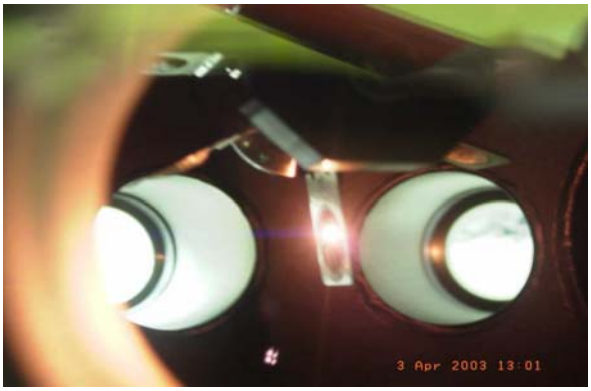
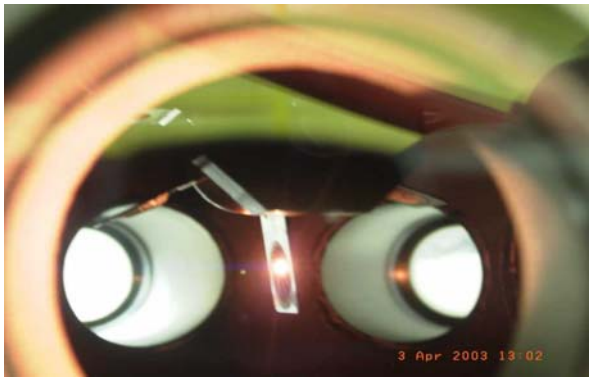
INTDS NEWSLETTER





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Cover

Photo coutesy of Dr. Vitaly Liechtenstein showing ultra-thin DLC foils under high irradiation for lifetime tests at the Heidelberg RFQ Linac.

EDITOR
John P. Greene
greene@anl.gov

DESIGN AND LAYOUT
Janelle Neubauer

SUBSCRIPTIONS
Bill Lozowski
lozowski@iucf.indiana.edu

ADVERTISING
John P. Greene
greene@anl.gov

Note from the Editor

Dear INTDS Newsletter Subscribers,

Welcome to the latest edition of the INTDS Newsletter. I apologize for the tardiness in publication. As you can see it is not for lack of suitable submissions. We missed the January issue and now, the July issue is woefully late in appearing. This is especially troubling in that it may be the only news some of our members receive about the Society's announcements. Advanced knowledge regarding the 23rd World Conference being held in Tsukuba, Japan as well as election of new Board Members has therefore not been disseminated through this vital conduit of our Society Membership. Also, there is some already dated information included in this issue and the Membership Listing at the back is not up-to-date which I hope to correct by next time. For this I beg your indulgence. I work alone without an assistant and under some new initiatives besides the standard target preparations. Realize - this is not an excuse to miss publication. I shall try to strive harder in the future to assure a timely issue.

Respectfully submitted,
John P. Greene
Newsletter Editor

NEWS OF THE INTDS

MINUTES OF THE 2005 INTDS BOARD MEETING

(Held electronically via email and Dated: 30 November 2005)

Dear INTDS Board Members,

We are required by our constitution and/or bylaws to have a Board Meeting every year. Customarily we hold this off-year meeting at the site of the upcoming conference to be held one year later. At the Membership during the Conference in Gaithersburg, the Society voted to hold the 23 World Conference in Japan. However, it is a bit more expensive and time consuming to travel to Japan for most of us. Therefore I am proposing that we make our 2005 Board Meeting a virtual meeting, to be held mostly by e-mail exchanges and conference-call-telephone discussion if needed. I propose that the date of the meeting be recorded as 30 November 2005, with all reports to be sent out to all Officers, Board Members, and leaders of the Local Organizing Committee.

Any additional reports and discussions desired by any Board Member or Officer should be sent to this entire mailing list. Discussion items may include Awards of Recognition, proposals for Karasek Memorial Fund awards, proposals for dealing with financial aid for attending the Conference in Tsukuba, and any other business.

