

# Lawrence Berkeley National Laboratory

## LBL Publications

### **Title**

Surface Science and Catalysis

### **Permalink**

<https://escholarship.org/uc/item/8hw9p6b1>

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### **Publication Date**

1990-07-01

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A NEW INDUSTRIAL  
COOPERATIVE PROGRAM

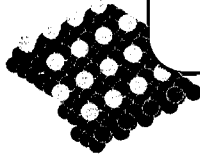
**SURFACE  
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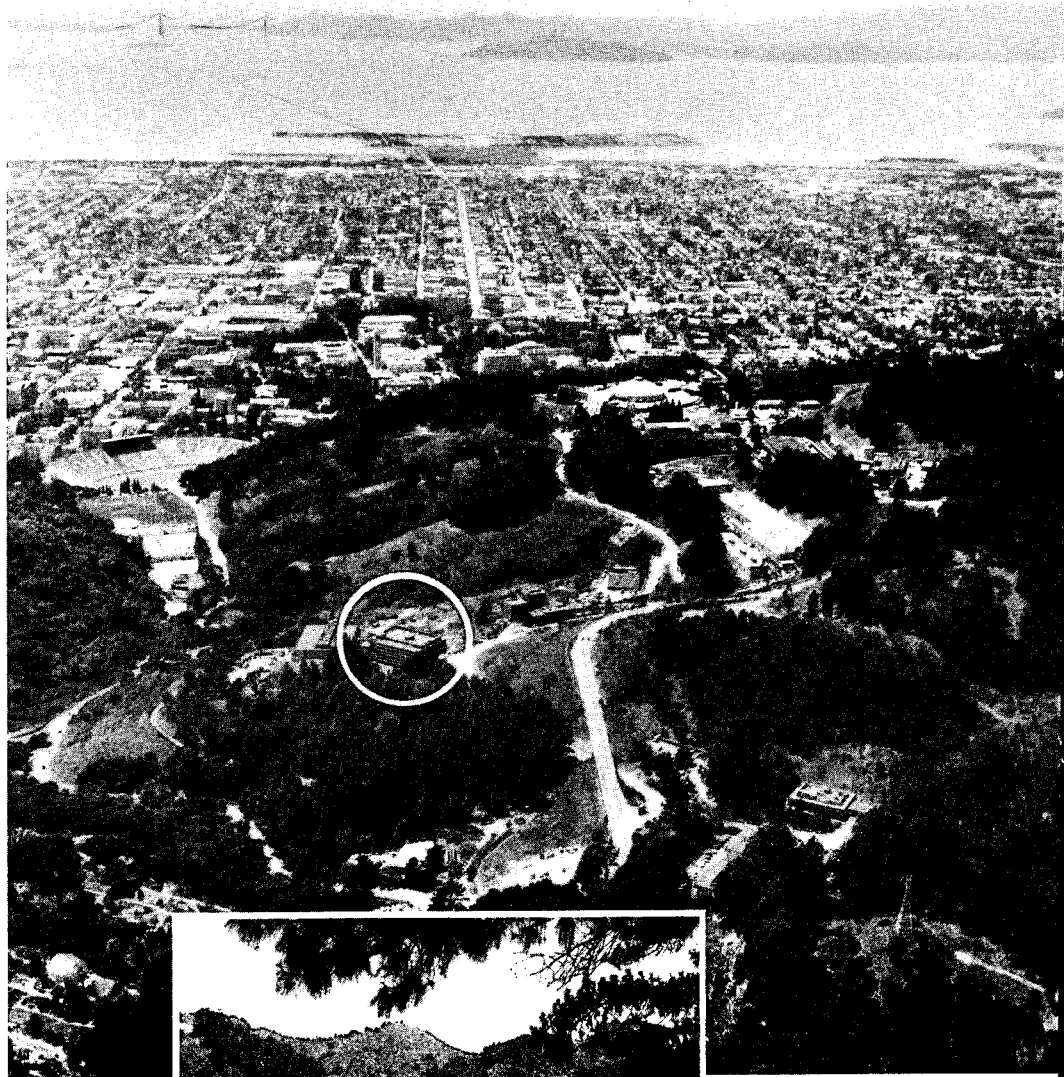
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Center for Advanced Materials  
Lawrence Berkeley Laboratory  
University of California  
Berkeley, California

The Surface Science and Catalysis Laboratory is in the Berkeley Hills overlooking the San Francisco Bay. It is part of the Lawrence Berkeley Laboratory and the University of California at Berkeley.



