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## MAJOR LANDMARKS OF NanoSPD: FROM NanoSPD7 to NanoSPD8 Report of International NanoSPD Steering Committee and Statistics on Recent NanoSPD Activities

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# Contents

> NanoSPD7: input into NanoSPD activity

- Main events as a platform for exchange of ideas and research in the NanoSPD field
- Major publications on NanoSPD research over 2017-2023
- Citation statistics for publications in NanoSPD
- Innovation activity

# NanoSPD6- Metz, France

NanoSPD7, the 7th International Conference on Nanomaterials by Severe Plastic Deformation, was held at the University of Sydney in Australia on July 2-7, 2017, with Prof. Xiaozhou Liao as Chair and Prof. Yuri Estrin as Honorary Chair. The conference was attended by more than 200 delegates from 24 different countries.

The published papers are available on the IOP Conference Series (Materials Science and Engineering, volume 194, 2017).



The NanoSPD Achievement Award for 2017 went to Zenji Horita (left), two NanoSPD Young Researcher Awards went to Anton Hohenwarter (center) and Megumi Kawasaki (right).







# Major NanoSPD related conferences and symposia over 2017-2023

- The 6th International Conference on Ultrafine Grained and Nanostructured Materials (UFGNSM-2017), held on November 12 and 13, 2017, on the Kish Island, Iran. The meeting consisted of oral presentations held in two parallel sessions and a very large number of poster presentations.
- **TMS Annual Meeting in Phoenix, Arizona, March 11-15, 2018**, including the session Ultrafine-grained Materials X (organized by Suveen Madhaudhu, Terry Lowe, et al). In 2018 TMS initiated the Oleg D. Sherby Award in honor of the late Professor Sherby of Stanford University who had a long and distinguished career in the fields of high temperature creep and superplasticity.

Terry Langdon of the University of Southampton was selected as the inaugural recipient of the award. The citation for the award reads "for leading research on the mechanical behavior of materials including three- and five-power law creep, superplasticity and creep fracture, as well as for groundbreaking research on ECAP".

> Terry standing with Dr. David DeYoung of Alcoa, the President of TMS.



The 14th International Conference on Nanostructured Materials (NANO 2018) held on June 24-29, 2018 in China by City University of Hong Kong. Chaired by Prof. Jian Lu and co-chaired by Prof. Ke Lu and Prof. Lei Lu, with about 600 international scholars and researchers famous in nanotechnology fields, coming from 35 countries/regions and 300 different research organizations. The conference hosted the session on SPD Processed Nanomaterials with Multifunctional Properties organized by Prof. Ruslan Valiev.



The 13th International Conference on Superplasticity in Advanced Materials
(ICSAM-2018) held in Saint Petersburg, Russia, August 19-22, 2018 consisting of several sessions on UFG materials. A new award was introduced named the Kaibyshev Award in honor of the late
Oscar Kaibyshev, the distinguished Russian scientist who founded and became Director in 1985 of the Institute of Metals Superplasticity Problems in Ufa. The inaugural recipient of this award was Kenji Higashi from Osaka Prefecture University. The conference proceedings are now available in volume 385 of Defect and Diffusion Forum (2018).



• International Workshop on Giant Straining Process for Advanced Materials in 2018 (GSAM2018) held September 2-4, 2018 in Fukuoka, Japan with the focus on "Significance of SPD for production of biomedical and biocompatible materials" chaired by Prof. Zenji Horita and Kaveh Edalati. The workshop was well attended and resulted in the excellent proceedings.



**The Sustainable Industrial Processing Summit and Exhibition (SIPS 2018)** was held in Rio De Janeiro, Brazil, from November 4 to 7, 2018. <text><text><text><image><image>

The summit covered sustainability areas: (1) Science, Technology & Industry, (2) Governance & Management and (3) Education & Civil Society, consisting of a number or related symposia, including 2018 honoree with **Zehetbauer International Symposium on Science of Intelligent and Sustainable Advanced Materials (SISAM).** 

