

Atom Probe Tomography and Microscopy APT&M 2018

Organized under the auspices of the International Field Emission Society
June 10th–15th, 2018, Gaithersburg, Maryland, United States

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Conference Co-Chair Person: Eric B. Steel (National Institute of Standards and Technology, USA)

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Gang Sha (Nanjing University of Science and Technology, China)
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Preface: The biennial International Field Emission Symposium, recently renamed Atom Probe Tomography and Microscopy (APT&M), has been in existence since 1952. It was at the 14th Field Emission Symposium (June 1967), held in the Green Auditorium at the National Bureau of Standards (now National Institute of Standards and Technology), that Erwin W. Müller and John A. Panitz first introduced the atom probe field ion microscope. A half-century later, the International Field Emission Society (IFES) returned to the NIST-Gaithersburg campus to hold APT&M 2018, the 56th International Field Emission Society Meeting (June 10–June 15).

APT&M 2018 was well attended, with 215 registered attendees representing institutions from 17 different countries. The meeting agenda offered a broad range of interdisciplinary topics related to atom probe microscopy, field ion microscopy, and high-field nanoscience. The schedule included 164 oral presentations (17 invited) and 94 poster presentations. Prominent plenary speakers delivered presentations on 3-D atomic electron tomography, VUV-EUV laser–matter interactions, density functional modeling of field evaporation, and artificial intelligence and machine learning. Seven tutorials were offered during the meeting on topics including: Avizo software, spatial reconstructions, IVAS-basics, IVAS-semiconductor analysis, IVAS-atomic positioning, sparse data sampling, and interlaboratory studies. The meeting also included two workshops, one on open software and the other on measurement science.

The International Field Emission Society presented several members of the community with honors and awards. The society named two new IFES Fellows, Dr. Nelia Wanderka (Helmholtz-Zentrum Berlin, Germany) and Dr. Frédéric Danoix (Université de Rouen, France). The prestigious J. H. Block Memorial Lecture was presented by Dr. David Saxey (Curtin University, Australia) on the topic of “Contributions of Atom Probe Microscopy Within the Geosciences.” The distinguished Dr. John A. Panitz (University of New Mexico, United States) delivered the first Erwin W. Müller Memorial Lecture, in the Green Auditorium, just prior to the Erwin W. Müller Young Scientist Award Competition. The winner of the competition was Dr. Sten V. Lamberts (Université Libre de Bruxelles, Belgium). The IFES Best Poster Awards were presented to Dr. Yu-Ting Ling (IMEC, Belgium) and Dr. Mohit Raghuwanshi (RWTH, Aachen, Germany). The Wiley Poster Award was

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presented to Dr. Paul Bagot (University of Oxford, United Kingdom). The first IFES Image Contest was held, and the winners were Dr. Mark Hagmann (University of Utah, United States) and Dr. Tong Li (MPIE, Germany). We were honored to have Dr. Sarah Hörst (Johns Hopkins University, United States) as the guest speaker at the IFES Awards Banquet.

The International Field Emission Society would like to express their sincere appreciation to CAMECA, Thermo Fisher Scientific, Carl Zeiss Microscopy, NanoMEGAS, and John Wiley & Sons for their recent support of the society and of IFES-organized events at APT&M. Together with their assistance, the IFES-organized events were very successful. Likewise, we acknowledge the help of both MSA-APT-FIG, MSA, and MAS leaderships for their help in promoting APT&M within their member communities. The organizers greatly appreciate the kindness and willingness with which the scientific staff at the Smithsonian National Air and Space Museum, National Gallery of Art, National Museum of Natural History, and Library of Congress Preservation Research and Testing Laboratories opened their laboratory spaces and exhibits to meeting attendees for off-site technical presentations.

The organizers would like to thank everyone who contributed to making this meeting a success, including: Topic Area and Session Chairs, Workshop and Tutorial Organizers, NIST Conference Services, NIST Transportation Services, NIST Audio Visual Services, NIST Computer Lab and IT, and NIST Administrative Assistants. Without their patience and efforts, the meeting would not have been possible. The organizers would like to give a special “thank you” to Dr. Keith Knipping for assembling and formatting the APT&M 2018 printed program and to Dr. Mattias Thuvander and Dr. Gang Sha in their roles as guest editor and assistant guest editor, respectively, for these conference proceedings.