## A NEW INDUSTRIAL COOPERATIVE PROGRAM

*"America's national labs offer resources that don't exist in one place anywhere else in the country. We have teams of highly trained and skilled people who work together and exchange ideas across disciplines. We are an extremely rich store of knowledge, not only in the results of our research but in the techniques and technologies with which we carry it out."—Charles V. Shank, Director, Lawrence Berkeley Laboratory*

**T**HE Surface Science and Catalysis Program (SSCP) within LBL's Center for Advanced Materials (CAM) invites your participation in a new industrial cooperative program that will allow your company to tap into our rich store of experience and expertise in several key areas of surface-science and catalysis research. At the same time, your participation will help us to achieve the critical level of effort necessary for continued leadership in research that is of major economic importance to the chemical, fuel, petrochemical, materials, and computer industries. And we will gain new insight into emerging industrial needs, both in research and in education of future scientists and engineers.

Designed to help U.S. industry maintain its traditional leadership position, the new cooperative program will provide participants with important competitive advantages. The program will be a key mechanism for the rapid transfer of technology from basic and applied research to commercial application. Participants will have the use of specialized LBL facilities and will have opportunities to consult with the SSCP staff, attend workshops, and to obtain research results in advance of publication. A prime benefit of participation will be long-term personal interaction between your company's technical and managerial staff and the SSCP scientific staff, many of whom have joint appointments with the University of California at Berkeley, and graduate students from the Berkeley campus.

# SURFACE SCIENCE AND CATALYSIS PROGRAM

**T**HE SSCP is part of the industry-oriented Center for Advanced Materials. From its inception its task has been to lay the scientific foundation for solution of significant problems that may provide leads to new products and to innovative technologies that have the potential to create new industries and transform markets. It is intended to develop, through long-range, interdisciplinary research, the scientific foundation that will assist industries in developing new and improved products that are critically dependent on surfaces and on the processes that take place at surfaces.

*Research*, including industrial collaboration, and education are the dual thrusts by which the SSCP meets this challenge. Research focuses on atomic-level understanding of surface structure and surface processes through the experimental and theoretical investigation of

- Heterogeneous catalysis
- Coatings and tribology (friction, wear, lubrication)
- New surface instrumentation

*Education*, under the guidance and direction of staff and faculty scientists, takes the form of training

- Visitings scientists
- Graduate students from the University of California at Berkeley
- Postdoctoral fellows

It also provides a source of knowledgeable and experienced graduates for industry.

Industrial participation in the cooperative program will provide continued support for ongoing work and will allow us to launch new projects in basic surface-science and catalysis research.

## RESEARCH: Heterogeneous Catalysis

**T**HE Heterogeneous Catalysis Program emphasizes the correlation of results of experiments on model systems (such as low-surface area single crystals) with high-surface area commercial catalysts. Past investigations have included

- The role of transition metals in ammonia synthesis, hydrocarbon conversion, hydrodesulfurization, and  $C_1$  chemistry
- The role of molecular and physical interactions in the synthesis of zeolites (NMR studies)

Such studies use and develop (in addition to chemical reaction kinetics) tools to investigate structure (LEED, STM, AFM, etc.) and to determine composition (AES, TDS, ISS, XPS, SIMS).

Under the industry cooperative program, it is proposed to extend molecular-level studies to include

- Catalysis by oxides (partial oxidation, oxydehydrogenation, combustion, reactions with steam, environmental control)
- Oxide-metal interface catalysis (CO-bond hydrogenation  $NO_x$  reduction, hydrocarbon conversion)
- Solid-liquid interface catalysis (selective hydrogenation)
- Promoters (structure and bonding modifiers)

## RESEARCH: Coatings and Tribology

**T**HE Coatings and Tribology Program focuses on atomic level determination of the structure and chemical bonding of interfaces. The aim is to relate these molecular properties to macroscopic mechanical properties of surfaces, adhesion, hardness, friction, and lubrication. At present studies explore the

- **Surface structure of transition metals and adsorbed organic monolayers**
- **Plasma deposition and characterization of hard coatings (SiC, TiN, and hard carbon)**

In the course of our research, we have developed techniques to characterize surface structures (low-energy electron diffraction, vibrational spectroscopies, and scanning tunneling microscopy); to measure mechanical properties in ultrahigh vacuum (indentation, scratch adhesion, and friction coefficient); and to characterize buried interfaces (scanning Auger, electron microscopy, Rutherford backscattering, and secondary ion mass spectroscopy).

