Radiation Protection Dosimetry

SOLID STATE DOSIMETRY

Proceedings of the 11th International Conference
Budapest, July 10–14 1995

PART I (of two Parts)

Proceedings Editors:

Á. Pető
Gy. Uchrin

ISBN 1 870965 39 6 (set of two volumes)
CONF 950708
RADIATION PROTECTION DOSIMETRY
Published by Nuclear Technology Publishing Vol. 65 Nos.1–4 1996

SOLID STATE DOSIMETRY

Proceedings of the
11th International Conference on Solid State Dosimetry

Held in Budapest, Hungary
July 10–14, 1995

PART I

Editors:

Á. Pető
Gy. Uchrin

Editorial Advisory Committee

R. Chen,
P. Christensen,
Y. Horowitz,
M. Oberhofer
M.P.R. Waligorski

ISBN 1 870965 39 6 (set of two volumes)
CONF 950708
RADIATION PROTECTION DOSIMETRY Vol. 65 Nos. 1–4 and Vol. 66 Nos. 1–4 (1996)
Nuclear Technology Publishing

11TH INTERNATIONAL CONFERENCE ON SOLID STATE DOSIMETRY

CONFERENCE CO-PRESIDENTS

Gy. Uchrin, Institute of Isotopes, Hungary
S. W. S. McKeever, Oklahoma State University, USA.

ORGANISING COMMITTEE

Á. Pető (Chair)
M. Osvay
L. Benkő
A. Kelemen

SCIENTIFIC ADVISORY COMMITTEE

M. Akselrod,	Russia	T. O. Marshall,	UK
E. V. Benton,	USA	S. W. S. McKeever,	USA
R. C. Bhatt,	India	M. Moscovitch,	USA
A. J. J. Bos,	Holland	T. Nakajima,	Japan
L. Bøtter-Jensen,	Denmark	Á. Pető,	Hungary
R. Chen,	Israel	E. Piesch,	Germany
P. Christensen,	Denmark	G. Portal,	France
A. Delgado,	Spain	A. S. Pradhan,	India
K. Duftschmid,	Austria	A. Scharmann,	Germany
C. R. Hirning,	Canada	T. G. Stoebe,	USA
Y. S. Horowitz,	Israel	L. Tommasino,	Italy
H. Ing,	Canada	Gy. Uchrin,	Hungary
H. Julius,	Holland	M. P. R. Waligórski,	Poland
A. Lucas,	USA		

Sponsored in part by:

Bubble Technology Industries
Harshaw/Bicron Technologies Vertriebs-GmbH
Hungarian Academy of Sciences
Hungarian National Committe for Technological Development
Institute of Isotopes, Hungary
Landauer, Inc.
Nuclear Technology Publishing
Paks Nuclear Power Plant Ltd.
Rados Technology Oy
Siemens Environmental Systems Ltd
Studsvik Instrument AB
Victoreen Inc.

Radiation Protection Dosimetry
Vol. 65, Nos. 1–4, pp. v–xi (1996)
Nuclear Technology Publishing

Contents (Part I)

Radiation Protection Dosimetry
Vol. 65, Nos. 1–4, pp. 429–435 (1996)
Nuclear Technology Publishing

Contents (Part II)

Radiation Protection Dosimetry
Vol. 65, Nos. 1–4, pp. xiii–xv (1996)
Nuclear Technology Publishing

Editorial

11th International Conference on Solid State Dosimetry

The conference was held in Budapest, Hungary, from 10th to 14th July, 1995 in the Hélia Hotel Conference Center. It was a great pleasure as well as an honour for Hungarian scientists working in the solid state dosimetry field to host such a well established traditional conference, and the selection of Budapest for its venue was also regarded as some form of acknowledgement of the achievements by Hungarian colleagues. Purely from the statistical viewpoint the 11th SSD Conference may be regarded as successful if one just takes into account the number of participants and papers presented. In order to demonstrate this a few of the details of SSD Conferences are given below.

Venue	Year	Participants	Countries	Papers
Stanford, USA	1965	260	14	45
Gatlinburg, USA	1968	144	11	76
Risφ, Denmark	1971	144	27	78
Krakow, Poland	1974	160	23	94
Sao Paulo, Brazil	1977	108	16	58
Toulouse, France	1980	179	22	95
Ottawa, Canada	1983	174	24	106
Oxford, UK	1986	160	26	107
Vienna, Austria	1989	247	36	184
Washington, USA	1992	195	28	165
Budapest, Hungary	1995	235	37	203

Participation is always influenced by many factors including the capacity of the individual countries in the field. The increased number of participants from Central and Eastern European countries, largely due to the efforts of local organisers, should be considered one of the successes of the conference; it is to be hoped that this trend will continue in the future. The promotion and inclusion of scientific achievements of the former Soviet Union into the SSD Conference is not only necessary, but such a real free exchange of ideas, results and cooperation is a vital need of this present era. It is by no means a new feature that some important schools of SSD (e.g. India, Brazil, Japan) were under-represented due to financial or other difficulties.