Sincerely,
David Gilliam, President - INTDS

11th Workshop on Targetry and Target Chemistry
Robinson College, University of Cambridge
28th to 31st August 2006


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FULL REGISTRATION CLOSED 15th AUGUST 2006
WORKSHOP FACILITIES ONLY AVAILABLE.
ACCOMODATION MUST BE ARRANGED INDEPENDENTLY

Outline Programme
Additional Information
Registration Form (please print, fill out and fax back)

TECHNICAL CONTRIBUTIONS

Preparative technologies for three-layer-sandwich targets used by measuring g-factor of rotational levels

Fan Qiwen Xu Guoji

(China Institue of Atomic Energy, Department of Nuclear Physics, P.O.BOX 275-62, Beijing 102413, China)

1. Introduction

The g-factors of the positive parity rotation band states needed to be measured by a TMF-IMPAD (transient-magnetic-field ion implantation perturbed angular distribution) method in the HI-13 tandem accelerator nuclear physics national laboratory at China Institute of Atomic Energy. Therefore, three-layer-sandwich targets of ^{67,68,70}Ni-Fe-Au needed to be prepared; the thickness of the ^{67,68,70}Zn target layers was 200~400 ug/cm^2, the middle layers were thin ferromagnetic Fe foils of 1.15~1.52 mg/cm^2, and the recoil stopper layers were thick crystallized and defect-free Au layers of 3~4 mg/cm^2. The uniformity should be better than 92%.

2 The preparative technologies of the three-layer-sandwich targets

2.1. The preparation of thin ferromagnetic Fe middle layers by rolling-annealing

The thin ferromagnetic Fe middle layers of 1.15 ~1.52 mg/cm^2 needed to be prepared for the experiments measuring g-factor of rotational levels.

Prior investigations[2,3,4] have demonstrated that two methods can be used to fabricate ferromagnetic films: evaporation-condensation and rolling-annealing.

Fe foils of 1~2 mg/cm^2 thickness with good magnetic properties have been prepared by rolling-annealing. The process was the following: (1) the original thick iron foils were put in the stainless steel sandwich, and then were rolled toward the same direction of the roller; (2) Fe foils were annealed between two electrodes in vacuum chamber.

In the whole preparative process of Fe foils, annealing was very critical. The Fe annealing was carried out at about 950K by resistance heating of sandwich Ta between two electrodes, and the annealing process lasted for about 1h in a vacuum better than 10^{-4}Pa. The Fe foils were about 18mm long and 17mm wide.

According to P. Maier-Komor[2], the annealing temperature can't be too high, because the first crystal structure of iron will be transited at about 1180K and iron will be diffused into and adhere to the sandwich material above 1000K.

2.2 The preparation of Au recoil stopper layers by vacuum evaporation-condensation and annealing

The thick cubic-lattice Au recoil stopper layers of 3~4 mg/cm^2 needed to be fabricated for the experiments measuring g-factor of rotational levels.

Au recoil stopper layers have been prepared by resistance heating. The crucibles were made from Ta materials, the distance of source-to-substrate was 10cm.

In the preparative process of Au recoil stopper layers of 3~4 mg/cm^2, glow discharge was carried out to clean the iron substrates in order to ensure that there is no space between the three layers.

In order to get crystallized and defect-free Au recoil stopper layers, it was very critical to anneal the Au foils deposited by vacuum evaporation. The Au/Fe annealing were respectively carried out at about 600K by resistance heating of sandwich Ta between two electrodes, and the annealing process lasted for about 1h in a vacuum better than 10^{-4}Pa.

Many experiments have demonstrated that the temperature of Au/Fe annealing can't be too high, because iron will be diffused into and alloyed with the gold at about 800K.

2.3. The preparation of target layers

The ^{67,68,70}Zn target layers of 200~400 ug/cm^2 needed be prepared for the experiments measuring g-factor of rotational levels. The area of the targets was $\phi 9mm$, and the uniformity should be better than 92%.

As we all know, it is very difficult to fabricate homogenous ^{67,68,70}Zn target layers. Also, we should take the most economic methods to prepare them, because these isotopes are very expensive.

Prior investigations[5,6,7] have demonstrated how rotating the substrate during evaporation-condensation can improve target homogeneity while preserving a reasonable collection efficiency.

