
# World-Wide Compact Model Standardization for an Expanding Industry

Si2 Compact Model Coalition

Peter M. Lee, Chairman

*December 7, 2016*

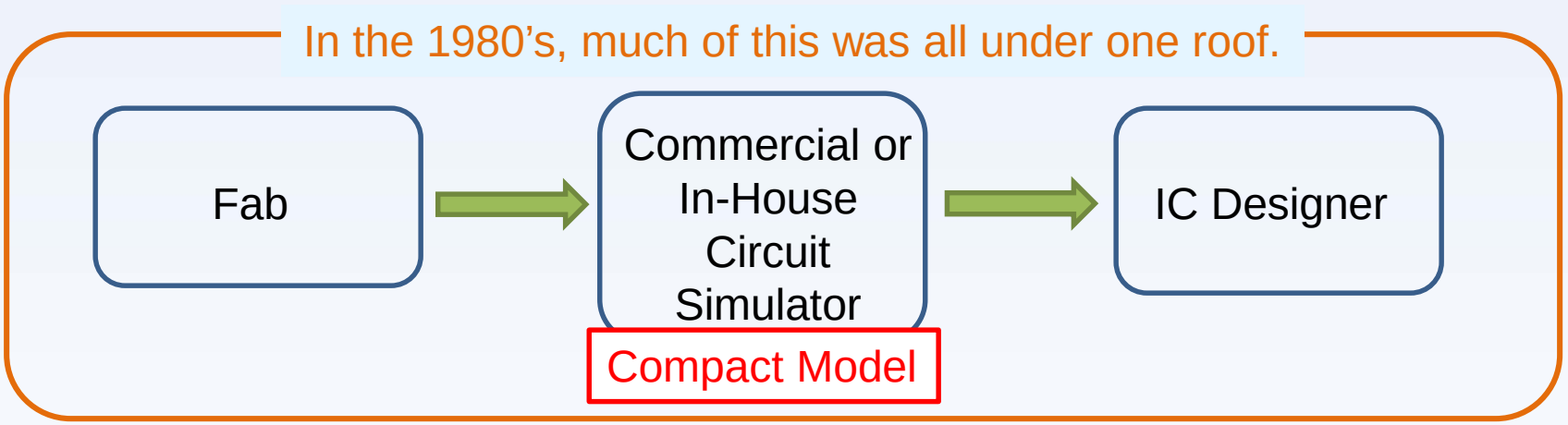
*MOS-AK Workshop*

# Outline

- The Birth of the CMC
- Operation, Members
- CMC Standards History and Works In Progress
- Membership Benefits
- Summary

# The Birth of the CMC

- Compact models provide the vital connection to convey the detailed physical behavior of devices to circuit behavior.

