



**26<sup>TH</sup> INTERNATIONAL  
FIELD EMISSION SYMPOSIUM  
BERLIN (WEST)**

**SEPTEMBER 3 - 8, 1979**

**FRITZ-HABER-INSTITUT DER  
MAX-PLANCK-GESELLSCHAFT**

26<sup>TH</sup> INTERNATIONAL FIELD EMISSION SYMPOSIUM

September 3 - 8, 1979

Program and Abstracts

Organized by the Fritz-Haber-Institut der Max-Planck-Gesellschaft,

and held on the campus of Evangelisches Johannisstift, Berlin-Spandau

Sponsored by the Fritz-Haber-Institut der Max-Planck-Gesellschaft

Deutsche Forschungsgemeinschaft and the Land Berlin (West)

Local Organizing Committee of the 26th International Field

Emission Symposium

September 2 - 8, 1979

J.H. Block (Fritz-Haber-Institut) Chairman

W.A. Schmidt (Fritz-Haber-Institut)

F.W. Röllgen (Universität Bonn)

R. Wagner (Universität Göttingen)

## Preface

It is a pleasure to welcome scientists from many countries in West-Berlin for the 26th International Field Emission Symposium. We are looking forward to a busy week with a broad and varied technical program and different social events. We hope that the symposium will be profitable and the visit to Berlin enjoyable.

We generously received financial support from the Max-Planck-Gesellschaft, the Deutsche Forschungsgemeinschaft and the Senator für Wirtschaft of Berlin-West. We are grateful also to the City of Berlin for an invitation for a reception at the Zitadelle Spandau.

The organizing committee received vigorous administrative support from the Fritz-Haber-Institut of the Max-Planck-Gesellschaft in particular secretary work by Mrs. Gross. The preparation of the book of abstracts was facilitated by the profitable co-operation with the printing office of the Institut für Bildungsforschung of the Max-Planck-Gesellschaft.

Finally we would like to thank the management of the Johannesstift, in particular Mr. Moisich, for their willingness to comply with many wishes we had while organizing this symposium.

J.H. Block  
Local Organizing Committee  
Chairman, 26th International  
Field Emission Symposium



### List of Past Field Emission Symposia and their Organizers

- |     |      |                               |                               |
|-----|------|-------------------------------|-------------------------------|
| 1.  | 1952 | McMinnville, Oregon           | W.P. Dyke                     |
| 2.  | 1954 | Pittsburgh, Pennsylvania      | M. Wachtel                    |
| 3.  | 1956 | Notre Dame, Indiana           | J.A. Becker                   |
| 4.  | 1957 | University Park, Pennsylvania | E.W. Müller                   |
| 5.  | 1958 | Chicago, Illinois             | R. Gomer                      |
| 6.  | 1959 | Washington, D.C.              | L. Marton                     |
| 7.  | 1960 | McMinnville, Oregon           | W.P. Dyke & F. Charbonnier    |
| 8.  | 1961 | Williamstown, Massachusetts   | G. Ehrlich                    |
| 9.  | 1962 | Notre Dame, Indiana           | E.A. Coomes                   |
| 10. | 1963 | Berea, Ohio                   | T. George                     |
| 11. | 1964 | Cambridge, England            | D.G. Brandon & M.J. Southon   |
| 12. | 1965 | University Park, Pennsylvania | E.W. Müller                   |
| 13. | 1966 | Ithaca, New York              | T.N. Rhodin                   |
| 14. | 1967 | NBS Gaithersburg, Maryland    | L. Marton                     |
| 15. | 1968 | Bonn, Germany                 | H.D. Beckey                   |
| 16. | 1969 | Pittsburgh, Pennsylvania      | S.S. Brenner & J.T. McKinney  |
| 17. | 1970 | New Haven, Connecticut        | F. Hutchinson                 |
| 18. | 1971 | Eindhoven, The Netherlands    | A. van Oostrom                |
| 19. | 1972 | Urbana-Champaign, Illinois    | G. Ehrlich                    |
| 20. | 1973 | University Park, Pennsylvania | E.W. Müller & T.T. Tsong      |
| 21. | 1974 | Marseille, France             | M. Drechsler                  |
| 22. | 1975 | Atlanta, Georgia              | H.E. Grenga, J.J. Hren et al. |
| 23. | 1976 | University Park, Pennsylvania | E.W. Müller & T.T. Tsong      |
| 24. | 1977 | Oxford, England               | G.D.W. Smith                  |
| 25. | 1978 | Albuquerque, New Mexico       | J.A. Panitz                   |

The 1979

Steering Committee of the International Field-Emission Symposium

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M.J. Southon (Cambridge University)  
Cambridge, England