- The Gordon Research Conference on Heterogeneous Materials held June 23-28, 2019 in the Hong Kong University of Science and Technology and chaired by Professors Qizhen Li and Yuntian T. Zhu. The conference subject areas included Heterogeneous Materials for Structural Applications, Multifunctional and Multiscale-architectured Materials, Dynamic Mechanical Behavior of Metals, Plastic Deformation and Strength of Metallic Materials, etc. The discussions were headed and conducted by leading world scientists in the relevant area.
- The 2020 TMS Annual Meeting held on February 23-27, 2020, in San Diego, California, USA with the session on Ultrafine-grained and Heterostructured Materials (UFGH XI), that traditionally continued during the 2022 TMS Annual Meeting held in-person on February 27-March 03, 2022, in Anaheim, California, USA presenting more than 90 symposia and covering a broad range of topics related to minerals, metals, and materials science and engineering. The event included the session on Ultrafine-grained and Heterostructured Materials (UFGH XII) with the focus on all aspects of the science and technology of heterostructured and UFG materials and covers a broad scope, ranging from fundamental science to their industrial applications.
- The Gleiter Symposium on Frontiers of Nanoscience (virtual) organized by Lanzhou University on Nov. 23, 2020 in recognizing Prof. Herbert Gleiter's ground-breaking contributions to nanoscience and nanotechnology. The Gleiter Symposium consists of plenary lectures, keynote lectures, and invited lectures covering a broad spectrum from new materials, new characterization methods and devices to the applications of nanotechnologies. Internet broadcast: https://www.koushare.com/lives/room/265347

• The 22nd Annual YUCOMAT Conference of the MRS Serbia was held in Herceg Novi, from August 30 to September 3, where were presented plenary lectures and virtual offline presentations of the most eminent scientists from around the world in materials science and nanotechnology.

#### Upcoming event:

24th Conference on Material Science, YUCOMAT 2023, Herceg Novi, Montenegro, September 4-8



Welcome Speech by the President of MRS Serbia

International Conference on Strength of Materials (ICSMA 19<sup>th</sup>) held on June 26 – July 01, 2022 in Metz, France and chaired by Professor Laszlo Toth with about 260 lectures and 88 posters presented on material strength of all engineering materials; from solid to bio-materials, from nanoscale to real size structures. The event included the symposium on SPD Materials (organizer: Hyong Seop Kim).

## Major NanoSPD related reviews, special issues on NanoSPD research over 2017-2023

- A. Vinogradov, Y. Estrin, Analytical and numerical approaches to modelling severe plastic deformation, Prog. Mater. Sci. 95 (2018) 172-242
- I.A. Ovid'ko, R.Z. Valiev, Y.T. Zhu, Review on superior strength and enhanced ductility of metallic nanomaterials, Prog. Mater. Sci. 94 (2018), pp. 462-540
- E. Bruder, Formability of ultrafine grained metals produced by severe plastic deformation – an overview, Adv. Eng. Mater. (2018) 1800316
- Y. Cao, S. Ni, X. Liao, M. Song, Y. Zhu, Structural evolutions of metallic materials processed by severe plastic deformation, Mater. Sci. Eng. R 133 (2018) 1-59
- Materials Transactions, Vol. 60 (2019) Special issue on Severe Plastic
   Deformation for Nanomaterials with Advanced Functionality (ed. by Z. Horita, K. Edalati)
- R.B. Figueiredo, T.G. Langdon, Deformation mechanisms in ultrafine-grained metals with an emphasis on the Hall-Petch relationship and strain rate sensitivity, J. Mater. Res. Technol.14 (2021) 137-159
- Y. Estrin, Y. Beygelzimer, R. Kulagin, P. Gumbsch, P. Fratzl, Y. Zhu, H. Hahn, Architecturing materials at mesoscale: some current trends, Mater. Res. Lett. 9 (2021) 399-421

- D. Hernández-Escobar, M. Kawasaki, C.J. Boehlert, Metal hybrids processed by highpressure torsion: synthesis, microstructure, mechanical properties and developing trends, Int. Mater. Rev. 67 (2021) 231-265.
- F.Z. Utyashev, Y.E. Beygelzimer, R.Z. Valiev, Large and severe plastic deformation of metals: similarities and differences in flow mechanics and structure formation, Adv. Eng. Mater. (2021) 2100110
- H. Azzeddine, D. Bradai, T. Baudin, T.G. Langdon, Texture evolution in high-pressure torsion processing, Prog. Mater. Sci. 125 (2022) 100886
- Y. Shi, W. Shang, T. Wang, X. Zhang, S. Liang, Z. Lu, L. Wang, H. Liu, Z. Xing, D. Xu, Enhancing mechanical properties of metallic materials by architecturing gradient structures, Mater. Sci. Technol. 2022
- ➤ K. Edalati et al. (49 co-authors), Nanomaterials by severe plastic deformation: review of historical developments and recent advances, Mater. Res. Lett. 10 (2022) 163-256
- R.Z. Valiev, B. Straumal, T.G. Langdon, Using severe plastic deformation to produce nanostructured materials with superior properties, Ann. Rev. Mater. Res. 52 (2022) 357-382
- > Y. Zhu, X. Wu, Heterostructured materials, Prog. Mater. Sci. 131 (2023) 101019
- H.Shahmir, M.S. Mehranpour, S.A.A. Shams, T.G. Langdon, Twenty years of the CoCrFeNiMn high-entropy alloy: achieving exceptional mechanical properties through microstructure engineering, J. Mater. Res. Technol. 23 (2023) 3362-3423