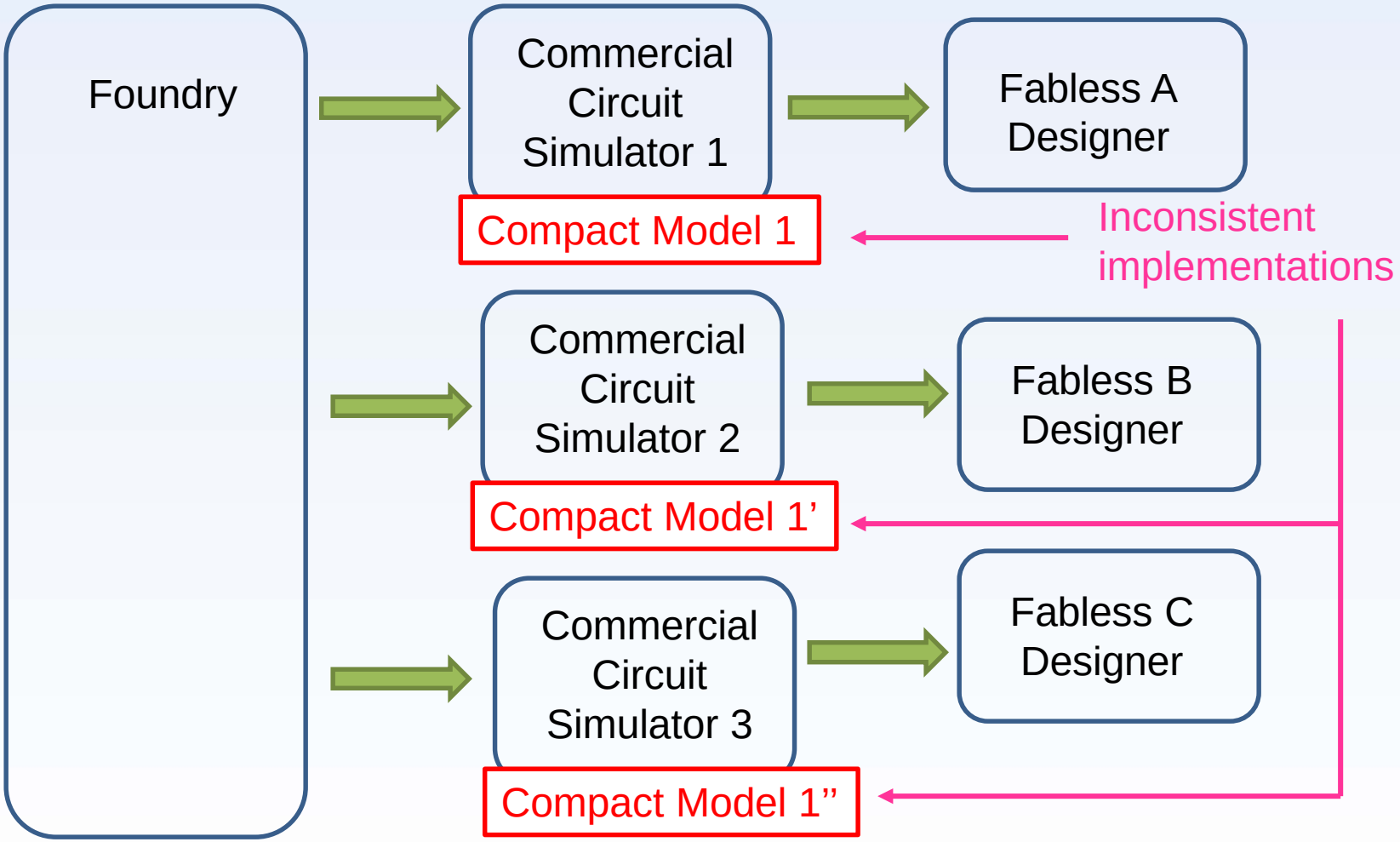



- This enables circuit designers to create the most optimum circuit taking into account the details of device physics.
- In the 1980's, the industry was dominated by IDMs with both the design and chip fabrication under one roof.
  - ❖ Many companies used in-house circuit simulators with some using in-house developed device models.

# Changes in the 1990's

- The 1990's saw a transformation to where chip fabrication was being done at a foundry while design was being done by separate fabless companies.
  - ❖ This necessitated using EDA vendors and the device models implemented into the EDA vendor tools.
  - ❖ This caused issues concerning obtaining inconsistent results due to no standards across different vendor tools and the models implemented.
  - ❖ Foundries had to qualify their PDKs using different vendor tools to make sure that consistent results would be obtained.

# Foundry/Fabless Model




- Multiple simulators with the "same" Model 1 but could result in different implementations (Model 1', Model 1'') which show inconsistencies in the results

# The Need for Standardization

- To solve the inconsistencies which result from using different implementations of the same model into different vendor tools, a group of foundries, fabless design houses, IDMs, EDA vendors, and universities got together in 1995 to form the Compact Model Council (CMC)
- The main goals were to:
  - ❖ Create a standardization body to solve the model inconsistency issues
  - ❖ Create a system to fund model developers so that the models would always be up-to-date and serve the needs of the industry

CMC was born in Washington, D.C., on December 15, 1995

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# Officers

**Chair:** Peter Lee (Micron)

**Vice Chair:** Josef Watts (GLOBALFOUNDRIES)

**Secretary:** Richard Williams (IBM)

**Treasurer:** Takeshi Naito (Toshiba)

Officers are elected to two-year terms by CMC member balloting.
Present officers are serving a 2016-2017 term.

# Members in 2016

| | | | | |
|---|---|---|---|---|
| Analog Devices | ams | AWR/National Instruments | Broadcom | Cadence |
| Fujitsu Semiconductor | Global Foundries | IBM | Infineon | Intel |
| Keysight | Mentor Graphics | Micron | NXP | Oracle |
| Peregrine Semiconductor | ProPlus | Qualcomm | Raytheon | Renesas Electronics |
| Ricoh | Samsung | Sandia Labs | Silvaco | SK Hynix |
| Sony | ST Micro | Synopsys | TI | Toshiba |
| TSMC | | | | |

- **Presently there are 31 member companies**

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# CMC Standards

Compact Models:

