SOLID STATE NUCLEAR TRACK DETECTORS (SSNTDS): CURRENT STATUS & TRENDS

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KEY-NOTE ADDRESS

This Key-Note Address Consists of Three Parts:

(a) **HISTORICAL INTRODUCTION TO SSNTDS.**

(b) **SCENARIO AT NATIONAL AND INTERNATIONAL LEVELS.**

(c) **CONTRIBUTIONS OF OUR OWN GROUP AT GURU NANAK DEV UNIVERSITY,AMRITSAR.**

(a) HISTORICAL INTRODUCTION

Development of SSNTD technique started with the discovery by Young (1958) and Silk and Barnes (1959) that charged particles produced invisible submicroscpoic damage (“tracks”) in many solid insulators. Young described etched shallow pits of fission fragments in lithium fluoride crystals while Silk and Barnes published transmission electron micrographs of fission tracks from ^{235}U in mica. This led to the development of a new class of detectors called Solid State Nuclear Track Detectors (SSNTDs).

The credit of introducing SSNTDs as a powerful research tool in the early sixties goes to P.B. Price, R.L. Fleischer and R.M. Walker of the General Electric Company of the United States of America. Basically, SSNTDs are dielectric materials or solid insulators such as mica, glass, synthetic plastics etc. which record and permanently store the trajectory of fast moving charged particles in the form of submicroscopic trails of continuous damage called latent tracks. Today, there is hardly a branch of science and technology where these detectors do not have an actual or potential application. Apart from the direct applications of far reaching consequences in nuclear physics, SSNTDs have been used in diverse fields, e.g., bio-medical sciences, environmental research, geological sciences, materials science, micro-analysis, nuclear imaging, nuclear technology, space physics, micro/nano electronics, uranium prospecting and oil exploration, etc. Quite possible, we may find newer applications in future.

Track Recording Solids

Solid state nuclear track detectors are insulating solids both naturally occurring and man-made. There are dozens of these detectors including inorganic crystals, glasses and plastics. Some examples are given in Table-1. When a heavily ionizing charged particle passes through such insulating solids, it leaves a narrow trail of damage about 50 A^0 in diameter along its path. This is called ‘latent track’ as it cannot be seen with the naked eye. It is possible to view this latent track with an electron microscope. The exact nature of the physical and chemical changes occurring at the damage site depends on the charge (Z) and speed (β=v/c, v=velocity of particle; c=velocity of light) of the particle, on the chemical structure of the detector material and also on the environmental conditions like temperature and pressure. These latent tracks can be enlarged/developed and can be viewed under an optical microscope by etching with some of the cheapest and commonest of chemicals such as sodium hydroxide and hydrofluoric acid. A list of chemical etchants, generally used along with the etching conditions for different detectors are also given in Table-1.

Table – 1: Examples of Solid State Nuclear Track Detectors (SSNTDs)

Type	**Detector Material**	**General Etching Conditions**	**Lightest Detectable Particle**	**Critical Angle θ_c**
Minerals crystals	Olivine Zircon Quartz Mica	KOH_{aq}, 160 ^{0}C, 10 min. 10% HF, 23 ^{0}C, 30 sec. 85% H_3PO_4, 500 ^{0}C, 1 min. KOH Soln., 210 ^{0}C, 10 min 48% HF, 23 ^{0}C, 1- 40 min.	Fe Ca Ar (100 MeV) Ne (20 MeV)	$4^0 30^/$
Glasses	Sodalime glass Phosphate Glass	48% HF, 23 ^{0}C, 5 sec 48% HF, 23 ^{0}C, 10 sec	Ne (20 MeV) F (20 MeV)	$\sim 50^0$
Plastics	Poly Carbonate Plastics (Lexan, Makrofol, Mylar) Cellulose Nitrate (Daicell, LR-115, CA-80-15) CR-39 (Allyl diglycol polycarbonate	6 N NaOH, 60 ^{0}C, 60 min. 3-6 N NaOH, 50 ^{0}C, 40 min. 6 N NaOH, 70 ^{0}C, 1-4 hr.	He (0.3 MeV) H (0.5 MeV) H (1.0 MeV)	$\sim 2\text{-}3^0$ $\sim 4\text{-}8^0$ -