## **New topics and developments**

- P. Sathiyamoorthi, H.S. Kim, High-entropy alloys with heterogeneous microstructure: Processing and mechanical properties, Prog. Mater. Sci. 123 (2022) 100709
- N. Choi, S. Taheriniya, S. Yang, V.A. Esin, J.H. Yu, J.S. Lee, G. Wilde, et al, Non-equilibrium grain boundaries in additively manufactured CoCrFeMnNi high-entropy alloy: Enhanced diffusion and strong segregation, J. Appl. Phys. 132 (24) (2022) 245105
- B.B. Straumal, R. Kulagin, B. Baretzky, N.Yu. Anisimova, M.V. Kiselevskiy, L. Klinger, P.B. Straumal, O.A. Kogtenkova, R.Z. Valiev, Severe plastic deformation and phase transformations in high entropy alloys: a review, Crystals 12 (2022) 54 (20 pages)
- S. Rzepa, Z. Trojanova, J. Džugan, R.Z. Valiev, M. Koukolikova, D. Melzer, M. Brazda, Effect of ECAP processing on microstructure and mechanical behaviour of Ti-6Al-4V manufactured by directed energy deposition, Mater. Charact. 196 (2023) 112622



Ti-6AI-4V processed by directed energy deposition (Rzepa et al, Mater Charater 2023)



ECAP-processed workpiece (Rzepa et al, Mater Charater 2023)

## **Ultralow-temperature superplasticity in commercial UFG Al alloys**



50 nm

1600 Maximum Elongation to Failure (%) 7xxx Al Alloys 1400 Other Al Alloys Commercial Al Alloys 1200 1000 **UFG AI Allovs** Ultralow 800 Temperature 600 400 Present Study 200 High Low Temperature Temperature 0.3 0.4 0.5 0.7 0.9 0.6 0.8 Homologous Testing Temperature

Chinh-Valiev's diagram, Mater. Res. Lett. 2022

Segregation of Zn atoms at grain boundaries



### Coming in 2023

Special issue of the *Journal of Materials Science* - will be published in January or February 2024 to be pub (Processing of Bulk Nanostructured Materials with Enhanced Properties and Functionalities) Guest editors: Prof. Praveen Kumar, Prof. Megumi Kawasaki

The book released in 2020 explores the formation and evolution of the microstructure, texture and ensembles of grain boundaries in materials produced by severe plastic deformation.



The textbook to be published by Springer in 2023

## Innovation Activity



A Publication of the Materials Research Society® Advancing materials. Improving the quality of life.

The March Issue of MRS Bulletin is here!

#### In this issue-

**Recent Developments in Nanostructured Metals and Alloys** 



# Commercialization of bulk nanostructured metals and alloys

Terry C. Lowe,\* Ruslan Z. Valiev, Xiaochun Li, and Benjamin R. Ewing

This article reviews examples of the use of nanostructured metals in engineering products that are currently commercially available, or will soon become available for specific biomedical, aerospace, electronics and energy industry applications.

MRS Bulletin 46 (201) pages 265–272

# Pilot implants from Ti nanomaterials with improved design and functionality





Nanostructured CP Ti used for spine functions recovery







2.0 mm diameter Nanoimplant® (www.timplant.cz/en/) from NS Grade 4 Ti in a panoramic X-ray radiograph after surgery (a), the right one, and the control radiograph obtained after incorporation of the implant (b).



mini plate with six holes made from NS Grade 4 Ti

See for details: Book on «Titanium for Medical and Dental Applications: A review of all aspects of titanium use in the medical and dental industries« edited by F. Froes, M. Qian, Elsevier in 2017-2018 with the chapters by Valiev, Estrin et al

## **Aluminium alloys for overhead power lines**



The choice of the conductors is a compromise between:

- Mechanical properties,
- Electrical properties,
- Investment,
- Cost of the losses along the life time,
- Environmental impact.