- Planar Bulk MOSFETs: BSIM3 (1995), BSIM4 (2000), BSIM6 (2013), PSP (2006), HiSIM2 (2011)
- LDMOS: HiSIM_HV (2007)
- SOI MOSFETs: BSIMSOI (2002), HiSIM-SOI (2012)
- BJTs: MEXTRAM (2004), HICUM (2004)
- Multi-Gate MOSFETs: BSIM-CMG (2012), **BSIM-IMG (2015)**, **HiSIM-SOTB (2015)**
- MOS Varactor: MOSVAR (2006)
- Resistors: R2_CMC (2005), R3_CMC (2007)
- Junction Diodes: DIODE_CMC (2009, 2016)

**Verilog-A**

**Expected in 2016: GaN HEMT**

Other Standards:

- OMI Modeling API (2010)
- Standard SPICE Language (2012)

Silicon Integration Initiative

# Working Groups and Chairs

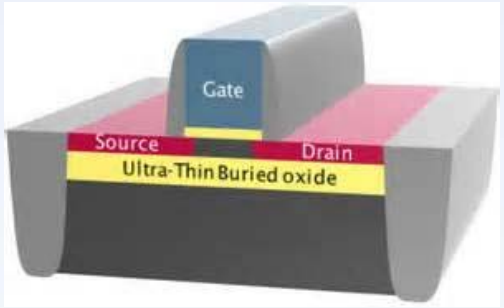
| | |
|---|---|
| BSIM-Bulk | Kaiman Chan (TI) |
| BSIM-SOI | Saurabh Sirohi (GLOBALFOUNDRIES) |
| BSIM-CMG | Richard Williams (IBM) |
| BSIM-IMG | Josef Watts (GLOBALFOUNDRIES) |
| Diode Reverse Recovery | Klaus-Willi Pieper (Infineon) |
| GaN HEMT | Samuel Mertens (Cadence) |
| HICUM | Didier Celi (ST) |
| HiSIM2 | Shigetaka Kumashiro (Renesas) |
| HiSIM-HV | Ehrenfried Seebacher (ams) & Takeshi Naito (Toshiba) |
| HiSIM-SOI | Marek Mierzwinski (Keysight) |
| HiSIM-SOTB | Marek Mierzwinski (Keysight) |
| MEXTRAM | Jin Tang (TI) |
| Model QA & Release | Shahriar Moinian (Avago) |
| MOSVAR | Geoffrey Coram (ADI) |
| PSP | Andries Scholten (NXP) & Gert-Jan Smit (NXP) |
| Standard Operating Point Variables | Samuel Mertens (Cadence) |
| OMI | Colin Shaw (Silvaco) |

**Currently 17 working groups**

# Recent New Standards

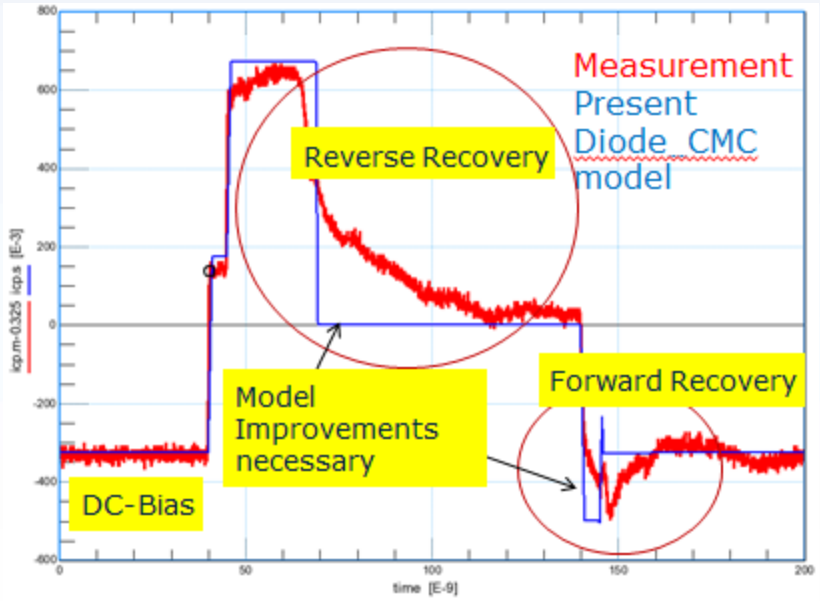
- Models for Fully-Depleted Silicon-on-Insulator (FDSOI) MOSFET Technologies

28nm → 10nm CMOS




- BSIM-IMG for the BSIM platform
- HiSIM-SOTB for the HiSIM platform

- Accurate forward and reverse recovery modeling in DIODE_CMC
  - Project 100% completed

