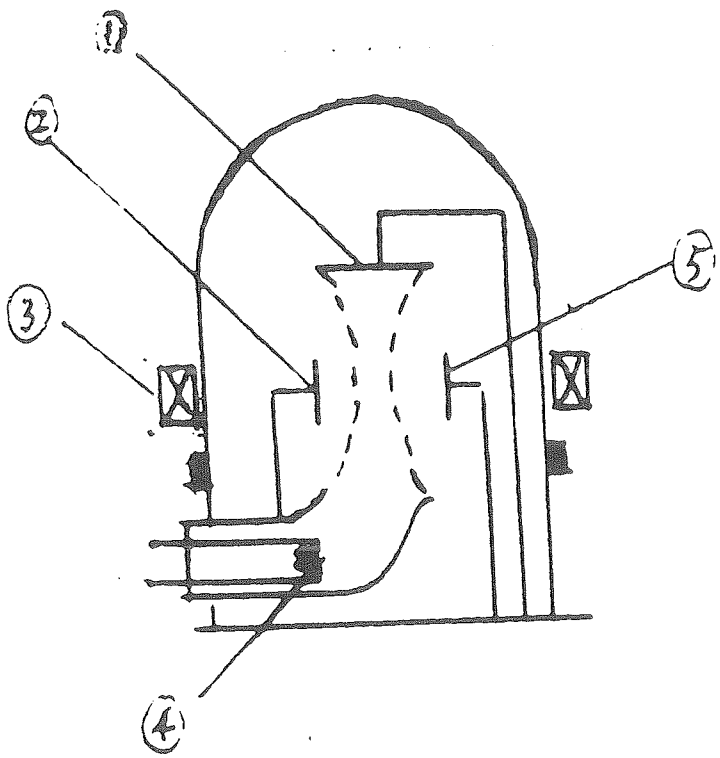
16mg /cm^2. The composition of films obtained was very good. Deposition yield is 86%.

6. Analysis

Analysis of target film contaminated by oil vapor and preparation of self-supporting thin metal target films without oil.

In $^{12}C + ^{27}Al$ and $^{12}C + ^{40}Ca$ nuclear reactions, it has been found that the carbon content was so high that the accuracy of nuclear-physics experimental data was affected. As shown in Fig. 5-7, we have improved the system in order to eliminate carbon contamination. It is very effective for eliminating contamination. Au, Cu, Sn and other metal self-supporting targets without oil contamination have been made. The analysis of carbon content has been made for targets with oil contamination and those prepared by the new system.

Using analytical instromentation from Italy, the results are as follows.