The schematic drawing of the rotating substrate setup is shown fig.1. Behrndt expresses the film thickness t at a distance s from the vertical axis of rotation by the equation[8]

$$t(s)=\frac{m}{\pi\rho}\frac{h^2(h^2+r^2+s^2)}{[(h^2+r^2+s^2)^2-4s^2r^2]^{3/2}} \qquad \textbf{(1)}$$

Where m is the mass of the evaporated material, ρ is the density of the evaporant, h is the source-to-substrate distance, and r is the horizontal distance between source center and substrate axis.

According to this formula, film thickness distributions have been calculated and plotted in fig.2.for experimentally relevant values of h =1.0cm and different values of r using Matlab. In order to obtain the target thickness units commonly used in nuclear physics, the eq.(1) needs to be rearranged

$$d(s)=1000\cdot t(s)\cdot\frac{\rho}{m}[\mu g\cdot cm^{-2}\cdot mg^{-1}] \qquad (2)$$

A differential collection efficiency for the individual target can be defined from the eq.(2)

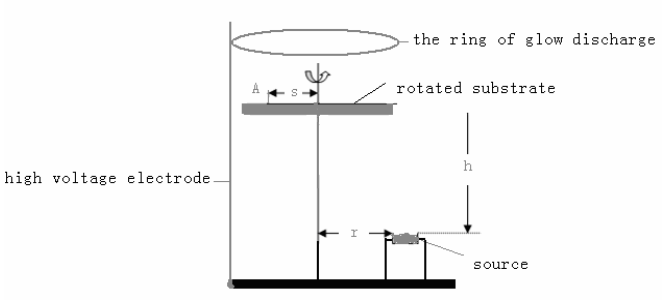

Fig.1.Schematic drawing of the rotating substrate set-up.

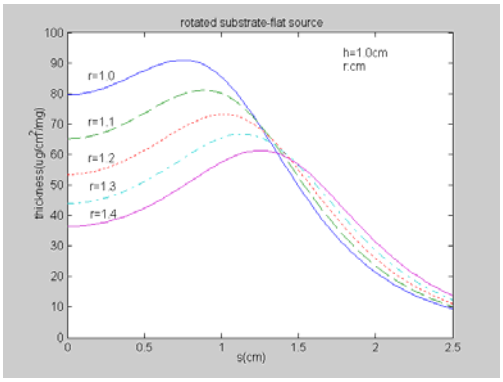

Fig.2. Theoretical film thickness distributions for a source-to-substrate distance h=1.0cm.

The inhomogeneity can be calculated by the following equation,

$$\eta = \frac{\sigma_p}{\bar{x}} \times 100\% \qquad (3)$$

Where η is the inhomogeneity of the target, $\bar{x}$ is the average value and σ_p is standard deviation

$$\sigma_p = \sqrt{\frac{\sum_{j=1}^{n}\left(x_j - \bar{x}\right)^2}{n(n-1)}} \qquad (4)$$

For a specific distance h, an optimum distance r between the source and the rotation axis can always be found which meets both the criteria of high collection efficiency and good target uniformity. This optimum depends on the spatial orientation of the desired target area on the rotating substrate, which is represented by the range of the parameter s.

In this experiment, the area of target layers was $\phi 9mm$, and the uniformity should be better than 92%. A substrate holder that was made from an aluminum disk axially mounted on the shaft of a small vacuum-qualified dc-motor. A substrate rotation speed of 25~30 rpm was used. The substrate holder had four apertures of $\phi 9mm$, the value of s was from 0.5cm to 1.4cm.

In order to find the optimum distance r, some theoretical values including the max, min, average, standard deviation and inhomogeneity have been calculated by Matlab for h=1.0cm and r=0.5cm~1.4cm. These value is shown in table.1.

Table.1.Some theoretical datum for h=1.0cm□s=0.5cm~1.4cm

	r	max	min	average	Standard deviation	inhomogeneity
	cm		$\mu g \cdot cm^{-2} \cdot mg^{-1}$			%
h=1.0cm s=0.5cm~ 1.4cm	1.0	90.95	57.4	81.95	9.69	11.82
	1.1	81.08	59.75	75.78	5.504	7.26
	1.2	73.17	61.09	68.98	3.911	5.67
	1.3	66.68	51.04	61.83	4.977	8.08
	1.4	61.27	42.39	54.63	6.312	11.55

According to fig.2 and table.1, considering some deviation of practical operation we should obviously choose the value of r=1.2cm .