Nowadays, Al-Mg-Si alloys (AA6xxx series) have been widely used as conductors for overhead power lines.

F. Kiessling, P. Nefzger, J.F. Nolasco, U. Kaintzyk. Overhead power lines: Planning, Design, Construction. Springer-Verlag, Berlin – Heidelberg, 2003.

## New approaches for producing wire with enhanced strength and electrical conductivity from NS alloy 6101 by means of SPD



- M. Murashkin, A. Medvedev, V. Kazykhanov, A. Krokhin, G. Raab, N. Enikeev and R.Z. Valiev: Metals 5(2015) 2148
- T.C. Lowe, R.Z. Valiev, X. Li, B. Ewing, Commercialization of bulk nanostructured metals and alloys. MRS Bulletin 46 (2021) 265–272

## Personal achievements and rewards in NanoSPD Community – congratulations to



Michael Zehetbauer (Austria) with Scientist Medal and Fellow (2022-) of the Internat Association of Advanced Materials (IAAM) as well as 2018 UNESCO Medal for Contributions to the Development of Nanoscience and Nanotechnologies



Yuntian Zhu (China) with Fellow of the US National Academy of Inventors (2023)







Xavier SAUVAGE (France) obtained the Silver Medal-2019 of Acta Materialia







Professor Rimma Lapovok (Australia) with 2018 IAAM Scientist Medal for outstanding research in the field of New Age Energy Materials and Technology.

Professor Terry Langdon (UK) was appointed an Honorary Professor of Harbin Institute of Technology, China, in 2019 He was also appointed Guest Professor of Nanjing University of Science and Technology, China, in 2021



A special edition of *Advanced Engineering Materials* was published as volume 22, issue 1, in January 2020 dedicated to Terry Langdon's 80<sup>th</sup> birthday. This issue was edited by Megumi Kawasaki, Roberto B. Figueiredo and Alexander P. Zhilyaev.

#### ADVANCED ENGINEERING MATERIALS



ABOUT V

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Volume 22, Issue 1

CONTRIBUTE V

Special Issue: Dedicated to Terence G. Langdon on the Occasion of his 80th Birthday

BROWSE V

SPECIAL FEATURES

January 2020 Issue Edited by: Megumi Kawasaki, Roberto B. Figueiredo, Alexander P. Zhilyaev

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The research.com website has analyzed all citation data available up to December 2021 and then, for different academic subjects, ranked the scientists in each country.

Resear	<b>ch</b> .com	Upcoming Conferences 🗸 🛛 Bes	t Conferences 🗸 🛛 Best Jou	ırnals 🗸 🛛 Best L	Jniversities 🗸 🛛 Best Scientists 🗸			
Home / Best Sc	ientists - Materials Science / Russia							
Best	Best Materials Science Scientists in Russia							
The 1st editi Position in th more	on of Research.com ranking of top M ne ranking is based on a scientist's D	laterials Science scientists is based on ( -index (Discipline H-index), which only i	data collected from Micro includes papers and citati	soft Academic G on values for an	araph on December 6th, 2021. Nexamined discipline. Show			
	Search by name or affiliation	Q Materials Science	✓ R	ussia (26)	~			
	World National S	icholar	D-Index	Citations	Publications			
	168   1 <b>               </b>	Ruslan Z. Valiev Jfa State Aviation Technical Jniversity, Russia	123	73,014	891			

Ruslan Valiev is ranked #1 in Materials Science in Russia.

Other NanoSPD Russian scientists with high ranking include Boris B. Straumal (#3), Rustam Kaibyshev (#7), Gennady A. Salishchev (#17). Ilya A. Ovid'ko (#23) and Andrey Belyakov (#26).

#### Research.com

Home / Best Scientists - Materials Science / United Kingdom

## Best Materials Science Scientists in United Kingdom

The 1st edition of Research.com ranking of top Materials Science scientists is based on data collected from Microsoft Academic Graph on December 6th, 2021. Position in the ranking is based on a scientist's D-index (Discipline H-index), which only includes papers and citation values for an examined discipline. Show more

Search by name or affiliation	Q Materials Science	~	United Kingdom (362)	
World National	Scholar	D-Index	Citations Publications	
14   1	Richard H. Friend University of Cambridge, United Kingdom	187	171,412 1,002	
53 2	Terence G. Langdon University of Southampton, United Kingdom	150	108,871 1,434	

Terry Langdon is ranked at #2 in U.K.