(b) INDIAN SCENARIO

SSNTD work started in India at Tata Institute of Fundamental Research (TIFR) Bombay after the visit of Professor P.B. Price. At present, about two dozen research groups are actively engaged in SSNTD work in India:

S.No.	Organisation/Institute	Location
1.	B.A.R.C (DAE)	Mumbai
2.	A.M.D. (DAE)	Hyderabad
3.	T.I.F.R (DAE)	Mumbai
4.	S.I.N.P (DAE)	Kolkata
5.	U.C.I (DAE)	Jaduguda
6.	P.R.L.	Ahmedabad
7.	G.N.D.U.	Amritsar
8.	K.U.K.	Kurukshetra
9.	A.M.U.	Aligarh
10.	N.E.H.U	Shillong
11.	B.H.U.	Varanasi
12.	W.I..H.G.	Dehradun
13.	Gauhati University	Guwahati
14.	Mysore University	Mysore
15.	Calicut University	Calicut
16.	Mangalore University	Mangalore
17.	Osmania University	Hyderabad
18.	I.I.T	Kharagpur
19.	T.I.E.T	Patiala
20.	H.N.B Garhwal University	Srinagar
21.	S.L.I.E.T	Longowal
22.	D.R.L	Jodhpur
23.	Panjab University	Chandigarh
24.	G.G.D. University	Bilaspur

(c) HIGHLIGHTS OF SSNTD GROUP AT GURU NANAK DEV UNIVERSITY

(a) Fission Track Age of Himalayas, Pegmatites, Iron & Copper Ores, Tektites, Volcanic Eruptions, Ocean - Bottom spreading and Meteorites.

(b) U-Estimation in Minerals, Water, Plants, Juices, Toothpastes, Fertilizers, Siwalik Fossil Bones, etc.

(c) Intercalibration of Glass Dosimeters for Neutron Dosimetry.

(d) 'Single Activation Energy Model' of Heavy Ion Annealing of Radiation Damage in SSNTDs.

(e) Uranium uptake in Plants and Discovery of U-Anomalies/Indicator Plants for U- Exploration in Lower Himalayas.

(f) Radon as a Precursor for Earthquake Prediction Studies.

(g) A Model for Correlation of Radon Anomalies with Magnitude of Earthquakes.

(h) National Survey for Radiation Dose Measurement in Punjab and Himachal Pradesh due to Indoor Radon Concentration.

(i) Radon/Helium Exploration in Thermal Springs.

(j) Range – Energy Measurements in SSNTDs.

(k) Preparation and Applications of Micro-filters.

(l) Heavy Ion Modification of Polymeric Materials.

NATIONAL SSNTD SEMINARS

S.No.	**Year**	**Organisation/Institution**	**Convener**
1.	1979	B.A.R.C. Trombay	R.H.Iyer
2.	1981	P.R.L. Ahmedabad	J.N.Goswami
3.	1983	G.N.D. University Amritsar	**H.S.Virk**
4.	1985	W.I.G.H. Dehradum	K.K.Sharma
5.	1987	S.I.N.P. Calcutta	B.Baliga
6.	1989	Gauhati University Guwahati	T.D.Goswami
7.	1991	D.R.L. Jodhpur	S.Kumar
8.	1993	A.M.U. Aligarh	D.S.Srivastava
9.	1995	B.A.R.C. Trombay	R.H.Iyer
10.	1996	K.U. Kurukshetra	Shyam Kumar
11.	1998	G.N.D. University Amritsar	Surinder Singh
12.	2001	D.A.V. College Jallandhar	Subhash Kumar