(1) Anode

(2) Substrate

(3) Magnetism focused

(4) Filament

(5) High voltage electrod

Fig.1. Plasma Spatting

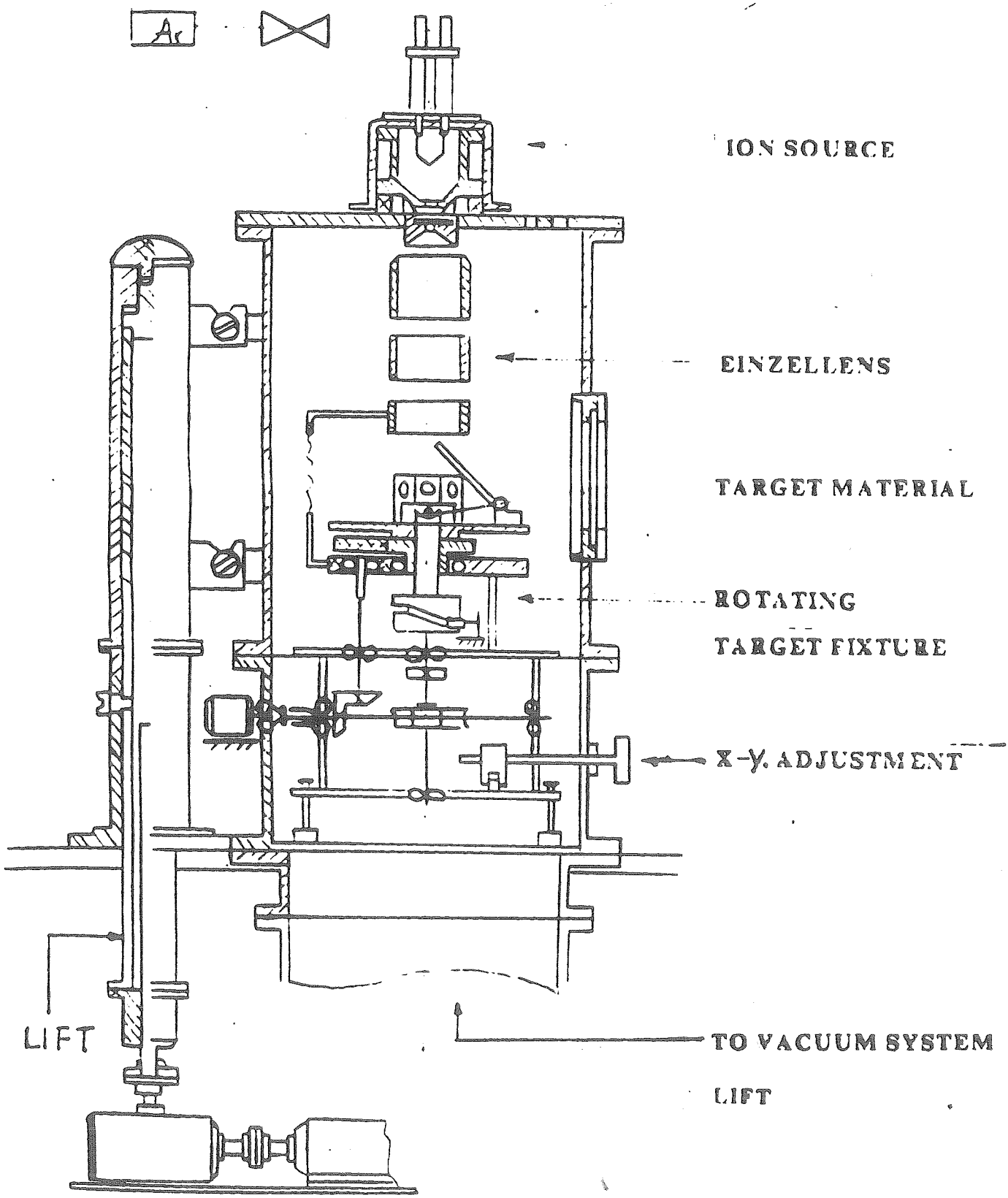


FIG. 2 FOCUSED ION BEAM SPUTTING EQUTPMENT

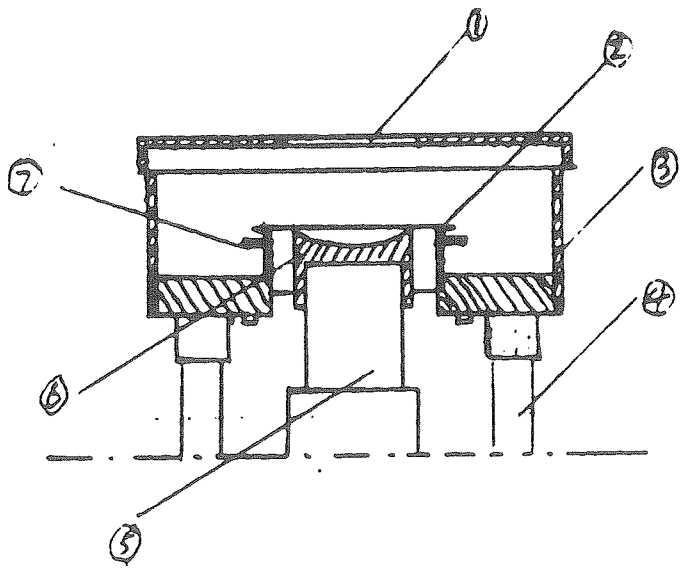
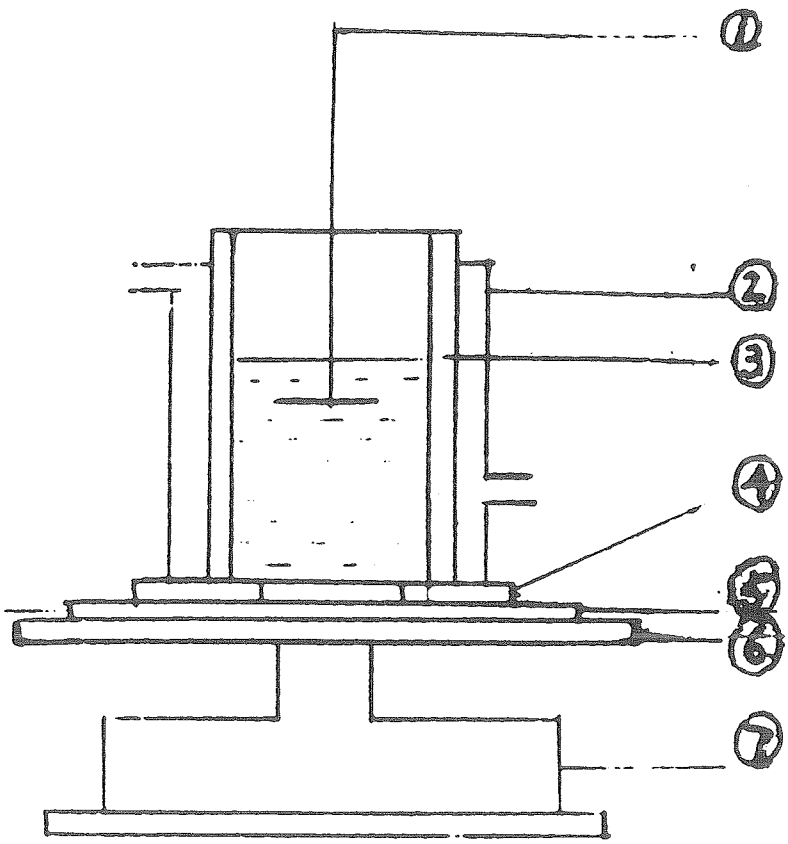


Fig.3. Electron bombardment cavity.

(1) First focused electrode
(2) Second focused electrod
(3) Shielded block
(4) Insulating ring
(5) Cooled water
(6) Crucible
(7) Filament



(1) Platinum plate
(2) Cooled water
(3) Plating cell
(4) O-ring seal
(5) Backing to be plated (cathode)
(6) Metal base
(7) Small electromoto

