The Mitsubishi Chemical - UCSB Alliance: A Model Research Partnership in Advanced Materials

Glenn Fredrickson, Director MC-CAM
A Unique Research Partnership

- MCC taps into the broad interdisciplinary materials expertise at UCSB
- UCSB researchers participate in creating exciting new materials, devices, and advanced fabrication technologies for the specialty chemical & electronic materials marketplace
- Mitsubishi Chemical – Center for Advanced Materials (MC-CAM), an international center of excellence in functional materials
- MC-CAM commenced in 2001; renewed in 2006 for 2006-2010
Why Did MCC Choose UCSB?

- A diverse set of faculty in materials research (~60 PIs) with
  - A superb record in interdisciplinary research and interactions with industry
  - Research impact that is #1 in the world (Science Watch 1993-97, 1998-2002)
  - Dedication to maintaining world-class central/shared equipment
- Mitsubishi’s CTO (G. Stephanopoulos) appreciated UCSB’s research excellence and effectiveness
- An administration and sponsored projects office that was supportive in crafting a research and intellectual property agreement
  - Flexible IP terms
  - Indirect cost of grant returned to build space for MC-CAM

These motivations are even more evident today!
MC-CAM Administrative Structure

Matthew Tirrell
Dean of Engineering

MC-CAM Governing Board
6 members

MC-CAM Steering Committee
10 members

Glenn Fredrickson
Director
Ted Cais
Associate Director

MC-CAM Research programs

Craig Hawker
Director of Materials Research Lab
MRL

MRL Research Programs
This Structure Has Served Us Well

- We have leveraged the physical plant, staff, and materials characterization facilities of the MRL.
- Both Centers benefit from the expanded staff, including administrative, financial, and computer support.
- More and better equipment and space is available for researchers of MC-CAM and MRL.
- The MC-CAM Steering Committee has effectively shaped the research portfolio in directions that are:
  - Intellectually stimulating
  - Relevant to MCC businesses
## Funding from MCC to UCSB (2001-10)

<table>
<thead>
<tr>
<th></th>
<th>$/Year</th>
<th>$/9 Years</th>
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<tbody>
<tr>
<td><strong>MC-CAM</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research Contract</td>
<td>2.000M*</td>
<td>17.500M*</td>
</tr>
<tr>
<td>Gift (for MC-CAM operations)</td>
<td>0.425M</td>
<td>3.825M</td>
</tr>
<tr>
<td><strong>SSLDC</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gift (for operations and research)</td>
<td>0.300M†</td>
<td>1.500M†</td>
</tr>
<tr>
<td><strong>COE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Philanthropy—MCC Endowed Chairs and Graduate Fellowships</td>
<td>0.200M</td>
<td>1.800M</td>
</tr>
<tr>
<td>Total</td>
<td>2.925M</td>
<td>24.625M</td>
</tr>
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*Amount to vary from $1.5M to $2.0M/yr for 2006-2010
†Amount only includes 2001-2006
MC-CAM Leveraged Resources

- We secured $2.5M in supplementary funding ($1.7M in 2001, $0.8M in 2005) from the UC-Discovery Program funded by the State of California.
- The overhead on the MC-CAM and MRL grants were generously returned by UCSB and applied to a $5M, 7000 ft² expansion of the MRL building.
- The MRL and MC-CAM contribute ~$1.4M/yr to shared equipment that benefits users across campus.
- The CNSI building will further consolidate materials characterization facilities.
- Technical leverage -- we have collaborations/subcontracts to:
  - F. Wudl at UCLA, fullerene synthesis
  - G. Strouse at FSU, nanoparticle synthesis
  - G. Coates at Cornell, polyolefin block copolymer synthesis
MC-CAM Space

- MC-CAM and MRL are delighted to share the new ~7000 s.f. space in the expanded MRL building.
- MC-CAM has its administrative headquarters in this space, as well as conference rooms, offices for researchers, and offices for visitors.
## MC-CAM Timeline--Highlights

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
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<tbody>
<tr>
<td>February 19, 2001</td>
<td>Tokyo Press conference announcing MCC-UCSB alliance</td>
</tr>
<tr>
<td>May 1, 2001</td>
<td>MC-CAM commenced operations/staff assembled</td>
</tr>
<tr>
<td>August 24, 2001</td>
<td>4 UC-SMART projects commenced</td>
</tr>
<tr>
<td>September 1, 2001</td>
<td>8 NRT projects commenced</td>
</tr>
<tr>
<td>January 1, 2002</td>
<td>6 NRT projects commenced</td>
</tr>
<tr>
<td>April 18, 2002</td>
<td>MC-CAM Grand Opening Celebration</td>
</tr>
<tr>
<td>September 1, 2002</td>
<td>5 IRP/1 NRT projects commenced</td>
</tr>
<tr>
<td>September 1, 2003</td>
<td>2 NRT projects commenced</td>
</tr>
<tr>
<td>September 1, 2004</td>
<td>4 NRT projects commenced</td>
</tr>
<tr>
<td>May 6, 2005</td>
<td>MC-CAM Partnership Celebration</td>
</tr>
<tr>
<td>September 1, 2005</td>
<td>1 IRP/2 NRT projects commenced</td>
</tr>
</tbody>
</table>

15 projects were discontinued over 2001-06
Character of Research Projects

- Project co-leaders from UCSB and MCC
  - MCC research partners are very involved!
  - Presence of MC-Research and Innovation Center (MC-RIC) in Goleta has been a big help
- Researchers from at least 2 disciplines
- Scientific novelty
- Clear connection with a potential product
- Involve the design of new functional materials, devices, or fabrication technologies
MC-CAM Project Statistics: 2001-2005