The Budapest Conference followed the well established structure of previous meetings: five days were devoted to oral presentations and poster paper discussions; each oral session started with an invited paper which also served as a means of reviewing different aspects of solid state dosimetry.

Before commenting further on the Budapest Conference itself, it might be useful to briefly run through the history of SSD Conferences. The idea of initiating a Conference on Luminescence Dosimetry was conceived at the Symposium on 'Personal Dosimetry Techniques for External Radiation' organised in Madrid in 1962. J. Schulmann took up the idea and in 1965 the first meeting was held at Stanford University in the United States. At this time the interest in thermoluminescence (TL) as well as radiophotoluminescence (RPL) was becoming more and more important. Many papers dealt with new substances using a large variety of simple readout instruments. Kinetic models of varying degrees of simplicity had been used to explain the shape of the measured glow curves. It was at that time that LiF first appeared on the scene and success of the meeting warranted the continuation of these conferences.

At the second conference (Gatlinburg, USA), new topics were included, such as lithium borate as a new TL material, application of thermally stimulated exoelectron emission (TSEE) and optically stimulated exoelectron emission (OSEE) for dosimetric purposes and TL dating for archeometry. Some 83% of the papers dealt with TL phenomena (almost 50% on LiF), 12% with radiophotoluminescence, and 5% with non-luminescent detectors. At the third meeting (Risø, 1971), the sensitivity of TL dosemeters was extended down to the 10 nGy range, and the first papers on the UV response of TL dosemeters and on environmental monitoring appeared. In Krakow (1974) many papers dealt with 'common' problems such as TL parameters, supralinearity of TL, fading, glow curve analysis and lattice defect mechanisms. For the first time occupational dosimetry and new methods such as lyoluminescence (LL) and radiation-induced thermally stimulated current (TSC) were discussed. Sao Paulo, Brazil (1977), saw the movement away from basic research towards large scale practical applications. This trend was in evidence at later conferences, perhaps up to and including the 10th Conference in Washington.

It was in Toulouse, France, in 1980, that the name of the conference was changed to 'Solid State Dosimetry Conference', the intention being that in the long run all solid state methods would be brought together. Further expansion took place in 1986 at Oxford, UK, when it was decided to widen the scope with the inclusion of a wide range of solid state processes and their application in personal and environmental dosimetry.

During the last three decades enormous developments have taken place, mainly in solving practical tasks of dosimetry. This includes nationwide dosimetry services run on the basis of TL techniques instead of film badges, thanks to the availability of automated TLD systems, and to a variety of 'well known' TL phosphors such as LiF, $Li_2B_4O_7$, CaF_2, $CaSO_4$:Dy(Tm), BeO, Al_2O_3, MgB_4O_7. Ultrasensitive materials have been developed for environmental application including LiF:Mg,Cu,P and Al_2O_3:C. Methods and materials have been applied to accidental dosimetry. Other developments include reassessment of TL detectors by phototransfer, use of special materials such as dental enamel, cotton, DNA, etc. Interesting developments have taken place in the fields of ESR methods, nuclear track emulsion technique for neutron dosimetry, radon measurements, bubble detectors, laser heated TL dosemeters and specially constructed dosemeters for beta and low energy gamma radiation. The fields of application of solid state dosimetric methods are continually being enlarged. For example TL and OSL dating methods are being applied to fossil materials, to sediments and to geological samples as well to archeological chronology.

The following remarks relate more closely to the Budapest conference and are, naturally, not free of subjectivity and space restrictions. The significance of research devoted to basic physical processes observed at the Washington Conference seems to have been continued. Significant experimental investigations such as optical spectroscopy, investigation of dielectric and magnetic properties, TL, TSEE, ESR, radioluminescence, etc., together with more sophisticated calculation and evaluation techniques including glow curve deconvolution and Monte Carlo calculations, may provide a reasonable basis for discussing the electronic processes in solids. LiF, MCP and α-Al_2O_3 detectors are subject to theoretical investigations as well as to practical applications, mainly in relation to environmental dosimetry. The results achieved up to now are already promising from both aspects.

Further developments have been observed in the optically stimulated luminescence technique (OSL) and its successful application to retrospective dosimetry and dating. During the last few years high dose dosimetry has made great strides with regard to the materials and techniques applied.