INTERNATIONAL SSNTD CONFERENCES

S.No.	**Year**	**City**	**Country**
1.	1957	Strasbourg	France
2.	1958	Montreal	Canada
3.	1960	Moscow	USSR
4.	1962	Munich	Germany
5.	1964	Geneva	Switzerland
6.	1966	Florence	Italy
7.	1970	Barcelona	Spain
8.	1972	Bucharest	Romania
9.	1976	Munich	Germany
10.	1979	Lyon	France
11.	1981	Bristol	England
12.	1983	Acapulco	Mexico
13.	1985	Rome	Italy
14.	1988	Lahore	Pakistan
15.	1990	Marburg	Germany
16.	1992	Beijing	China
17.	1994	Dubna	Russia
18.	1996	Cairo	Egypt
19.	1998	Besancon	France
20.	2000	Portoroz	Slovenia
21.	2002	New Delhi	India

TRENDS AT INTERNATIONAL SSNTD CONFERENCE

(2000)

S.No.	Theme	No. of Papers
1.	Nuclear Tracks : Basic Processes	46
2.	Instrumentation Methods & Software	36
3.	High Energy Interactions & Cosmic Rays	29
4.	Nuclear Physics & Chemistry	11
5.	Earth Sciences, Dating	47
6.	Radiation Protection Dosimetry	32
7.	Environmental Science, Dosimetry	21
8.	Material Science, Radiography	11
9.	Nuclear Technology	25
	Total	258

COUNTRYWISE CONTRIBUTIONS TO 20TH INTERNATIONAL SSNTD CONFERENCE

S.No.	Country	No. of Papers
1.	Argentina	2
2.	Algeria	1
3.	Australia	4
4.	Armenia	2
5.	Brasil	5
6.	Belarus	4
7.	Belgium	4
8.	China	7
9.	Czechoslovakia	4
10.	Denmark	1
11.	Egypt	13
12.	France	10
13.	Germany	10
14.	Greece	1
15.	Hungary	7
16.	India	25
17.	Italy	8
18.	Iraq	4
19.	Iran	4
20.	Ireland	2
21.	Japan	17

22.	Jordan	5
23.	Korea	2
24.	Latvia	1
25.	Malaysia	2
26.	Mexico	10
27.	Morocco	3
28.	Poland	6
29.	Pakistan	12
30.	Romania	5
31.	Russia	36
32.	Spain	5
33.	Slovenia	5
34.	Saudi Arabia	3
35.	Sweden	1
36.	Syria	1
37.	Tajikistan	2
38.	UK	2
39.	USA	3
40.	Uzbekistan	4
41.	Ukraine	6
42.	Venezuela	1
43.	Yemen	1
44.	Yugoslavia	7

SSNTD APPLICATIONS

(a) Nuclear Physics : (i) Nuclear Fission

(ii) Transuranium Elements

(iii)Heavy Ion Reactions

(iv) Nuclear Lifetimes (10^{-16}-10^{-19}s)

(v) Excitation function for (p,α) reaction

(b) Trace Element Analysis : Micromapping of U, Th, Ra and B

(c) Radiation Dosimetry : (i) Thermal and fast neutron dosimertry

(ii) Personnel and area dosimetry

(d) Geochronology : F.T. Dating of rocks & minerals, tektites, meteorites and moon rocks. Thermal history and uplift rates.

(e) Solid State Physics : Defect identification, channeling and blocking.

(f) Solar Physics & Cosmic Rays : Nature of solar nuclei, Energy & composition of cosmic rays, Cosmic ray exposure ages.

(g) Miscellaneous : (i) Uranium Exploration

(ii) Earthquake Forecasting

(iii) Oil Exploration

(iv) Nuclear Medicine and Biology

(v) Environmental Pollution

(vi) Reactor Fuel Development

(vii) Metallurgy

(viii) Materials Science

(ix) Radwaste Disposal

(x) Cluster Radioactivity

(xi) Fragmentation of Relativistic Heavy Nuclei

(xii) Radon Monitoring in Dwellings