## Citation data for NanoSPD and UFG papers

## published in major research journals



Numbers of papers published on research in SPD and HPT Z. Horita and K. Edalati, Mater. Trans. 61 (2020) 2241 NanoSPD1 (Moscow region, Russia, August 1999): establishment of NanoSPD community

- Universality of fabrication of ultrafine grains by SPD for various metals and alloys
- R.Z. Valiev, R.K. Islamgaliev, I.V. Alexandrov: Bulk Nanostructured Materials from Severe Plastic Deformation, Prog. Mater. Sci. 45 (2000) 103-189.

NanoSPD2 (Vienna, Austria, December 2002): establishment of International Steering Committee for the purpose of coordination of the activities in the field of SPD nanomaterials (from left to right): Prof. M. Zehetbauer, R.Z. Valiev, T.G. Langdon, Y.T. Zhu, Y. Estrin, Z. Horita







Extracted from WoS (by Feb. 2023): 5,578 in WoS Core Collection

## Ranking for Prog. Mater. Sci.

Ranking	Author(s)	Year	No. of citations	Reference
2	Valiev <i>et al</i> .	2000	5,574	(1)
5	Gleiter	1989	3,482	(2)
6	Meyers et al.	2006	3,411	(3)
7	Valiev & Langdon	2006	3,400	(4)
13	Zhilyaev & Langdon	2008	2,299	(5)

All-time ranking for *Progress in Materials Science* (892 papers; IF = 48.16)

- (1) R. Z. Valiev, R. K. Islamgaliev and I. V. Alexandrov, Bulk Nanostructured Materials from Severe Plastic Deformation, *Prog. Mater. Sci.* 45 (2000) 103-189.
- (2) H. Gleiter, Nanocrystalline Materials, Prog. Mater. Sci. 33 (1989) 223-315.
- (3) M.A. Meyers, A. Mishra, D.J. Benson, Mechanical properties of nanocrystalline materials, *Prog. Mater. Sci.* 51 (2006) 427-556.
- (4) R.Z. Valiev, T.G. Langdon, Principles of equal-channel angular pressing as a processing tool for grain refinement, *Prog. Mater. Sci.* 51 (2006) 881-981.
- (5) A.P. Zhilyaev, T.G. Langdon, Using high-pressure torsion for metal processing: Fundamentals and applications, *Prog. Mater. Sci.* 53 (2008) 893-979.

## Ranking for Acta Mater.

All-time ranking for Acta Materialia (8,480 papers in Metallurgical Eng.; IF = 9.209)

Ranking	Author(s)	Year	No. of citations	Reference
2	Gleiter	2000	2,414	(6)
3	Kumar <i>et. al</i> .	2003	1,932	(7)
4	Saito <i>et al</i> .	1999	1,816	(8)
9	Estrin & Vinogradov	2013	1,240	(9)

- (6) H. Gleiter, Nanostructured materials: Basic concepts and microstructure, Acta Mater. 48 (2000) 1-29.
- (7) K.S. Kumar, H. Van Swygenhoven, S. Suresh, Mechanical behavior of nanocrystalline metals and alloys, Acta Mater. 51 (2003) 5743-5774.
- (8) Y. Saito, H. Utsunomiya, N. Tsuji, T. Sakai, Novel ultra-high straining process for bulk materials - Development of the accumulative roll-bonding (ARB) process, Acta Mater. 47 (1999) 579-583.
- (9) Y. Estrin, A. Vinogradov, Extreme grain refinement by severe plastic deformation: A wealth of challenging science, Acta Mater. 61 (2013) 782-817.