Personal dosimetry has not changed to any large extent in recent years. Most of the problems have become technical rather than scientific and are being solved at the industrial commercial level, except for accidental and environmental dosimetry. Even though beta and low energy gamma radiation dosimetry problems are not entirely solved, good, alternative solutions are already in use. Inevitably, neutron dosimetry research will continue despite the appearance of sophisticated bubble and nuclear track emulsion detectors.

It was interesting to note that activity in some fields of solid state dosimetry including lyoluminescence, TSEE, and OSEE appear to have declined or are possibly in a quiescent state. Some of the reasons are obvious; some of the limited number of groups involved have disappeared and the lack of commercial readers and other instrumentation may also have contributed. Some inherent unsolved disadvantages of these methods, such as complexity, reproducibility etc., still remain.

It is no easy matter to offer any forecast for the future of SSD. There are contradictory trends: 100 years of radiation history (X rays, radioactivity, the peaceful uses of nuclear energy) gives no guidance. Most of the practical dosimetric problems, if not already solved, will become technical as opposed to scientific. Neutron dosimetry, low dose measurements, accidental dosimetry, alpha dosimetry, population dose measurement, etc. will remain as vital tasks. Standardisation and unification, intercomparisons, appropriate measurement of relevant

radiation quantities will remain as firm duties for a long time to come. All these matters are of great importance. The level of fundamental research should be strengthened, thereby offering the possibility of new applications, but further financial support is necessary for this. Perhaps the newly formed International Solid State Dosimetry Organisation, a new outcome of the Budapest Conference, will promote this movement. Let us hope that our up-to-date means of communication will also help us to form a really active community.

The Budapest Conference highlighted a number of promising aspects. Many talented young scientists reported their valuable contributions; the importance of basic research seems to be increasing. It is to be hoped that the giants of SSD, who are still active, will be followed by newer outstanding scientists.

The tradition started in Washington to award a prize for the best presentation was continued. The *ad hoc* Award Committee, set up by the Local Organisers, and comprising A. Scharmann (chair) S.W.S. McKeever, Y. Horowitz, H. Julius and A. Delgado was faced with some difficult decisions. These were announced during the closing ceremony. The best oral presentation was 'A Novel Radiochromic Film for Clinical Dosimetry', by W.L. McLaughlin, A. Miller, A. Kovács, L. Wojnárovits and D.F. Lewis. The best poster presentation was 'Influence of the Calcining Conditions on the Thermoluminescence of Pure and Doped α-Alumina Powders' prepared by E. Papin, P. Grosseau, B. Guilhot, M. Benabdesselam, D. Lapraz and P. Iacconi.

The local organisers 'established' a further award for the best presentation by a young scientist. The winner of this award was Ute Fill, whose oral presentation 'PC Assisted Dose Assessment in Clinical TL Dosimetry and QA Programs', was coauthored by D. Regulla and M. Sprunk.

The Proceedings of this conference could not be presented without acknowledging the great help of the many people who made the conference possible and successful. In particular we cordially thank S.W.S. McKeever for passing on all the useful experiences of the Washington conference to us, as well as the members of the Scientific Advisory Committee and members of the Standing Committee. I do hope that I will be forgiven for making special mention here of Y. Horowitz, who was a tower of strength. Special thanks are expressed to R. Chen, Y. Horowitz, P. Christensen, M.P.R. Waligorski and M. Oberhofer who undertook the difficult task of acting as associate editors of the proceedings thereby easing the load of the local organisers. Thanks are also due to all the staff at Nuclear Technology Publishing for their contribution to publishing this two volume set of Proceedings. On a personal note, I should like to thank Ákos Pető without whose immense contribution the conference and the proceedings would not have been possible.

And to all who came to Budapest thereby contributing to the success of the Conference we offer our thanks and sincerely hope that they left Hungary with enlightenment and fond memories.

George Uchrin
Co-president
11th SSD Conference

PUBLISHERS NOTICE

Due to the large number of pages in these Proceedings it has been found to be of practical necessity to publish in two separate parts. Without this there would be some danger that, because of the high use expected of this publication, it could become damaged in use. The two parts are published as Volumes 65 (Nos. 1–4) and Volume 66 (Nos. 1–4) of Radiation Protection Dosimetry. Each part includes the contents of both parts, for easy reference. The author index is repeated in both parts, with entries identified to enable the location of any paper to be easily identified.