In the process of evaporation-deposition, the following was very key and important: (1) we must use glow discharge to clean the Fe substrates, or it was very difficult to deposit the homogenous ^{67,68,70}Zn target layers on the iron substrates; (2)As ^{67,68,70}Zn materials have a low melting point and are sublimation material, a small crucible must be used, or homogeneous ^{67,68,70}Zn target layers can't be deposited due to excessive heating. Many experiments demonstrated that the evaporation current of about 25A was a safe value; (3) As ^{67,68,70}Zn materials have a low melting point and are sublimation material, it was necessary to use clean Al foils to cover the upper Fe foils so that the upper Fe foils were not polluted by ^{67,68,70}Zn vapor.

^{67,68,70}Zn target layers of 200~400 ug/cm^2 which meets both the criteria of high collection efficiency and good target uniformity have successfully been prepared using a rotated substrate under the condition of h=1.0cm and r=1.2cm. The average collection efficiency was 65.42ug/cm^2/mg. We can prepare the target layers using only 4~5mg of isotopic materials.

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The TASCA Project

Matthias Schädel[#] for the TASCA collaboration

Gesellschaft für Schwerionenforschung (GSI), Planckstr. 1, D-64291 Darmstadt

The **T**rans**A**ctinide **S**eparator and **C**hemical **A**pparatus, **TASCA**, [1] is a project which was discussed in the heavy element community over several years and at several workshops, see e.g. [2]. The main goal of TASCA is to build a physical recoil separator

- with **maximized transmission (efficiency)**
- for the production and separation of **transactinides** (TAN, $Z \geq 104$) or **superheavy elements** (SHE)
- from **hot fusion reations**[$] with **high intense ion-beams**
- and **actinide targets**
- for **chemical investigations of transactinides**, and
- for **nuclear structure** and **nuclear reaction** studies of **most neutron-rich nuclides**.

The official start to built TASCA at GSI's UNILAC accelerator came early in 2005. While novel chemical investigations of transactinide elements [3] - after preseparation with a physical recoil separator - is one of the main goals, a rich nuclear structure investigation program is foreseen complemented by typical hot-fusion nuclear reaction studies. As the central device for all these research programs we opted for a gas-filled recoil separator [1,4] making at least partially use of existing components from the former NASE separator [5].

As a typical reaction for design studies we took 5-6 MeV/u ^{48}Ca on a 0.5mg/cm^2 actinide target (^{238}U, ^{244}Pu). To find the best configuration and to optimize all components, simulations were performed [4] for various combinations to couple one dipole (D) magnet and up to three quadrupole (Q) magnets; e.g. DQ_hQ_v, DQ_vQ_h, or $Q_vDQ_hQ_v$ structure were investigated (index h and v denotes focusing in horizontal and in vertical plane, respectively). The DQQ configuration, which was selected as the best choice [2,4], allows operation in two possible modes. Figure 1 shows the dipole and the two quadrupole magnets in their final position at the X8 beam line.

While the DQ_hQ_v mode gives the highest possible transmission the smallest image size results from the DQ_vQ_h mode. New ducts were designed and built for the dipole and the quadrupoles to maximize the transmission in both modes. Model calculations [4,6] for the Ca on U reaction indicate that a transmission of about 45% or even higher can be expected for element 112 in the DQ_hQ_v configuration. This would yield a slightly higher transmission as compared with the gas-filled recoil separators at the Flerov Laboratory, Dubna (DGFRS)[7] or at RIKEN, Wako, (GARIS) [8] and somewhat less than the value obtained with the BGS [9] at the LBNL, Berkeley.

[#] e-mail: m.schaedel@gsi.de

[$] Hot fusion = fusion reactions of a light or medium heavy projectile, say between ^{12}C and ^{48}Ca, with an actinide target leading to an excited compound nucleus which typically emits 3 to 5 neutrons before reaching its ground state.

Fig. 1: View (from right to left, beam direction) of the end of the X8 beam line, the dipole the two quadrupole magnets (red), and the two detector chambers.