Thank you to everyone who attended APT&M 2018. We hope you enjoyed the meeting and that your experiences foster new ideas and developments in your own research. We look forward to seeing you all at the University of Oxford (UK), for APT&M in July 2020.

Fred Meisenkothen, Eric Steel, David Larson

Presidents of IFES

Years	President	Vice-President
1987–1990	J.H. Block (Germany)	G.D.W. Smith (UK)
1990–1992	G.D.W. Smith (UK)	H. Nordén (Sweden)
1992–1993	G.D.W. Smith (UK)	G.L. Kellogg (USA)
1993–1995	M.K. Miller (USA)	M. Yamamoto (Japan)
1993–1995	M.K. Miller (USA)	D. Blavette (France)
1996–1997	R.G. Forbes (UK)	M.K. Miller (USA)
1997–2000	R.G. Forbes (UK)	A.J. Melmed (USA)
2000–2001	D.N. Seidman (USA)	R.G. Forbes (UK)
2001–2002	D.N. Seidman (USA)	D. Blavette (France)
2002–2006	R.G. Forbes (UK)	T.F. Kelly (USA)
2006–2008	T.F. Kelly (USA)	R.G. Forbes (UK)
2008–2014	N. Kruse (Belgium)	S.P. Ringer (Australia)

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Years	President	Vice-President
2014–2018	D.J. Larson (USA)	F. Vurpillot (France)
2014–2018	D.J. Larson (USA)	J. Cairney (Australia)

LOCATION OF PREVIOUS INTERNATIONAL FIELD EMISSION SYMPOSIA

No.	Conference Site	Conference Organizers	Proceedings Publishers (Year), Eds.
1.	1952 McMinnville, OR	W.P. Dyke	
2.	1954 Pittsburgh, PA	M. Wachtel	
3.	1956 Notre Dame, IN	J.A. Becker	
4.	1957 University Park, PA	E.W. Müller	
5.	1958 Chicago, IL	R. Gomer	
6.	1959 Washington, DC	L. Marton	
7.	1960 McMinnville, OR	W.P. Dyke, F. Charbonnier	
8.	1961 Williamson, MA	G. Ehrlich	
9.	1962 Notre Dame, IN	E.A. Coomes	
10.	1963 Berea, OH	T. George	
11.	1964 Cambridge, UK	D.J. Brandon, M.J. Southon	
12.	1965 University Park, PA	E.W. Müller	
13.	1966 Ithaca, NY	T.N. Rhodin	
14.	1967 Gaithersburg, MD	L. Marton	
15.	1968 Bonn, Germany	H.D. Beckey	
16.	1969 Pittsburgh, PA	S.S. Brenner, J.T. McKinney	
17.	1970 New Haven, CT	F. Hutchinson	
18.	1971 Eindhoven, Netherlands	A. van Oostrom	
19.	1972 Urbana-Champaign, IL	G. Ehrlich	
20.	1973 University Park, PA	E.W. Müller, T.T. Tsong	
21.	1974 Marseille, France	M. Drechsler	
22.	1975 Atlanta, GA	H.E. Grenda, J.J. Hren	
23.	1976 University Park, PA	T.T. Tsong, E.W. Müller	
24.	1977 Oxford, UK	G.D.W. Smith	
25.	1978 Albuquerque, NM	J.A. Panitz, G.L. Kellogg	
26.	1979 Berlin, Germany	J.H. Block	
27.	1980 Tokyo, Japan	Y. Yashiro, N. Igata	The University of Tokyo (Tokyo, 1980)

