

SPALLATION MATERIALS TECHNOLOGY

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My Background

Radiation Materials Science Group Leader, Oak Ridge
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These workshops (with friend and colleague H. Ullmaier)

WELCOME TO PARTICIPANTS

from the IWSMT organizers, sponsors and Journal of Nuclear Materials

- Twentieth anniversary
- Motivations
- Early goals and present status
- Similarities and differences from 20 years ago
- Opportunities
- Impact
- Future

TIME TRAVEL IN NUCLEAR MATERIALS (IN ONE SLIDE)

- The field was born in the 1950's to support nuclear energy
- Materials science itself was just then being synthesized
- Nuclear materials drew from and helped to unify metallurgy, ceramics, materials physics, materials chemistry, ...
- Initial work was directed toward applications for fission reactor fuels and structural materials
- By the mid-1970's, applications to fusion reactor issues grew into what is now a second major sector
- In the 1990's, there was a burgeoning interest in high power accelerator targets irradiated with GeV energy particle beams--a unique irradiation environment

MOTIVATIONS

- Designs were underway in the 1990's and earlier for high powered spallation neutron sources
- Aggressive conditions, well beyond then-current experience, were anticipated
- Nearly no irradiation data were available for high energy-high power beams on liquid metal targets
- With no directly applicable data, our approach was to assess the relevance of available GeV irradiations, as well as fission, fusion and other irradiation activities
- Existing spallation materials groups?--few, small, internationally dispersed, and just getting started
- Compelling case to evaluate potential for joint research collaborations

EARLY GOALS (ACHIEVEMENTS)

- Review and assess materials experience from existing spallation devices, as well as applicable information from fission, fusion and other irradiation programs
- Make preliminary target materials selections
- Begin new research immediately to obtain needed information on which to base design decisions and target lifetime estimates
- Create collaborations among the relatively few internationally dispersed spallation materials groups

NEW GOALS FROM EVOLVING KNOWLEDGE--EXAMPLES

- Begin to publish the wealth of results being developed in the spallation materials community
 - Since 2001 papers from this workshop have been published in special issues of Journal of Nuclear Materials
- Understand the unexpectedly important phenomenon of beam-pulse-induced cavitation erosion
 - Enormous progress in the experimental characterization of cavitation erosion, in predicting some features of the phenomenon, and in developing several mitigation measures
- Goals for future
 - We'll ask the question later in this talk and workshop

TWENTY YEARS AGO—IWSMT-1



International Workshop on
Spallation Materials Technology
April 23-25, 1996

TODAY VS FIRST WORKSHOP

- Similarities, 1996 and 2016
 - Small and internationally dispersed spallation materials groups
 - Thorough intermixing of basic work with applications and materials engineering
 - Strong interfacing with particle transport and mechanical engineering

TODAY VS FIRST WORKSHOP

- Differences 1996 and 2016
 - 1996--only a few groups, mainly in startup mode
 - 2016--experienced and highly productive groups
 - 2016--more researchers, more institutions and countries involved
 - IWSMT-1: much time discussing what was to be done; less time presenting hard knowledge
 - Today (& recent workshops): overwhelming productivity of experimental data and analyses; discussion time now suffers vs results presentation
 - Benefits from research interactions with high energy target groups outside spallation applications

TODAY VS FIRST WORKSHOP

- IWSMT-1
 - 5 countries, 11 institutions, 52 participants
- IWSMT-13
 - 9 countries, 25-30 institutions, 58 participants (List, 10/28/2016)
- “The faithful”--4
 - Y. Dai, S. Maloy, L. K. Mansur, M. Wendel
- “New Blood”--54

SPALLATION MATERIALS RESEARCH

- Spallation materials is now an important area of nuclear materials and radiation materials science
- In historical perspective it is quite a young field
- **Greater opportunities are available for original work than in heavily raked areas**
- **Brilliant career choice for young researchers**

OPPORTUNITIES IN SPALLATION MATERIALS SCIENCE

- Expand basic science of radiation effects to higher energy phenomena and more transmutations-- radiation damage by GeV particles superimposed on MeV neutron damage
- Examples
 - At high energy transfers there is potential for large displacement cascades. Although large cascades usually break up into low-energy-like subcascades, new phenomena cannot be ruled out
 - Higher production of He and H
 - Many heavy transmutation products

OPPORTUNITIES IN SPALLATION MATERIALS ENGINEERING

- Materials issues triggered by pulsed high energy beams on liquid metal and solid targets
- Erosion of target structures caused by liquid cavitation
- Compatibility of liquid metals with structural materials during irradiation
- Unique combinations during irradiation of hyper high cycle fatigue, high cycle fatigue, low cycle fatigue, and high velocity flow of liquid metals

