INTDS NEWSLETTER

The Masters Series

International Nuclear Target Development Society

George Thomas
1921-2006

July 2007
Volume 34
Number 1

Contents

www.intds.org

Cover Photo

Photo courtesy of John Greene showing George Thomas in the Target Lab at Argonne National Laboratory.

EDITOR
John P. Greene
greene@anl.gov

DESIGN AND LAYOUT
Alanna Pawlak

SUBSCRIPTIONS
Bill Lozowski
lozowski@iucf.indiana.edu

ADVERTISING
John P. Greene
greene@anl.gov

Note from the Editor

To the INTDS Membership,

With this issue we are reviving publication of the INTDS Newsletter after an unfortunate absence of a few years. The workload demands in the target lab shifted the timely publishing of our Society Newsletter to a lower priority. My sincere apologies to you, the membership, for my tardiness regarding this responsibility as editor. A recent acquisition of a student assistant has enabled us to once again bring to publication our society's periodical.

So, we begin by having a backlog of approved minutes to present as well as a couple of Technical Contributions for inclusion. Also, sitting on my desk for a while now were the news of the passing of G. Thomas, I. Feigenbaum and H. Wirth. I have made the editorial decision to include announcements about each of these distinguished members as cover stories under the heading of "The Master Series" for this group of Newsletters – Volume 34 Nos. 1-3. I further ask your indulgence to allow me to date these issues as 2007, 2008 and 2009 as they will then reflect those past Minutes and article submissions had it been published on time.

With this assembled material, including noteworthy informative articles regarding the INTDS, we were then able to print and disburse it quickly to the membership in a manner which now brings us up-to-date. I can assure you that moving forward we will try and redouble our efforts to maintain the yearly distribution of the INTDS Newsletter. I look forward to your continued support and feedback.

John P. Greene
Editor

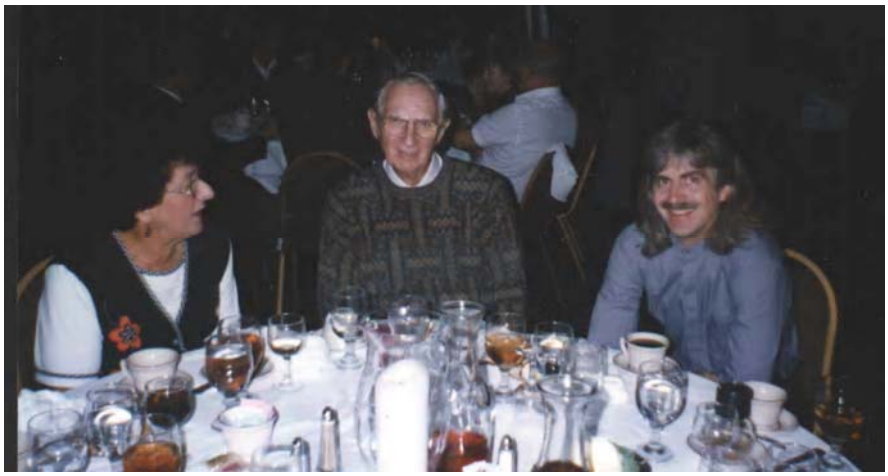
The Masters Series

George Thomas

In Memory of George E. Thomas Jr.

George was born July 18, 1921 in Bloomington, IL to George E. (Sr.) and Eva O'Neal Thomas. He married Elaine Bohlander on July 30, 1944 in El Paso, IL. Elaine passed away on April 23, 2004.

George graduated from Illinois Weslyan University and was employed in the Physics Division of Argonne National Laboratory for 40 years. He was a contributing Member of the International Nuclear Target Development Society throughout his life, receiving a Award of Recognition from the Society in 1984. After his retirement from Argonne in 1983 George farmed in the El Paso area. He was a member of the Woodford County Farm Bureau and the El Paso Kiwanis. Along with his family, George enjoyed raising and showing Morgan horses.