- Breakdown of Researchers & Faculty in MC-CAM

<table>
<thead>
<tr>
<th>Dept</th>
<th>Res.</th>
<th>Faculty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemistry</td>
<td>33</td>
<td>7</td>
</tr>
<tr>
<td>Chem. Engr.</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td>Materials</td>
<td>16</td>
<td>7</td>
</tr>
<tr>
<td>Physics</td>
<td>9</td>
<td>2</td>
</tr>
</tbody>
</table>

- Project Areas

<table>
<thead>
<tr>
<th>Area</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polymers &amp; hybrids</td>
<td>7</td>
</tr>
<tr>
<td>Nanocomposites</td>
<td>2</td>
</tr>
<tr>
<td>Organic electronics &amp; Phosphors</td>
<td>13</td>
</tr>
<tr>
<td>Fullerenes</td>
<td>3</td>
</tr>
<tr>
<td>Battery &amp; fuel cells</td>
<td>7</td>
</tr>
</tbody>
</table>
What Constitutes Success?
Our Vision in 2001

- First-rate science and engineering ✓
- Quality publications ✓
- Well-trained students and post-docs ✓
- Patents ✓
- Technology transfer
  - to MCC, ✓
  - joint ventures, or startups ☹
- Products, sales, and profits! ☹
Research results:
First-rate science and engineering

- Organic white PLED fabricated by wet coating
  - Worlds best luminescent intensity
- Fuel Cell proton exchange membrane
  - Meeting DOE target
- III-V nano particle
  - Highest quantum efficiency
- Organic two photon absorption dye
  - Highest TPA cross section
- Functional polyolefins
  - First all polypropylene TPE
- Phosphors
  - New important families of R,G,B,Y
  - White LED independent of Nichia patents
- Fullerene Derivatives
  - Enhanced solubility and functionality to add value
• 33 publications over 2001-05 in prestigious journals including
  – *Advanced Materials*
  – *Proc. NAS*
  – *Advanced Functional Mater.*
  – *J. Appl. Phys.*
  – *Nanoletters*
  – *Synth. Metals*
  – *Langmuir*
  – *Macromolecules*
  – *Angew. Chemie*
**Device Physics**

**Enlightening solutions**

Klaus Meerholz

White-light-emitting diodes are becoming increasingly important, but what is the best way to build compact devices possessing high efficiencies? Bright prospects are offered by multi-layer organic devices grown from solution.

- Source of this light and how it varies in an external field.
- How to achieve high efficiency in organic light-emitting diodes (OLEDs).
- The role of host-guest materials in improving the performance of OLEDs.
- The potential of new materials for enhancing the efficiency of white-light OLEDs.

**Multilayer White Polymer LEDs**

- Ideally Ordered Nanoporous Alumina Films
- Peptide-Based Nanotubes
- Crosslinked Quantum Dot Capsules

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**References**

Synthesis of Block Copolymer Segments Containing Different Ratios of Ethylene and 5-Norbornen-2-yi Acetate

Steve J. Diamanti,† Vikram Khanna,† Atsushi Hotta,† Diane Yamakawa,† Furumiko Shimizu,‡ Edward J. Kramer,*† Glenn H. Fredrickson,† and Guillermo C. Bazan*†

Institute for Polymers and Organic Solids and Mitsubishi Chemical Center for Advanced Materials, Departments of Materials, Chemical Engineering, and Chemistry & Biochemistry, University of California, Santa Barbara, California 93106, and Mitsubishi Chemical Corporation, Science and Technology Research Center, 1000 Kamoshida-Cho, Aoba-Ku, Yokohama 227-8502, Japan

Received May 11, 2004; E-mail: bazan@chem.ucsb.edu

Block copolymers contain two or more chemically distinct sequences covalently bound in an end-to-end fashion.1 This molecular architecture leads to microphase separation (5–100 nm) of the individual segments, which is driven by their immiscibility.2,3 Complex nanostructures self-assembled in this way have found use in applications such as drug delivery,4 organic electronic and photonic devices,5 and nanolithography.6

Block copolymers that modify the interfacial energy7 and adhesion8 between polyethylene and more polar commodity plastics are highly sought after.9 Polar functionalities within a hydrophobic polyethylene backbone influence important properties, such as toughness, solvent resistance, blend compatibility with other functional polymers, and rheological properties.9 In view of the

Scheme 1. Synthesis of Block-Type Copolymers

![Scheme 1](image-url)
Patent Activity: 2001-05

- 30 patent disclosures
- 9 joint UCSB/MCC applications
- 26 options elected
- 5 licenses under discussion

30 patents/33 papers is a very large ratio for a university research program!
Inventions per Research Dollar

Research Institution Average\(^1\)
$2.4M expended per invention disclosure

Tech Company Rule of Thumb\(^2\)
$500K expended per invention disclosure

MC-CAM\(^3\)
$340K expended per invention disclosure

- More Productive than Universities and Tech Companies!

1. Average from 2001-2003 AUTM licensing surveys.
2. The Economist, October 22, 2005.
3. Assume 35 patents by end of FY 05/06; $12.0M expended.
Ongoing Challenges

- Maintaining clear channels of communication
- Managing expectations of UCSB faculty and MCC scientists and management
  - Project timescales
  - Basic versus applied
- Keeping UCSB faculty and researchers focused on IP considerations and release procedures
- Balancing UCSB’s research and educational missions