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No.	Conference Site	Conference Organizers	Proceedings Publishers (Year), Eds.
			Eds.: Y. Yashiro, N. Igata
28.	1981 Portland, OR	L.W. Swanson	
29.	1982 Göteborg, Sweden	H. Norden, H.-O. Andren	Almquist and Wiksell (Stockholm, 1982)
			Eds.: H. Norden, H.-O. Andren
30.	1983 Philadelphia, PA	W.R. Graham	
31.	1984 Paris, France	P. Sudraud, P. Ballongue	J. de Physique 45-C9 (1984)
			Eds.: P. Sudraud, P. Ballongue
32.	1985 Wheeling, WV	S.S. Brenner, M.K. Miller	J. de Physique 47-C2 (1986)
			Eds.: M.K. Miller, S.S. Brenner
33.	1986 Berlin, Germany	J.H. Block, W.A. Schmidt	J. de Physique 47-C7 (1986)
			Eds.: J.H. Block, W.A. Schmidt, M.K. Miller
34.	1987 Osaka, Japan	S. Nakamura, O. Nishikawa	J. de Physique 48-C6 (1987)
			Eds.: S. Nakamura, O. Nishikawa, M.K. Miller
35.	1988 Oak Ridge, TN	M.K. Miller	J. de Physique 49-C6 (1988)
			Ed.: M.K. Miller
36.	1989 Oxford, UK	G.D.W. Smith, A. Cerezo	J. de Physique 50-C8 (1989)
			Eds.: A. Cerezo, M.K. Miller, G.D.W. Smith
37.	1990 Albuquerque, NM	G.L. Kellog, J.A. Panitz	Surf. Sci. 246 (1991)
			Eds.: G.L. Kellog, J.A. Panitz, P.R. Schwoebel
38.	1991 Vienna, Austria	J. Mitterauer	Surf. Sci. 246 (1992)
			Ed.: J. Mitterauer
39.	1992 Halifax, Canada	H.J. Kreuzer	Appl. Surf. Sci. 67 (1993)
			Eds.: M.K. Miller, H.J. Kreuzer
40.	1993 Nagoya, Japan	F. Okuyama, M. Yamamoto	Appl. Surf. Sci. 76/77 (1994)

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No.	Conference Site	Conference Organizers	Proceedings Publishers (Year), Eds.
			Eds.: M. Yamamoto, F. Okuyama, M.K. Miller
41.	1994 Rouen, France	D. Blavette, A. Menand	Appl. Surf. Sci. 87/88 (1995)
			Eds.: D. Blavette, A. Menand, M.K. Miller
42.	1995 Madison, WI	T.F. Kelly, P.P. Camus	Appl. Surf. Sci. 94/95 (1995)
			Eds.: M.K. Miller, T.F. Kelly
43.	1996 Moskau, Russia	R. Bakhtizin, A.L. Suvorov	J. de Physique C5 (1996)
			Eds.: M.K. Miller, A.L. Suvorov, R. Bakhtizin
44.	1997 Tsukuba, Japan	K. Hono	Ultramicroscopy 73 (1998) & Mater. Sci. Eng. A 250 (1998)
			Eds.: K. Hono, M. Tsukada
45.	1998 Irbid, Jordan	M.S. Mousa	Ultramicroscopy 79 (1999) & Mater. Sci. Eng. A 270 (1999)
			Eds.: M.S. Mousa, F. Danoix
46.	2000 Pittsburgh, PA	A.J. Melmed, J.M.K. Wiezorek	Ultramicroscopy 79 (1999) & Mater. Sci. Eng. A 270 (1999)
		D.N. Seidman, W.A. Soffa	Eds.: F. Danoix, D.N. Seidman
47.	2001 Berlin, Germany	N. Wanderka	Ultramicroscopy (2002) & Mater. Sci. Eng. (2002)
			Eds.: N. Wanderka, F. Danoix, R. Forbes
48.	2002 Lyon, France	V.T. Binh and D. Blavette	Surf. Interface Anal. 36 (2004)
			Eds.: F. Danoix, R. Forbes
49.	2004, Seggau, Austria	M. Leisch	Surf. Interface Anal. 39 (2007)
			Eds.: F. Danoix, J. Xanthakis, R. Forbes