George, to me was many things; the utmost being a good friend. Of course I first knew George through our working together at Argonne; he was, in fact, already retired! He was always held in the highest esteem for his abilities, not only by me but also his co-workers and colleagues throughout the world. Whatever his chosen endeavor, he did it well! As my mentor, he imparted his methodical approach to sometimes intractable problems to me with great care. His knowledge of the field, having been one of its early practitioners seemed, at times, boundless! In this he shall be truly missed. I always looked forward to his visits to the lab. As a dear personal friend he will be impossible to replace. His genuine concern for my well being and especially my children struck me as deeply heartfelt. His gentle manner, never raising his voice, and his homespun philosophy were the things I find I cherished most. Above all he always believed in me, both in my personal life as well as in my professional development. I am glad to have had the chance to acknowledge this support and to have thanked him for it. Although a truly humble man, he took immense pride in what he began and what I have gone on to accomplish in the target lab with his help and guidance. He was a wonderful human being.

John P. Greene
Saturday, March 25th 2006

MINUTES OF THE 2006 INTDS BOARD MEETING

(Held electronically via email and Dated: 15 October 2006)

Opening Remarks and Introductions – I. Sugai
D. Gilliam starts the meeting – 10:00 AM

ATENDEES: Gilliam, Irie, Stoner, Yoshida, Eberhardt, Saettel, Sugai, Lozowski, Grossman, Stolarz, Greene

1. D. Gilliam announces a few minor changes to the agenda that was distributed previous to the meeting via email.

2. Approval of the minutes of the 2005 INTDS Board Meeting held electronically 30-NOV-05 with copies distributed by J. Greene. Unanimously APPROVED.

   There was some minor discussion regarding the workings and handling of the electronic meeting format.

3. INTDS Financial and Membership Status Report by W. Lozowski.

MINUTES OF THE 2006 INTDS MEMBERSHIP MEETING

(Held in Tsukuba, Japan and Dated: 20 October 2006)

The agenda was displayed – Greene

The meeting was opened by Gilliam at 12:00 PM

Saettel distributed ballots for those yet to vote.
There were TWO nominations from the floor; Stolz and Sugai.

Minutes from the Board Meeting were read by Greene – APPROVED.
(Lozowski gave Membership Report & Treasurers Report)

Conference Presentations;
by Sugai/Yoshida to the Conference Secretaries and Computer support persons.

Manuscript Deadlines:
25-DEC-06 ALL papers to Sugai
12-FEB-07 ALL papers to NIM

Gilliam spoke about distribution of the 2004 Proceedings by post.
Second authors may receive copies.

Distribution of papers for review: Stolarz/Yoshida
CD plus listing of ALL papers to reviewers.

Location of 2008 INTDS Conference – Greene/Chauvin

Election Results: Lommel, Stolarz, Zeisler

Concluding Remarks by Sugai

Meeting closed by Gilliam

THE FRANK KARASEK MEMORIAL SCHOLARSHIP

John P. Greene
Argonne National Laboratory
(submitted 3 August 2010)

The Frank Karasek Memorial Scholarship Fund was established by the International Nuclear Target Development Society (INTDS) in 1996 in recognition of Frank's enormous contributions to the production of thin metal foils by the method of rolling. This fund is designated for the support (travel or conference fee subsidy) of young researchers engaged in target foil rolling.

Frank's prodigious work is well known throughout the world, even to this day [1, 2]. The large rolling mills he used at Argonne National Laboratory are still in use in the Material Science Division. After his passing, much of his Microfoils Company equipment was acquired by Trace Sciences International in Canada.

Photograph of the Frank Karasek rolling mill at Trace Sciences International.

As stated, the disbursement of these funds was to further the art of rolling foil targets by instructing young investigators who might not otherwise have the opportunity to experience the techniques employed. The scholarships are awarded to researchers from other laboratories involved in target making for nuclear physics research [see 3, 4]. This support to young researchers engaged in foil rolling for target preparation should be continued and encouraged wherever and whenever possible.