PROGRAM OF THE 26TH INTERNATIONAL FIELD EMISSION SYMPOSIUM

Monday, September 3, 1979

9:00 am Opening Remarks: J.H. Block

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Chairman: T.T. Tsong

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#### EXCURSION

1:30 pm Coach Departure

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8:15 pm Dinner

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- 9:30 am VISIT OF THE FRITZ-HABER-INSTITUT



On the Atomic Structure of (001)W

A. J. Melmed and J. J. Carroll  
National Bureau of Standards, U.S.A.

and

W. R. Graham\* and R. T. Tung\*  
University of Pennsylvania, U.S.A.

and

G.D.W. Smith  
University of Oxford, U.K.

Investigations of the structure of clean (001)W by (primarily) LEED have shown that the "normal", that is (1x1), symmetry reversibly changes as the crystal is cooled below  $\sim 300\text{K}^{(1)}$  -  $370\text{K}^{(2)}$  to a structure which yields a c(2x2) diffraction pattern<sup>(1)</sup> or, if the crystal has an appropriate abundance of step edges, to an aggregate of two domains with ( $\sqrt{2} \times \sqrt{2}$ )R45° symmetry.<sup>(2)</sup> The most recent work<sup>(2)</sup> concludes that the presence of step edges and other defects inhibits the transformation so that at  $\sim 190\text{K}$  only 50-60% of the surface may be reconstructed. Two reconstruction models have been proposed involving either lateral<sup>(1,2)</sup> or perpendicular<sup>(3)</sup> displacements of surface atoms. FEEM and FIM have all but been ruled out<sup>(2)</sup> as feasible observational techniques for exploring the problem.

The capabilities of FEEM and FIM to meaningfully contribute information bearing on the question of (001)W reconstruction will be elucidated.

An early FIM report<sup>(4)</sup> mentioned a reconstructed c(2x2) structure for (001)W; and a recent FIM report<sup>(5)</sup> concluded that the structure of (001)W at low temperature (down to 21K) is (1x1).

We have reviewed old micrographs and obtained new evidence, all of which indicates that indeed the structure of (001)W obtained by low-temperature ( $\sim 300\text{K} - 15\text{K}$ ) field-evaporation (in helium gas) is often not (1x1). Examples will be shown of (1x1), c(2x2), and mixed structures observed by FIM, and

possible interpretations will be discussed. Most of the examples of non- (1x1) structures do not seem to be consistent with the LEED-derived lateral-displacement models. One or two examples may be consistent with the lateral  $\langle 100 \rangle$  displacement model,<sup>(1)</sup> but most appear to relate to periodic vertical displacements or lateral-plus-vertical displacements. The presence of the strong FIM electric field complicates, but does not preclude accumulating evidence for reconstruction of (001)W.

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- 1) K. Yonehara and L. D. Schmidt, Surf. Sci. 25 (1971) 238-260.
  - 2) M. K. Debe and D. A. King, J. Phys. C10 (1977) L303 and Surf. Sci. 81 (1979) 193-237.
  - 3) Barker, Estrup, Jona, and Marcus, Solid State Comm. 25 (1978) 375-379.
  - 4) E. W. Müller, Abstracts 15<sup>th</sup> IFES (September 1968).
  - 5) J. Sweeney and T. T. Tsong, 39<sup>th</sup> Physical Electronics Conference (June 1979).

\* Funded by the National Science Foundation, Metallurgy Division  
Grant # DMR 07542

FIM Observation of Superstructures  
on W and Mo (001) and (011) Planes

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FIM observation has revealed that the Ga atoms on the W and Mo (011) plane form a monoatomic layer arranged in the (3x3) superstructure assembled by the zigzag chains which are identical to that observed for W atoms.<sup>1,2</sup> Color-superposed images indicate that the Ga atoms of the zigzag chains are displaced in the  $[0\bar{1}1]$  or  $[01\bar{1}]$  direction from an open W lattice site to the position where displaced atoms are stabilized by contacting three substrate W atoms. No superstructure of Sn was observed on the (011) plane.

While the Ga atoms on the (001) plane exhibit the densely packed (1x1) structure, Sn shows a clear image of the (2x2) superstructure which is closely connected to the arrangement of several W atoms remaining on the same plane. The observed results indicate that the surface structure is not influenced by the field strength and that the arrangement of W atoms on the (001) plane is the (1x1) structure except for a few atoms at an edge of and on the plane.

1. S. Nishigaki and S. Nakamura: Jpn. J. Appl. Phys. 14 (1975) 769.
2. M. Audiffren, P. Traimond, J. Bardon and M. Drechsler: Surface Sci. 75 (1978) 751.