Fig.4 Electroplating cell

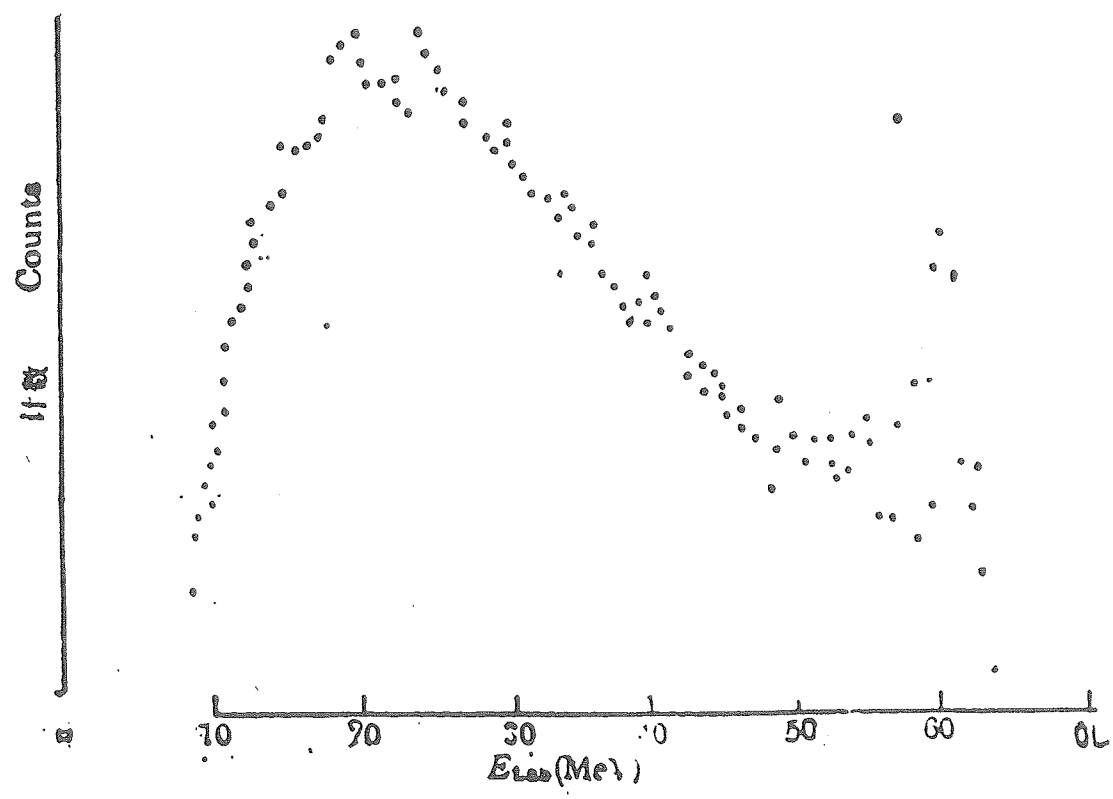


Fig.5 Energy spectrum of products from reaction $^{12}C+^{27}Al$ (with carbon contamination)

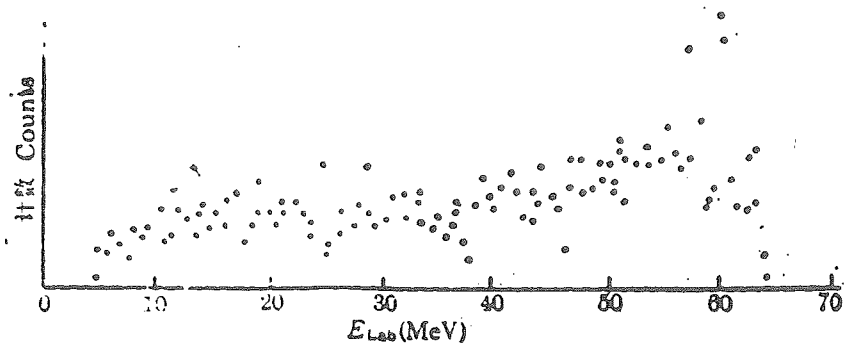


Fig.6 Energy spectrum of products from reaction $^{13}C+^{27}Al$ (without carbon contamination)

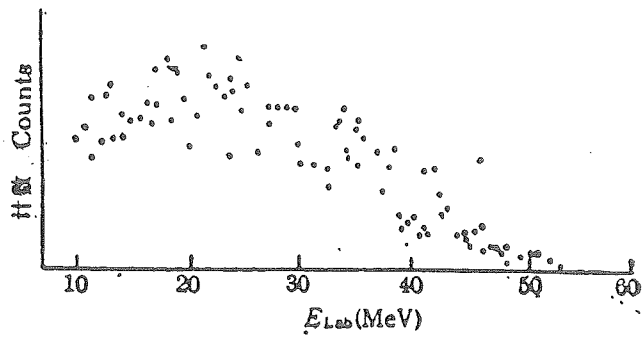


Fig.7 Energy spectrum of products from reaction $^{12}C+^{12}C$(carbon background)

Table 1 The Carbon content in films

Element	In material	In film with carbon contamination	In film without carbon contamination
Au	0.16	0.49	0.193
Sn	0.22	0.25	0.235
Cu	0.00	0.147	0.0