[1] Frank J. Karasek, Proc. Of the Seminar on the Preparation and Standardisation of Isotopic Targets and Foils, Harwell, England, **AERE-R** 5097 (1965) p.111
[2] F. J. Karasek, Nucl. Instr. and Meth. **102** (1972) 457-458
[3] John P. Greene, George E. Thomas and Massimo Loriggiola, INTDS Newsletter **Vol. 27, No. 1** (2000) p.3
[4] John P. Greene and Janette Campbell, INTDS Newsletter **Vol. 31, No. 2** (2004) p.9

Technical Contributions

DEVELOPMENT OF THE CHARGE PARTICLE DETECTOR BASED ON CVD - DIAMOND

S. V. Akulinichev, V. S. Klenov, L. V. Kravchuk, S. G. Lebedev, A. V. Feschenko, V. E. Yants
Institute for Nuclear Research of the Russian Academy of Sciences, 60-th October Anniversary Prospect, 7A, Moscow, 117312
E-mail: lebedev@inr.ru

(submitted 14 January 2006)

High radiation hardness, chemical resistance, high temperature operation capabilities stimulate a growing interest to use diamond materials as detectors of ionizing radiation. Samples of CVD-diamond materials in sizes 4x3 mm and 4×1 mm with thickness from 50 microns up to 500 microns have been grown in INR RAS using a DC glow discharge in a mixture of gases CH4/H2 on molybdenum substrates.

PACS: 29.40.Wk; 81.05.T

1. INTRODUCTION

A number of unique properties of diamond such as extremely high radiation hardness, chemical resistance against all chemicals, absolute non-toxicity call for an increasing interest to use diamond materials as detectors of ionizing radiation operating in hostile environments or in conditions imposing special requirements to stability of measurement of a dose, for example in medical installations for radiotherapy. Moreover, the atomic number of diamond Z = 6 that is close to the effective atomic number of a soft tissue Z = 7.4, so the diamond is a nearly tissue equivalent, that allows to avoid energy dependent corrections of the detector signal. Initially, natural diamonds with suitable electronic properties were used in radiation detection [1]. The main disadvantage of the natural diamond detectors is a high cost due to extremely rare detector-grade natural diamond (Type IIa), which limits the availability of these detectors and moreover, electronic properties of diamond stones within the Type IIa category can vary strongly. Therefore, the production of sufficiently cheap diamond plates with sizes at least 4 mm and thickness 50 – 500 μm with sufficient quality to build a detector is rather an urgent problem.

The promising technology for synthesis of diamond materials is the Chemical Vapour Deposition (CVD) technology, which can grow diamond material plates in controllable vacuum with specified thickness and sizes, which are determined by substrate size and duration of the process. However, the CVD-diamond has a polycrystalline structure with crystallites sizes about 10-20 % of the thickness of the grown plates. Also, crystallites bounderies could act as the traps and decrease the charge collection efficiency [2,3].

2. APPARATUS FOR CVD-DIAMOND PLATES SYNTHESIS

We have developed a CVD apparatus based on DC glow discharge for manufacture of cost effective CVD-diamond plates. This apparatus is schematically shown in Fig.1. In the reaction chamber, glow discharge is sustained in a mixture of gases CH_4 and H_2 between a molybdenum cathode 25 mm diameter and molybdenum anode 11 mm diameter. The cathode is mounted on the copper water-cooled holder. The front surface of the anode is polished and segmented by grooves 0.5 mm in depth into sites 4×1 mm^2 or 4×3 mm^2, which simultaneously are the substrates for growth of diamond plates. The conditions of synthesis (gas pressure, power density in the discharge) are fitted in such a manner, that the growth of diamond takes place only on the surface of the substrates.