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No.	Conference Site	Conference Organizers	Proceedings Publishers (Year), Eds.
50.	2006, Guilin, China	Ningsheng Xu	Ultramicroscopy 107 (2007) Eds.: K. Stiller, N. Wanderka, Y. Suchorski
51.	2008, Rouen, France	A. Menand	Ultramicroscopy 109 (2009) Eds.: K. Stiller, N. Wanderka, Y. Suchorski
52.	2010, Sydney, Australia	S.P. Ringer	Ultramicroscopy 111 (2011) Eds.: Y. Suchorski, G. Schmitz
53.	2012, Tuscaloosa, AL, USA	G.B. Thompson	Ultramicroscopy 132 (2013) Eds.: G. Schmitz, B. Deconihout, H. J. Kreuzer
54.	2014, Stuttgart, Germany	G. Schmitz	Ultramicroscopy 159 (2015) Eds.: B. Deconihout, H.J. Kreuzer, G. Schmitz
55.	2016, Gyeongju, Korea	C.G. Park	Micosc. Microanal. 23 (2017) Eds.: M. Thuvander, S.S.A. Gerstl, J.M. Cairney

WINNERS OF THE E.W. MÜLLER OUTSTANDING YOUNG SCIENTISTS MEDAL

(1978)	A.R. Waugh	Cambridge University, UK
(1979)	H.-W. Fink	Technische Universität Clausthal, Germany
(1980)	Y. Kuk	The Pennsylvania State University, USA
(1981)	S.J. Banard	Oxford University, UK
(1982)	J.M. Derocette	University of Liege, Belgium
(1983)	D.R. Kingham	Cambridge University, UK
(1984)	M.G. Hetherington	Oxford University, UK
(1985)	M. Ahmad	The Pennsylvania State University, USA

(1986)	L. Karlsson	Chalmers Institute of Technology, Sweden
(1987)	P.P. Camus	Oak Ridge National Laboratory, USA
(1988)	A. Cerezo	Oxford University, UK
(1989)	J. Dirks	Fritz-Haber-Institut der Max-Planck-Gesellschaft, Germany
(1990)	J.E. Brown	Oxford University, UK
(1991)	F. Danoix	University of Rouen, France
(1992)	H. Schmid	IBM, Switzerland
(1993)	M.C. Reckzügel	Fritz-Haber-Institut der Max-Planck-Gesellschaft, Germany
(1994)	R.C. Thomson	Cambridge University, UK
(1995)	C. Voss	ETH Zentrum Zürich, Switzerland
(1996)	L. Li	Tohoku University, Sendai, Japan
(1997)	C. Schmuck-Pareige	University of Rouen, France
(1998)	K. Nagaoka	Waseda University, Japan
(2001)	Ch. Lang	Universität Göttingen, Germany
(2002)	E. Marquis	Northwestern University, USA
(2004)	B. Cho	Waseda University, Japan
(2006)	W.M. Tsang	University of Surrey, UK
(2008)	M. Moors	Université Libre de Bruxelles, Belgium
(2010)	P. Stender	University of Münster, Germany
(2012)	M. Roussel	University of Rouen, France
(2014)	C. Oberdorfer	University of Stuttgart, Germany
(2016)	M. Dagan	Oxford University, UK
(2018)	S.V. Lambeets	Université libre de Bruxelles, Belgium

SCIENTISTS SELECTED FOR THE HONORY J. H. BLOCK LECTURE

Since 2010, the International Field Emission Society has decided to give a special tribute to young but well established scientists who have brought a new and important contribution to the field.

(2010)	Thierry Visart de Bocarmé, Université Libre de Bruxelles, Belgium
(2012)	Angela Vella, University of Rouen, France
(2014)	Peter Hommelhoff, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany
(2016)	Paul Bagot, Oxford University, UK
(2018)	David Saxey, Curtin University, Australia

Commemorating Robert Gomer



Robert Gomer, one of the pioneers in Surface Science, died on 12 December 2016 in Chicago at age 92, after long suffering from Parkinson's disease. He is survived by his wife Anne, two children and three grandchildren. For the Field Emission community his death is a particularly sad loss.