Under the industry cooperative program, it is proposed to extend molecular-level studies to include

- **Polymer surfaces (in collaboration with the polymer and composite CAM program)**
- **Buried oxide-metal, polymer-metal, liquid-metal interfaces**



## RESEARCH: New Instrumentation Program

**T**HE Instrumentation Program has concentrated on the development of techniques that monitor interface properties (structure, composition, bonding) with atomic spatial resolution, shorter time scale, and in the absence of long range order. These include

- Scanning tunneling and atomic force microscopy
- Nonlinear laser optics
- Low-energy electron diffraction

for studies of surfaces and interfaces. The program aims are to obtain molecular-level information with atomic spatial resolution and to improve both time and energy resolution. Techniques cover low-surface area systems ( $\sim 2 \text{ m}^2/\text{gm}$ ), as well as high-surface area systems ( $\sim 500 \text{ m}^2/\text{gm}$ ).

Under the industry cooperative program, it is proposed to extend the instrumentation program to molecular-level studies of solid-liquid and solid-solid interfaces and on the development of real-time measurements of dynamic surface properties under reaction conditions. The focus will be on

- Atomic force microscopy for studies of surface structure, friction, and wear
- Laser spectroscopies for studies of buried interfaces (solid-liquid and solid-solid)
- Scanning tunneling microscopy studies of surface structure during catalytic reactions

## EDUCATION

**T**HE education program is directed at (1) developing the skill of *visiting industrial scientists* through tools of modern surface science and catalysis and through various research programs, and (2) training *graduate students and postdoctoral fellows* who will likely enter industrial employment upon completion of their project or degree.

Under the industry cooperative program, it is proposed to extend the education program to include workshops of three to five days duration on the general topics of

- **Modern instrumentation**
- **New concepts and research advances**
- **Overview of international research**

Selection of specific topics will be tied to the ongoing research interests of the SSCP staff and the industrial participants.

The instruments and techniques that are available to the participants of SSCP for their use in the various studies include

- **Scanning tunneling and atomic force microscopes**
- **Fourier transform infrared and laser-Raman spectrometers**
- **Solid state and solution NMR**
- **Low energy electron diffraction and x-ray diffraction**
- **Electron spectrometers for XPS, UPS, HREELS**
- **Ion spectroscopies, ISS, SIMS**
- **Nonlinear laser spectroscopies, SHG, SFG**
- **Rutherford backscattering**
- **Gas chromatographs and mass spectrometers**

## INDUSTRIAL COOPERATIVE PROGRAM MEMBERSHIP

Y

OUR participation in the SSCP industrial cooperative program in surface science and catalysis is invited.

Membership subscriptions will be available for 1-year and 3-year periods. The costs are

Annual cost:                   \$30,000

Three-year cost :           \$80,000

Members will have the opportunity to

- **Participate in a special annual meeting to discuss future directions of the program**
- **Obtain licenses on patents developed during their period of membership**

Additionally, members will

- **Be invited to participate in workshops, annual review, and discussion meetings**
- **Be able to send industrial fellows to participate in SSCP research for any length of time**
- **Have access to graduate students and postdoctoral fellows for recruiting**
- **Receive annual reports and reprints of published papers**
- **Have unlimited visits to SSCP**

## ALTERNATIVE MODES OF PARTICIPATION

**T**HE charter of the Center for Advanced Materials permits numerous alternative modes of participation in the activities of the SSCP should the particular needs of a company not be met by the industrial cooperative program. Patent rights and protection of proprietary information can be negotiated to meet the needs of the sponsor. The possible alternatives include

- **Unrestricted gifts**
- **Fellowship sponsorship**
- **Gifts of material and equipment**
- **Research contracts**



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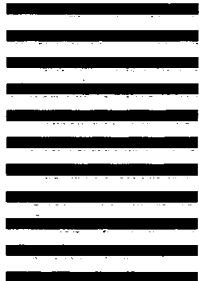
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Berkeley, CA 94720**

Attn: Professor Gabor A. Somorjai  
Center for Advanced Materials  
MS 66



For more information about the **INDUSTRIAL COOPERATIVE PROGRAM IN SURFACE SCIENCE AND CATALYSIS**, fill out and return this postage-paid form

- I am interested in the cooperative program
- I am interested in alternate modes of participation
- Please telephone me as soon as possible

Name \_\_\_\_\_

Company \_\_\_\_\_

Address \_\_\_\_\_

Phone \_\_\_\_\_

Research Interests \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

## LBL PRINCIPAL INVESTIGATORS IN THE CAM SURFACE SCIENCE AND CATALYSIS PROGRAM

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## INDUSTRIAL ADVISORY BOARD