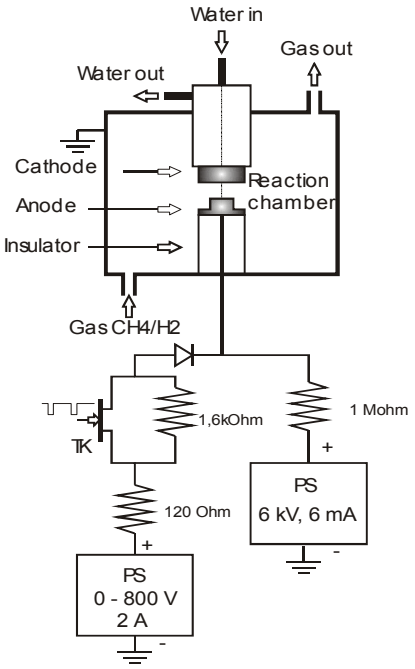


Fig.1. Scheme of CVD-diamond plates synthesis

It is well known that glow discharge with a current close to a critical one has a considerable probability to transform into an arc discharge with drastic contraction of a discharge channel, which could result in damages in growing material. To decrease the probability of these transitions, similarly to [4], the pulse operating mode of the discharge is used. The duration of pulses and pauses of the discharge current is set by a transistor modulator TK. The resistor connected in parallel to TK is important as it provides decreasing of the current in the pause not to zero, but to a magnitude ~$0.15I_{nom}$, which facilitates the subsequent transition to the rated current and raises stability of operation. Furthermore, the transistor modulator TK provides fast (~ 10 μs) switching-off of the discharge current source in case the discharge starts to transform into an arc mode and the current exceeds a preset value. The additional power supply with a constant voltage of 6 kV is connected to the discharge gap in series with 1 MOhm resistor for providing a discharge ignition in case of accidental extinction.

Synthesis of CVD-diamond plates was carried out under the following conditions in the reaction chamber: typical gas mixture – 2.5%CH_4 in H_2, gas pressure 300 Torr, discharge voltage 540 V, discharge current 1.7 A, current duty factor 95%.

Oscillogram of discharge current is shown in Fig.2. Material growth rate for these conditions was around 12 -15 μm/hour.

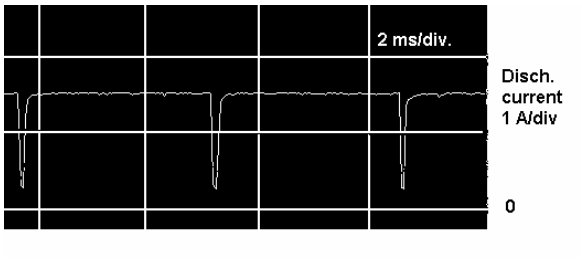


Fig.2. Oscillogram of the discharge current

3. CHARACTERIZATION OF THE GROWN MATERIAL

In deposition runs lasting from 3 to 35 hours, CVD-diamond plates with the sizes 4×1 mm^2 and 4×3 mm^2 and the thickness from 50 to 500 μm have been grown. After deposition and cooling down the CVD-diamond plates can be easily detached from the substrates due to different thermal expansion of diamond and molybdenum. The grown material has a polycrystalline structure with, clearly visible in the cracked samples, crystallites of columnar shape elongated along the growth direction. The facets of about 0.1 - 0.2 plate thickness can be observed on the crystallites at the growth side of the plate. Fig.3 shows the image of the growth side of the plate with thickness 100 μm (scanning electron microscope). Fig.4 shows the spectra of Raman scattering analysis, which was performed with an argon laser of wavelength λ =514 nm. The narrow diamond peak at 1333 cm^{-1} is clearly visible.

X-ray diffraction analysis of the plates was made with the DRON-3 diffractometer using the CuKα1 line with λ = 0.154057 nm. Fig.5 shows a XRD pattern measured at the growth side of a 500 μm plate.