IMPACT

- Spallation materials continues to develop, especially by participants in these workshops, into an important field in radiation materials science and nuclear materials
- Wide ranging opportunities for researchers--more possibilities for original work
- IWSMT is the main forum for presentation of research and discussion of results
- Journal of Nuclear Materials is the home journal for spallation materials publication

FUTURE

- Imagination and initiative of participants will determine future of the field
- Increasing mutual benefit from collaborations with high power target groups
- Installation of dedicated irradiation facilities within target areas of high energy, high power accelerators
- New materials issues, not limited to higher damage rates, for even more ambitious higher power targets

MEETINGS

Meeting	Date	Location	Country
1	Apr 1996	Oak Ridge	U.S
2	Sep 1997	Ancona	Italy
3	Apr 1999	Santa Fe	U.S.
4	Oct 2000*	Schruns	Austria
5	May 2002	Charleston	U.S.
6	Nov 2003	Hayama	Japan
7	May 2005	Thun	Switzerland
8	Oct 2006	Taos	U.S.
9	Oct 2008	Hokkaido	Japan
10	Oct 2010	Beijing	China
11	Nov 2012	Ghent	Belgium
12	Oct 2014	Bregenz	Austria
13	Oct 2016	Chattanooga	U.S.
14	??? 2018	TBA	

*First published in
Journal of Nuclear
Materials

THE IWSMT SERIES PUBLICATIONS

- L.K. Mansur, H. Ullmaier (Eds.), Proceedings of the International Workshop on Materials for Spallation Neutron Sources, Laboratory Report, CONF-9604151, 1996.
- F. Carsughi, L.K. Mansur, W.F. Sommer, H. Ullmaier, in: Proceedings of the Second International Workshop on Spallation Materials Technology, Forschungszentrum Jülich Report, Jül-3450, Ancona, Italy, September 19–22, 1997.
- W.F. Sommer, H. Ullmaier, L.K. Mansur (Eds.), Proceedings of the Third International Workshop on Spallation Materials Technology, Los Alamos National Laboratory Report, LA-UR-00-3892, Santa Fe, New Mexico, April 29–May 4, 1999.
- Y. Dai, L.K. Mansur, G.S. Bauer, H. Ullmaier, S. Maloy (Eds.), Proceedings of the Fourth International Workshop on Spallation Materials Technology, Schruns, Austria, October 8–13, 2000, J. Nucl. Mater. 296 (2001) 1–335.
- L.K. Mansur, G.S. Bauer, Y. Dai, J.D. Hunn, S.A. Maloy, H. Ullmaier (Eds.), Proceedings of the 5th International Workshop on Spallation Materials Technology (IWSMT-5), Charleston, South Carolina, USA, May 19–24, 2002, J. Nucl. Mater. 318 (2003) 1–389.

THE IWSMT SERIES PUBLICATIONS

- K. Kikuchi, M. Kawai, L.K. Mansur, G.S. Bauer, Y. Dai, S.A. Maloy (Eds.), Proceedings of the 6th International Workshop on Spallation Materials Technology (IWSMT-6), Hayama, Kanagawa, Japan, November 30–December 5, 2003, J. Nucl. Mater. 343 (2005) 1–387.
- Y. Dai, L.K. Mansur, K. Kikuchi, M. Kawai, G.S. Bauer, S.A. Maloy (Eds.), Proceedings of the 7th International Workshop on Spallation Materials Technology (IWSMT-7), Thun, Switzerland, May 29–June 3, 2005, J. Nucl. Mater. 356 (2006) 1–339.
- S.A. Maloy, L.K. Mansur, Y. Dai, M. Kawai, K. Kikuchi (Eds.), Proceedings of the 8th International Workshop on Spallation Materials Technology (IWSMT-8), Taos, USA, October 16–22, 2006, J. Nucl. Mater. 377 (2008) 1–306.
- K. Kikuchi, L.K. Mansur, M. Kawai, S.A. Maloy, Y. Dai (Eds.), Proceedings of the 9th International Workshop on Spallation Materials Technology (IWSMT-9), Hokkaido, Japan, October 19–24, 2008, J. Nucl. Mater. 398 (2010) 1–250.

THE IWSMT SERIES PUBLICATIONS

- Y. Dai, L.K. Mansur, K. Kikuchi, S.A. Maloy, X. Jia, M. Kawai (Eds.), Special Issue of the Tenth International Workshop on Spallation Materials Technology (IWSMT-10), Beijing, China, October 18–22, 2010, J. Nucl. Mater. 431 (2012) 1–234.
- J. Van den Bosch (Ed.), Special Theme Issue on Spallation Materials Technology. Selected papers from the Eleventh International Workshop on Spallation Materials Technology (IWSMT-11), J. Nucl. Mater. 450 (2014) 1-322
- Y. Dai, Special Theme Issue on Spallation Materials Technology, Selected papers from the Twelfth International Workshop on Spallation Materials Technology (IWSMT-12), J. Nucl. Mater. 468 (2016) 209-359.