E.P. Goldfinch
Executive Editor
Radiation Protection Dosimetry

Radiation Protection Dosimetry
Vol. 65, Nos. 1–4, pp. xxiii–xxiv (1996)
Nuclear Technology Publishing

Opening Address

11th International Conference on Solid State Dosimetry

Mr Chairman, Ladies and Gentlemen,

On behalf of the Hungarian Atomic Energy Commission I would first like to give a warm welcome to all the prominent personalities attending this conference in Budapest, including speakers and participants from more than 30 countries, in this opening address of the 11th International Conference on Solid State Dosimetry. It is a great pleasure for the Hungarian organisers, especially the Institute of Isotopes of the Hungarian Academy of Sciences, to welcome to our country specialists in such a broad field, covering theoretical background investigations as well as a large variety of practical applications.

Being a nuclear energy specialist and working on the authority side, in my short opening address I can give you some information on topics of common interest, which I hope can form useful background in your discussions not only in the conference but also during associated events.

The history of atomic science and nuclear technology in Hungary goes back to the turn of the last century. According to evidence at the Technical Museum in Budapest, the first nuclear devices were ionisation chamber electroscopes used to compare the levels of radioactivity in the thermal springs in Hungary. These springs can be found in many places in Hungary, including here in Budapest in a 15 km line on the banks of the river Danube, following a geological fault between the hills of Buda and the plains of Pest. So far as I know, the warm water in this hotel comes mainly from these springs.

Returning to science, the first nuclear group in this country was formed in the 1930s at the Kossuth Lajos University in the Hungarian town of Debrecen. Cosmic radiation research began in 1951 in the Central Research Institute of Physics (CRIP) founded a year earlier in Budapest.

In 1954 the Institute of Nuclear Research (ATOMKI) was established in Debrecen and in the same year the first consignment of radioactive isotopes arrived in Hungary. The Hungarian Atomic Energy Commission was formed in order to supervise development and application of nuclear technology. I represent that authority here. In turn my Commission set up the Institute of Isotopes for trade and research purposes.

1959 was the year of the first controlled nuclear chain reaction in Hungary. In this year a Soviet type research reactor was put into operation. The Training Reactor of the Budapest Technical University commenced operation under our initiative and support in order to promote education and training in the field. Except for the fuel, this reactor was designed and constructed entirely by Hungarian institutes and industry.

At present radioactive isotopes are used in Hungary at more than 2300 sites; approximately 30,000 radioactive preparations and sealed sources are put to use annually.

Generation of electric power by nuclear means started in Hungary approximately 12 years ago, with the commissioning of the first reactor of the Paks Nuclear Power Plant. Presently this plant, with its four WWER-213 type PWR reactors, produces roughly half of the electric power generated in Hungary. The plant has earned a good reputation for safe and reliable operation.

The first steps in the field of environmental monitoring was taken in Hungary in 1952, when the gross beta activity concentration of fall-out fission products was measured in rain in Debrecen. In 1961 a continuously operating environmental monitoring system was set up in the territory of the CRIP. This was necessary because in the same year our isotope production activity started at the same site. The environmental monitoring system of the Paks NPP site was installed in 1981-2, before the first reactor started operation.

Country-wide environmental monitoring work has been delegated to the 'Frederic Joliot-Curie National Research Institute for Radiobiology and Radiohygiene' in Budapest. This Institute has operated the network since

1982 using the National Meteorological Service stations. Integrating TLDs are set up indoors and out of doors at these 123 sites and are replaced by postal delivery at monthly and quarterly intervals. During the last 12 years more than 17,000 TLD measurements have been registered. Geographical and temporal variations of the out of doors dose-rate distribution were obtained across the country before and after the Chernobyl accident. After the Chernobyl accident the monitoring of environmental radiation in Hungary has been followed with increased attention. As a result of this our various other authorities now have their own control networks and systems. The integration is still in progress under the leadership of the previously mentioned institute.

The National Dosimetry Service of this authority, besides the generally used film service, has an automated TLD reader operated within the country-wide monitoring programme for special dosimetric purposes. A survey has been initiated for assessment of radiation exposures to the extremities of personnel involved in the use of X ray screen amplifiers in intervention radiology. The whole-body exposure of workers employed in the Proton Emission Tomograph Laboratory and in a therapeutic hospital cave are also being monitored by lithium fluoride TLDs.

I think that there are many other applications of your science in Hungary and a number of them will either be demonstrated at this conference or are well known to you.

Let me therefore close my introductory remarks. I would like to wish all of you a successful conference, closer contacts not only with the experts present here, but with the nations they represent, a fruitful exchange of experience, not only here and now, but also into the future. And, if it happens by chance that you visit one of our swimming pools during the hot weather, on an even warmer day than you have found today, I suggest that you do not give up trying to make a portable TL detector system sensitive enough to measure the radioactivity of the water in the swimming pool.

Thank you for your patience, Ladies and Gentleman. I now declare the conference open.

József Vigassy
Vice President
Hungarian Atomic Energy Commission