4. CVD-DIAMOND DETECTION PERFORMANCE

The surface morphology of plates from a growth side and from a substrate side is essentially different. Whereas on the growth side the typical sizes of crystallites make up tens of micron, on the substrate

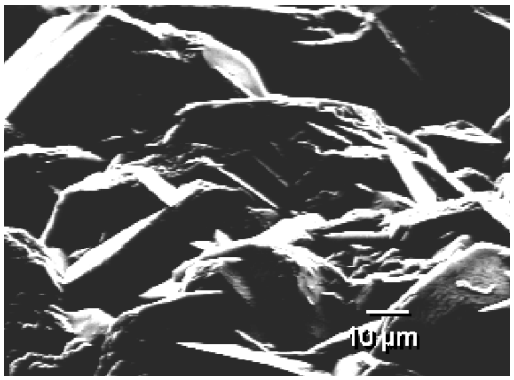


Fig.3. Scanning electron microscope (SEM) image of growth side 100 μm thickness plate

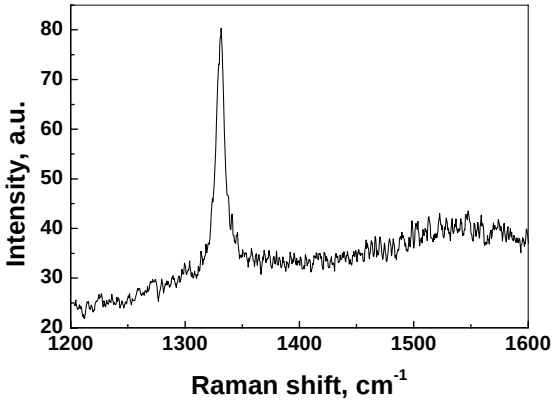


Fig.4. Raman spectra at growth surface of CVD diamond plate

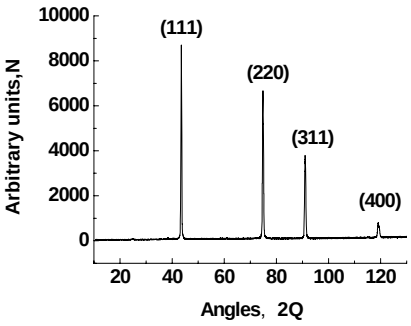


Fig.5. XRD pattern for 500 μm plate

side these sizes do not exceed a micron. The numerous defects on crystallites borders can serve as traps for the charges induced in the detector by ionizing particles.

In order to decrease the influence of these traps, the coplanar type detecting device [5] was made with both electrodes located on the growth side of the plate. The distance between the electrodes makes up 200 micron. For measurement of efficiency of collection of the charges induced by incident alpha-particles, the installation schematically represented by Fig.6 has been assembled.

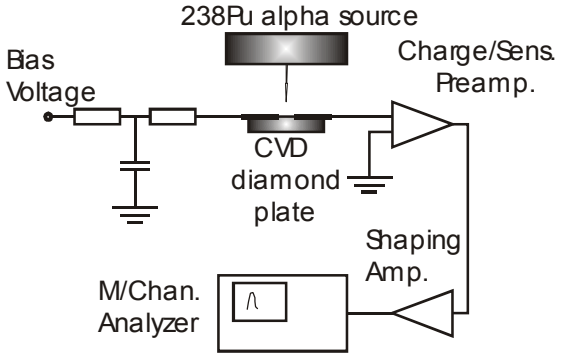


Fig.6. A schematic diagram of the charge collection efficiency measurement.

We used a ^{238}Pu α-particles source which emits α-particles with the energy Eα = 5.5 MeV.
The estimated range of these particles in diamond is ~ 13 μm. The total charge Q_{ind}, induced by an α-particle in diamond $Q_{ind} = eE_\alpha/\varepsilon$, where ε = 13 eV is the energy of electron-hole creation in diamond. The charge is collected by the non-uniform inter-electrode field of the bias voltage feed at the entrance of the charge sensitive preamplifier followed by a shaping amplifier (Schlumberger Type 7129) and multichannel analyzer (Norland 5300). Pulse height spectra were measured as differences of counts with and without the α-source for subtraction of the electronic noise of the system. Pulse height spectra for a bias voltage of 40 V is shown in Fig.7. The charge collection efficiency was estimated as a ratio of collected and induced charges and comes to around 1%.