## Ranking for Scripta Mater.

Ranking	Author(s)	Year	No. of citations	Reference
1	Iwahashi <i>et al</i> .	1996	1,644	(10)
3	Saito <i>et al</i> .	1998	1,075	(11)
4	Tsuji et al.	2002	958	(12)
7	Mukai <i>et al.</i>	2013	724	(13)

All-time ranking for *Scripta Materialia* (6,956 papers in Metallurgical Eng.; IF = 5.611)

- (10) Y. Iwahashi, J. Wang, Z. Horita, M. Nemoto, T.G. Langdon, Principle of equalchannel angular pressing for the processing of ultra-fine grained materials, *Scripta Mater.* 35 (1996) 143-146.
- (11) Y. Saito, N. Tsuji, H. Utsunomiya, T. Sakai, R.G. Hong, Ultra-fine grained bulk aluminum produced by accumulative roll-bonding (ARB) process, *Scripta Mater*. 39 (1998) 1221-1227.
- (12) N. Tsuji, Y. Ito, Y. Saito, Y. Minamino, Strength and ductility of ultrafine grained aluminum and iron produced by ARB and annealing, *Scripta Mater.* 47 (2002) 893-899.
- (13) T. Mukai, M. Yamanoi, H. Watanabe, K. Higashi, Ductility enhancement in AZ31 magnesium alloy by controlling its grain structure, *Scripta Mater.* 45 (2001) 89-94.

## Ranking for Mat. Sci. Eng. A

All-time ranking for Materials Science & Engineering A (23,269 papers in Metallurgical Eng.; IF = 6.004)

Ranking	Author(s)	Year	No. of citations	Reference
3	Segal	1995	1,996	(14)
9	Valiev <i>et al</i> .	1993	1,154	(15)
10	Calcagnotto <i>et al</i> .	2010	1,107	(16)
14	Furukawa <i>et al</i> .	1998	958	(17)

- (14) V.M. Segal, Materials Processing by Simple Shear, *Mat. Sci. Eng. A* 197 (1995) 157-164.
- (15) R.Z. Valiev, A.V. Korznikov, R.R. Mulyukov, Structure and Properties of Ultrafine-Grained Materials Produced by Severe Plastic-Deformation, *Mat. Sci. Eng. A* 168 (1993) 141-148.
- (16) M. Calcagnotto, D. Ponge, E. Demir, D. Raabe, Orientation gradients and geometrically necessary dislocations in ultrafine grained dual-phase steels studied by 2D and 3D EBSD, *Mat. Sci. Eng. A* 527 (2010) 2738-2746.
- (17) M. Furukawa, Y. Iwahashi, Z. Horita, M. Nemoto, T.G. Langdon, The shearing characteristics associated with equal-channel angular pressing, *Mat. Sci. Eng. A* 257 (1998) 328-332.

## Ranking for JOM

Ranking	Author(s)	Year	No. of citations	Reference
1	Valiev <i>et al</i> .	2006	1,317	(18)
9	Ma	2006	373	(19)
12	Valiev <i>et al</i> .	2016	283	(20)

All-time ranking for *JOM* (6,081 papers; IF = 2.471)

- (18) R.Z. Valiev, Y. Estrin, Z. Horita, T.G. Langdon, M.J. Zehetbauer, Y.T. Zhu, Producing bulk ultrafine-grained materials by severe plastic deformation, *JOM* 58(4) (2006) 33-39.
- (19) E. Ma, Eight routes to improve the tensile ductility of bulk nanostructured metals and alloys, *JOM* 58(4) (2006) 49-53.
- (20) R.Z. Valiev, Y. Estrin, Z. Horita, T.G. Langdon, M.J. Zehetbauer, Y.T. Zhu, Producing Bulk Ultrafine-Grained Materials by Severe Plastic Deformation: Ten Years Later, *JOM* 68(4) (2016) 1216-1226.

The results from these analyses are remarkable.

## NanoSPD and UFG papers are ranked at

### #2 in Prog. Mater. Sci., #2 in Acta Mater.,

## #1 in Scripta Mater., #3 in Mater. Sci. Eng. A

and #1 in JOM

## <u>Summary</u>

1.NanoSPD has established a remarkable impact on modern Materials Science.

2. Although it has a very short history, it accounts for four or five of the most-cited papers in several major journals **including the first or second most-cited paper in each journal.** 

3. These citations demonstrate the considerable current interest in using SPD as a processing tool for grain refinement.

# Conclusions

- Conferences of NanoSPD series regarded as the main events in the field of SPD processing of UFG/nanostructured materials, comprising all the aspects from fundamentals to applications.
- Worldwide R&D efforts in this field have been growing every year as evidenced by exponential increase in publications and frequent international conferences such as the series of UFG symposia (TMS), THERMEC, EUROMAT, E-MRS, ICSMA, BNM, ISMANAM, ISOPE, ICSAM, etc.
- Transition from laboratory-scale research to industrial applications is now starting to emerge and many companies worldwide are involved in the R&D activities in this area, medicine holding one of the leading positions