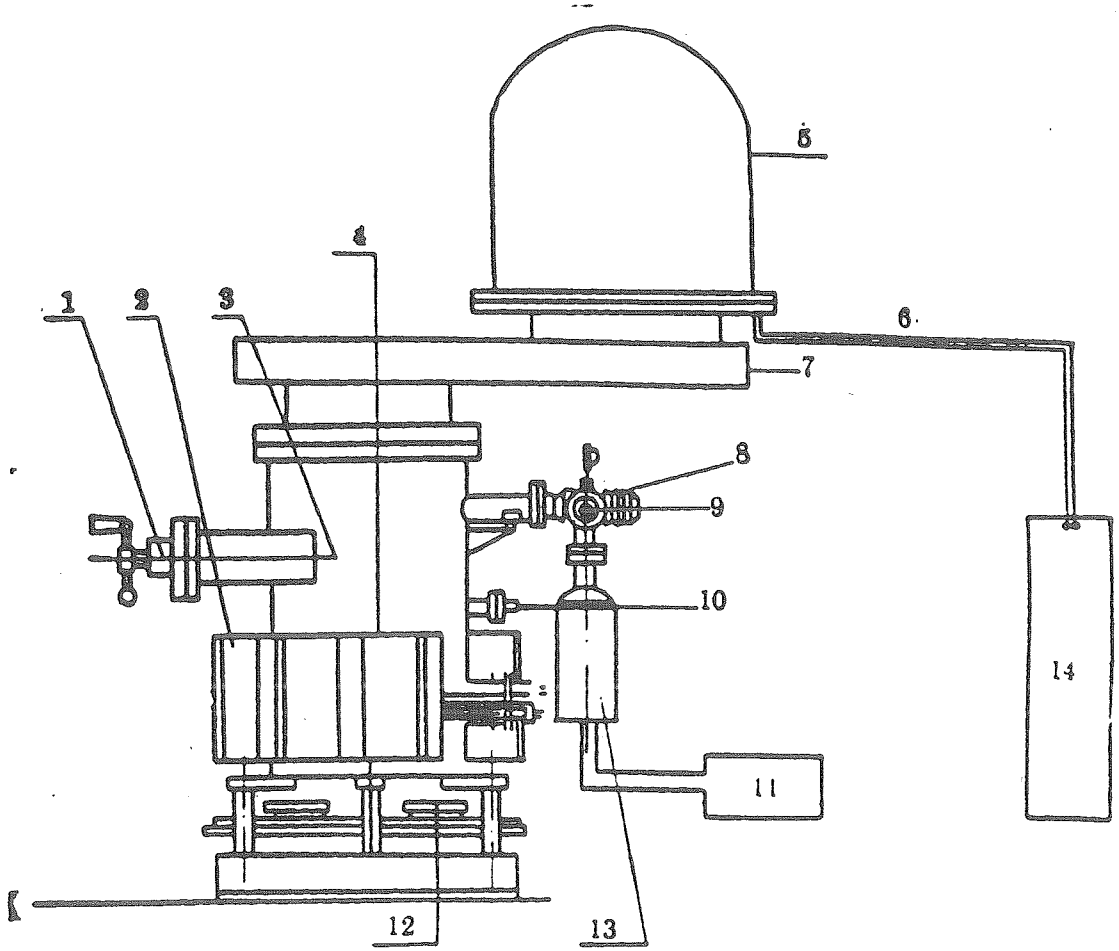


Fig.8 Schematic of equipment for preparing no oil film

1、8. Supervacuum valves (OF-200、CF-40) 2. Ion pump (JLP-400) 3. Main body of pump (350) 4. Sublimating pump (JJ-01) 5. Bell 6. Connective wire of electrode 7. Connecting pl Highvacuum valves 10. High voltage stretching wire 11. Mechanical pump 12. Baking oven Adsorption pump (SP-40) 14. Evaporating electrode of the vacuum coating unit

References

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