5. CONCLUSION

Our measurements have demonstrated that relatively cheap CVD diamond, produced by glow discharge, is suitable for the detection of charged particles. The next tack which will be studied is the stability of such diamond detectors against neutron and particle irradiation which can be done at the RADEX facility [6-9] of INR RAS. Further investigations of radiation hardness and stability should be made in the radiological center of INR RAS on the beams of 200 MeV protons and 6 MeV photons. It is believed, that CVD diamond based charge particle detectors will continue the sucsessful sequence of particle detectors developed up to today in INR RAS [10-13].

ACKNOWLEDGEMENTS

Special thanks are given to I.I. Vlasov (GPI RAS) for performing of Raman analysis and V. Vlasenko (CryoLab, MSU) for SEM images.

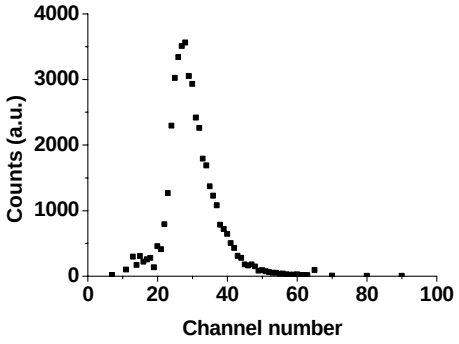


Fig.7. Pulse height spectra for bias voltage 40 V

REFERENCES

1. S.F. Kozlov, E.A. Konorova, Y.A. Kuznetsov et al., IEEE Trans. Nucl. Sci. NS-24 (1977) 235.
2. C. Bauer, I. Baumann, C. Colledani, e.a., Recent results from RD-42 Diamond Detector Collaboration, Nucl. Instr. and Methods in Phys. Res., A, 1996, v. 383, p. 64-74.
3. T. Bacci, E. Borchi, M. Bruzzi, e.a., Synthesis of low leakage current chemical vapour deposition (CVD) diamond for particle detection, Nucl. Physics B (Proc. Suppl.), 1998, v. 61B, p. 303-310.
4. S. Sciortino, S. Lagomarsino, F. Pieralli, e.a., Polycrystalline diamond synthesis by means of high power pulsed plasma glow discharge CVD, Diamond and Rel. Materials, 2002, v.11, p. 573-578.
5. A. Galbiati, M.B.H. Breese, A.P. Knights, e.a., Characterisation of a coplanar CVD diamond radiation detector, Nucl. Instr. and Methods in Phys. Res., 2001, A466, p.52-57.
6. S.V.Akulinichev, S.G.Lebedev, G.N.Vyalov, et al. Present Status andFuture Prospects of the Work on the Moscow Meson Factory, Atomic Energy, v.94, N1, 2003, p.45-49.
7. E.A.Koptelov,S.G.Lebedev e.a., Prospects for Study Radiation Damage at RADEX-15 - RADiation EXperiment Facility Based on the Beam Stop of Moscow Meson Factory, Journ. of Nucl.Mater., 233-237(1996)1552.
8. S.G.Lebedev, Limitation Factors of Target Behaviour in Accelerator Experiments, Nucl. Instr. and Meth. A397(1997)172-176.
9. E.A.Koptelov, S.G.Lebedev, e.a., Proton Beam Stop of Moscow Meson Facility as a Device for Producing and Research of Radiation Defects in Structure Materials, Voprosyi Atomnoi Nauki i Techniki, 1999.
10.S. G. Lebedev, D. N. Abdurashitov , E. A. Koptelov, and V. E. Yants, A Gaseous Radiochemical Neutron Monitor. Instruments and Experimental Techniques, v.47,N3, 2004, p.294-299.
11. S.G.Lebedev, nucl-ex/0510015.
12. S.G.Lebedev, cond-mat/0510304.
13. S.G.Lebedev, cond-mat/0509535.


Argonne
NATIONAL LABORATORY