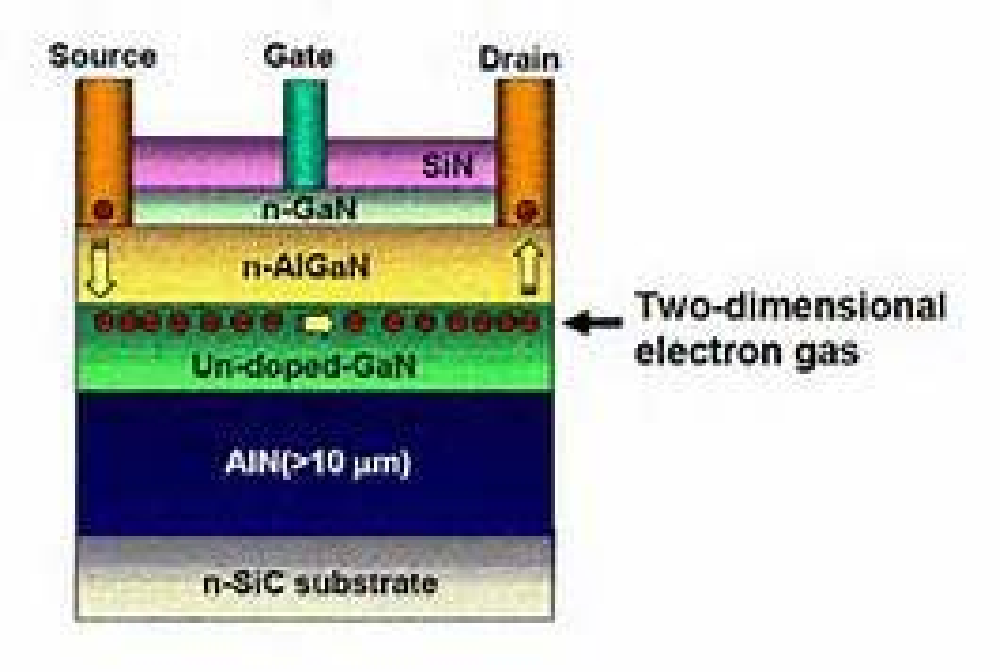



Silicon Integration Initiative

# 2015-2016 Key Works In Progress

- GaN HEMT Model Standard

Power & RF




**Current Status:** Balloting for a GaN standard model has started this month to choose one or two standard models from two candidates. Decision will be made before the end of December.

# External Collaboration

- **NEEDS Project:** Have started information exchange and studying how we can effectively collaborate to enhance model quality and development of the standard models.
- **Accellera SystemVerilog-AMS**: Information exchange to make sure we align on Verilog practices for standard model code. Currently we use the Verilog-AMS LRM Version 2.4.

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# Member Benefits

- **Members have a say** in what models become a standard
- **Members** have the opportunity to request enhancements specific to their needs
- **Members attend** quarterly CMC meetings with leading industry and academic model developers, where they learn about technology, often before they are published in the literature
- **Members have access** to model beta code
- **Members have access** to functional assets such as the model implementation QA suite and API code
- All of the information from the meetings is available to **members only** on the CMC website

# Asset Availability

| General Standard Type | Model / API Documentation or Specification | Released Code and Other Ancillary Files |
|---|---|---|
| University-Developed Compact Model, e.g., BSIM6 | On University Site with Link from Si2 CMC Site | On University Site with Link from Si2 CMC Site |
| CMC modified or Developed Compact Model, e.g., MOSVAR | On Si2 CMC Public Site | On Si2 CMC Public Site |
| Quality Assurance Program | Si2 CMC Private Site | Si2 CMC Private Site |
| Test Suite for Verilog-A Compliance | Si2 CMC Private Site | Si2 CMC Private Site |
| Application Programming Interfaces | Si2 CMC Public Site | Si2 CMC Private Site |
| Standard Netlist and File Format | Si2 CMC Public Site | Si2 CMC Public Site |

# Research Institution Partners

- **University of California at Berkeley – Professor Chenming Hu**
  - ❖ BSIM3, BSIM4, BSIM6, BSIM-SOI, BSIM-IMG and BSIM-CMG
- **Hiroshima University – Professor Mitiko Miura-Mattausch**
  - ❖ HiSIM2, HiSIM_HV, HiSIM-SOI and HiSIM-SOTB
- **University of California at San Diego – Professor Michael Schroter**
  - ❖ HICUM
- **Auburn University – Professor Guofu Niu**
  - ❖ MEXTRAM
- **CEA-Leti – Dr. Jean-Charles Barbé**
  - ❖ PSP

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- The CMC enhances the IC development process
  - ❖ Standardizing high-quality device models and simulator interfaces
  - ❖ Providing a forum and mechanism to keep these standards current to expanding industry needs

- The CMC is a member-driven organization open to any company in the semiconductor business

http://projects.si2.org/cmc_index.php