In common with all programs of the Center for Advanced Materials, SSCP activities are regularly reviewed by an advisory board whose members come from a broad but appropriate spectrum of industrial firms. Current members of the SSCP advisory board are the following:

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**CENTER FOR ADVANCED MATERIALS**  
**Surface Science and Catalysis Program**

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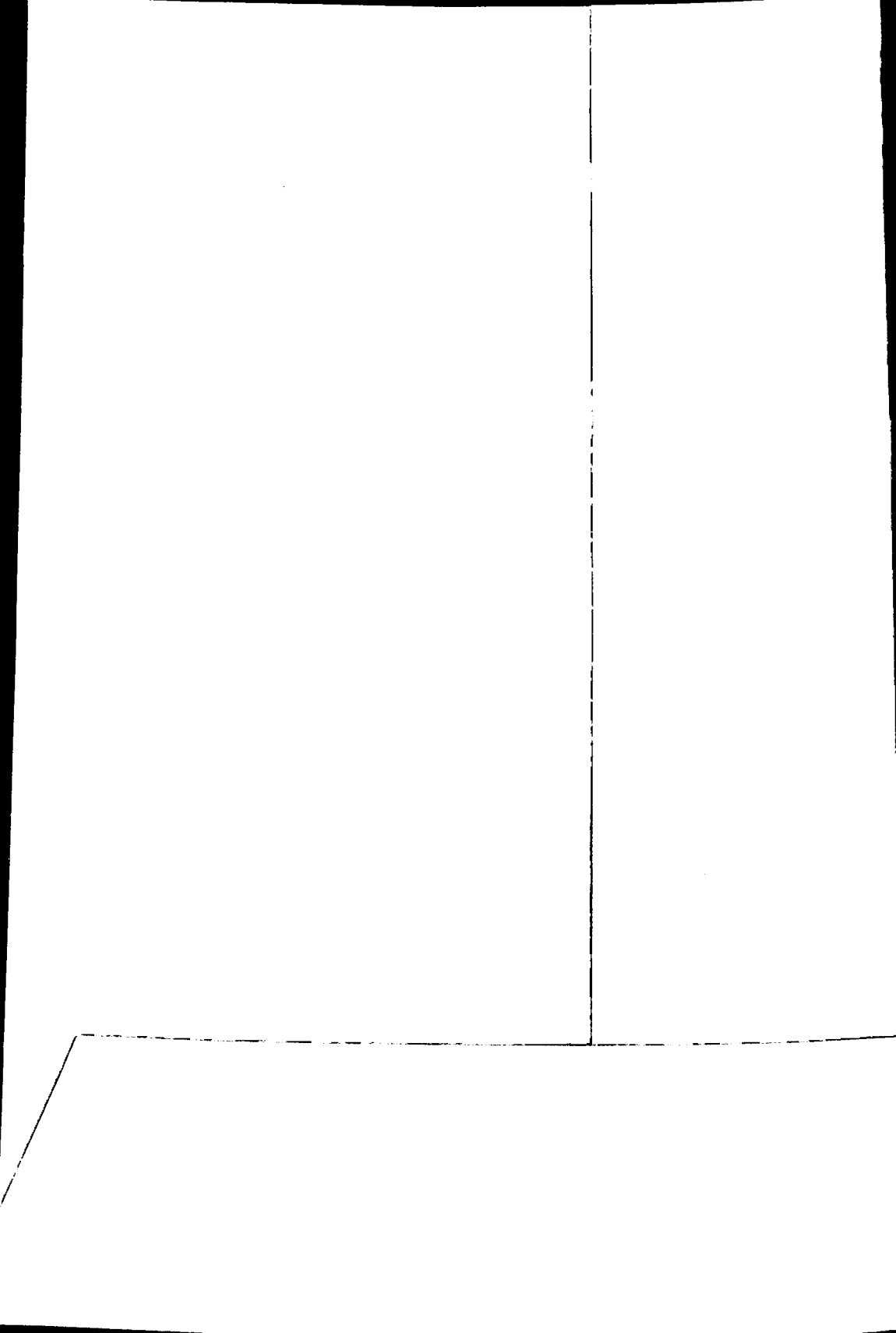
Gabor A. Somorjai

Program Director

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PUB-674

July 1990

Prepared for the U.S. Department of Energy under Contract DE-AC03-76SF00098

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