In the DQ_vQ_h mode a reduced horizontal acceptance presumably yields only about 30% transmission. However, an extraordinarily small image area of less than 10 cm^2 should be achievable - a key issue to build small recoil transfer chambers (RTC) for a fast transport of superheavy elements into any chemistry set-up. The RTC will be attached to the end of the detector chamber and any focal plane detector will be retracted during the chemistry experiments.

All magnets, including ducts and water cooling, are now installed in the newly built cave at the UNILAC beam line X8. Magnets are connected to power supplies and are successfully tested. Commissioning of the main components of the TASCA separator will begin during the first half of 2006.

Maximizing the production rate of transactinides or superheavy elements is always the crucial first step for a successful investigation of chemical or nuclear properties of these elements beyond atomic number 104. To make use of highest available beam intensities, a windowless operation is planned. To this end a differential pumping section was installed and was successfully tested [10]. Simultaneously and very actively, developments began[11] to have actinide targets on suitable backing available which can stand high intense beams. A new, segmented target chamber was designed and was built, see central part of Figure 2, which accommodates (i) the rotating actinide target wheel ARTESIA [3] in an easily removable cassette, (ii) a newly built drive, (iii) collimators, (iv) beam diagnostic components, and (v) the first differential pumping section with a Roots pump (not visible in Fig. 2).

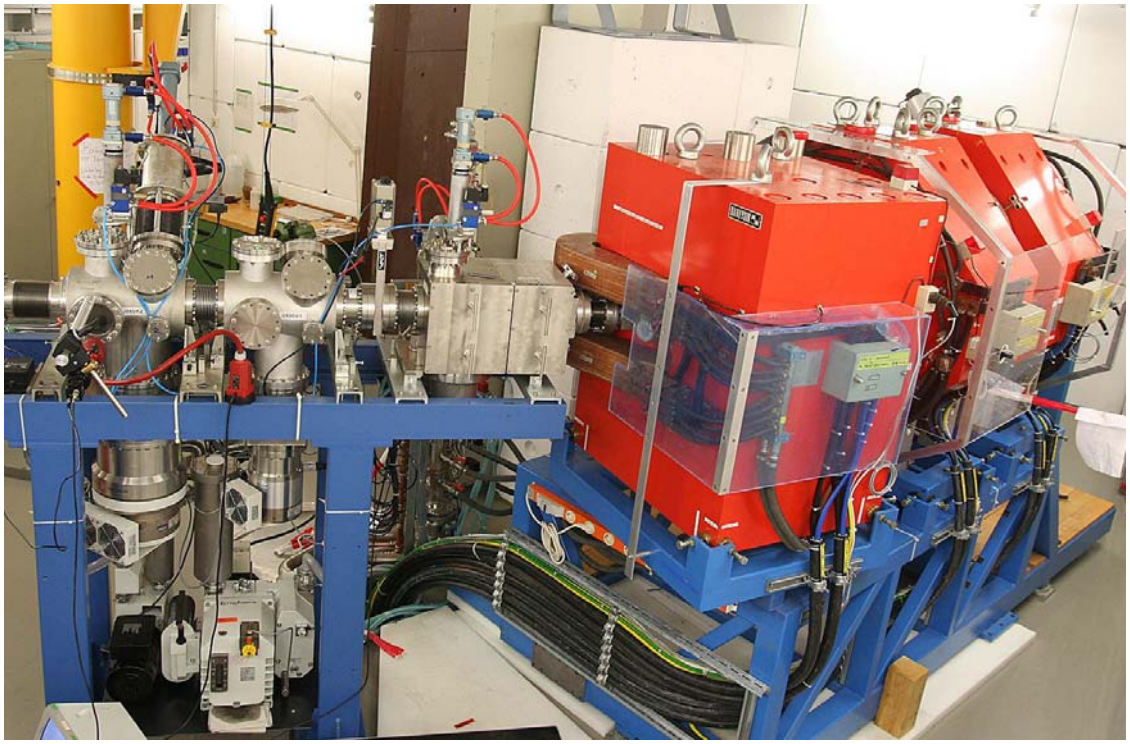

Fig. 2: View (from left to right, beam direction) of two diagnosis chambers, the target chamber (center) and the TASCA magnets.