Robert Gomer was born on 24 March 1924 in Vienna, Austria. He had to leave his home town in 1938 with a child transport to England, from where he went on to the USA in 1940 to be reunited with his parents. He was educated at Pomona College and the University of Rochester, where he received his PhD in Chemistry in 1949. He then worked as a postdoctoral fellow at Harvard with G.B. Kistiakowsky on molecular chemical kinetics. From there he moved to the James Franck Institute and the Department of Chemistry of the University of Chicago, first as an instructor and then as a Professor. From 1977 to 1983 he was director of the James Franck Institute; in 1984 he was named the Carl W. Eisendrath Distinguished Service Professor until 1996 when he became professor emeritus. He won numerous awards including national ones: the Davison-Germer Prize of the American Physical Society, the Medard W. Welch Award of the American Vacuum Society, and the Arthur W. Adamson Award for Distinguished Service in the Advancement of Surface Chemistry of the American Chemical Society. He was elected to the National Academy of Sciences in 1981.

His research centered on the investigation of surface processes. He became a world authority in the field now called Surface Science. In the 1950s the investigation of surface processes had not proceeded much beyond Langmuir's achievements, because it was limited by the inability to define the composition of a surface, to routinely establish sufficient ultrahigh vacuum (UHV) conditions, to measure the residual pressure, and to prepare and define clean samples. It was still the "tungsten age" because this metal was the sample of choice: its high melting point made it likely that a clean surface could be obtained, although success

could not be easily verified. None of the now amply available surface spectroscopies used for standard characterization were available then. Also, since commercial UHV apparatus and single crystals were not available, filaments and evaporated films of often uncertain surface composition were used. The field emission microscope (FEM) offered a way out. Using bakeable glass apparatus and tungsten tips, the FEM image could be used to check surface cleanliness, observe the adsorption of atoms and molecules, measure work function changes to quantify adsorption, and to estimate residual pressure. Prompted by hearing a talk by E.W. Müller, Gomer became interested in this technique; he built an apparatus himself, and used it for the investigation of atomic and molecular surface processes. In this emerging field he soon became one of the world's top experts, carrying out elegant experiments on the adsorption and thermal desorption of simple gases and alkali atoms. His book on field emission, based on lectures given in 1958 at Harvard, is still a classic in the field. He also was very interested in the theory of these processes and developed a theory of field-induced surface processes, and of desorption of adsorbates stimulated by electron impact. In the 1960s, when surface theory was in its infancy, he collaborated with J.R. Schrieffer (Nobel Prize 1972) and published the first theoretical description of the adsorption bond. A textbook mechanism explaining electron stimulated desorption as a transition from the neutral bound to an ionic unbound state, is the so called MGR (Menzel-Gomer-Redhead) mechanism. Later his interest shifted to surface diffusion, a key process related to catalysis and dynamics of 2D systems. He developed a novel method to study diffusion under equilibrium conditions by measuring concentration fluctuations on the FEM tip from fluctuations in the tunneling current that can be used to measure time-dependent correlation functions and test predictions of 2D dynamics in statistical mechanics (his 1990 classic review paper in *Reports on Progress* has been cited 1069 times).

Bob Gomer transmitted his enthusiastic approach to research to his doctoral students and postdocs. He was a person of high standards carrying out exhaustive sets of experiments and developing a theoretical understanding of the phenomena being investigated. His high expectations and stringent insistence on hard work, experimental skill, and theoretical understanding have been lifelong lessons for his coworkers and contributed immensely to their maturing, scientifically and personally, as I can amply testify.

Besides his scientific interests Gomer had an unusually broad range of interests in theatre, culture, and government policies that made him a very popular discussion partner in Chicago and at conferences. He was an outspoken opponent of the proliferation of nuclear weapons, and chaired the board of the *Bulletin of Atomic Scientists*. In his later years he organized lectures about these problems at his house in Chicago. He was an avid skier and hiker.

Bob Gomer was an eminent scientist and a great human being. He will be commemorated dearly by all who met him.

Prof. Dietrich Menzel (Technische Universität München and Fritz-Haber-Institut der Max-Planck-Gesellschaft).