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TASCA Target Group Status Report

K. Eberhardt, J. V. Kratz, D. Liebe, P. Thörle, Johannes Gutenberg-Universität, Mainz (UMZ)
H.-J. Maier, J. Szerypo, Sektion Physik, Ludwigs-Maximilians-Universität München, (LMU)
W. Brüchle, Ch. Düllmann, W. Hartmann, A. Hübner, E. Jäger, B. Kindler, B. Lommel,
M. Schädel, B. Schausten, E. Schimpf, A.Semchenkov, J. Steiner, GSI, Darmstadt, Germany
A. Türler, A. Yakushev, Institut für Radiochemie, Technische Universität München (TUM)
K. E. Gregorich, R. Sudowe, Lawrence Berkeley National Laboratory, Berkeley (LBNL)

The **T**rans-**A**ctinide **S**eparator and **C**hemistry **A**pparatus **TASCA** is currently installed at cave X8 and is dedicated to investigate the chemical and physical properties of the heaviest elements. An overview of the current status is given in a separate report [1].

For the production of Rf and Db isotopes, cold fusion reactions can be applied using Ti-beams with Pb- or Bi targets, respectively. Low melting metals can be substituted by compounds for application in high intensity beams [2]. However, to produce longer-lived isotopes of neutron-rich heavier actinides and transactinides hot fusion reactions with actinide targets are required. Here, possible target materials range from Th up to Cm or heavier elements.

We combined the different methods and capabilities of the four target laboratories involved to solve the challenging task of developing appropriate backings and targets. For first tests, we kept the geometry of the existing target wheel of the nuclear chemistry experiments at GSI unchanged. As we plan to install thinner backings for TASCA – so far 15 to 20 µm thick Be foils were used - it is necessary to fix the backing on an adequate frame, as can be seen in Figure 1.

Figure 1: ^{238}U-target (265 µg/cm^2) produced by molecular plating of uranyl- nitrate from isobutanolic solution.

Al backings and Ti backings, supplied from different companies with different qualities, were produced by cold rolling. C backings were produced by resistance heating and applied without annealing. After two test beam times with ^{12}C beam (500 pnA) and ^{40}Ar beam (800 pnA), we now focus on 3 µm Ti or 35 µg/cm² annealed C, alternatively, which will be tested with thermally evaporated UF_4, a target material in the near future.

As the target laboratory at GSI is specialised in evaporation, sputtering, and rolling of stable elements up to natural uranium, the foils discussed above were prepared there. The other three laboratories have the expertise of handling highly radioactive materials including the chemical purification of target material and the recovery of rare target material from used targets. After the decision for the appropriate backing has been made, backing foils will be given to the target laboratory at the LMU, where radioactive targets (Ra, Ac, Th, U, Pu, Cm) can be prepared by microevaporation. The group at the TUM offers the analytical capabilities to measure concentrations of actinide elements in solution (also Pu, Cm). For the nuclear chemistry experiments at GSI the radioactive actinide targets are prepared by electrochemical deposition at UMZ.

The search for optimal conditions for the electrochemical deposition of U (as uranylnitrate) from organic solution by molecular plating on thin Al- and Ti-backing foils is currently going on at LBNL and UMZ [3]. Figure 1 shows

a picture of a 265 μg/cm^2 ^{238}U-layer produced by molecular plating on a 25 μm thick Al-backing [3]. Target performance - when exposed to an ion beam - has not been tested yet. At UMZ a new electrochemical cell for improved deposition yield and uniformity of the target layer is under construction based on the design and the experience obtained at RIKEN [4]. Furthermore, optical microscopy, electron microscopy, and energy dispersive x-ray analysis are used for monitoring target thickness, chemical purity and homogeneity of the target surface. UMZ is testing a commercially available autoradiographic imager (Packard Instant Imager).

A new target station for TASCA is currently developed at GSI. This device is designed so that it can be used with the existing rotating actinide target wheel from GSI and with the new rotating target wheel system that is presently under development at LBNL for the Berkeley Gas-filled Separator (BGS), as well.

All contributions to the TASCA Working Group meetings and Workshops are accessible via www-w2k.gsi.de/tasca.

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