60 YEARS OF SID SYMPOSIA – ENABLING PROGRESS IN LIQUID CRYSTAL TECHNOLOGY

AM Technology SID Award Winners

JAN RAJCHMAN PRIZE
Terry J. Scheffer, 1993
William Doane, 1998
Shunsuke Kobayashi, 1995
Tatsuo Uchida, 2004
Shin Tson Wu, 2008
E. Peter Raynes, 2009
Dwight Berreman 2010
Dr. Dirk J. Broer, 2014
Dr. Shohei Naemura, 2015
Seung Hee Lee, 2016
Shui-Chih Alan Lien, 2017
Pochi Yeh, 2018
Hoi-Sing Kwok, 2019

KARL FERDINAND BRAUN PRIZE
George W. Gray 1986
Martin Schadt 1992
Richard Williams 2008
Frederic J. Kahn 2010
Rudolf Eidenschink 2011
Dr. Jun Souk, 2012
Dr. Katsumi Kondo, 2014
Hidefumi Yoshida, 2018
Wei Chen, 2022
John Zhong, 2022

FRANCES RICE DARNE MEM. AWARD
James L. Fergason

SLOTTOW-OWAKI PRIZE
William Donae 2007
Tatsuo Uchida 2008
Philip J. Bos 2010
Shin-Tson Wu 2011

DAVID SARNOFF INDUSTRIAL ACHIEVEMENT PRIZE
Sang Deog Yeo, 2022

PETER BRODY PRIZE
Yi-Pai Huang, 2017

OTTO SCHADE PRIZE
Louis D. Silverstein, 2008
Candice Brown Elliott, 2014
Dr. Ingrid Heynderickx, 2015

FELLOWS
Koichi Miyaji, 1977
Peter Pleshko, 1978
Frederic J. Kahn, 1981
Lawrence Tannas, Jr., 1983
Werner E. Haas, 1984
P. Andrew Penz, 1984
Cornelius J. Gerritsma, 1985
Allan R. Kmetz, 1985
Paul M. Alt, 1986
Tomio Wada, 1986
Shunsuke Kobayashi, 1987
Dwight W. Berreman, 1988
Martin Schadt, 1992
E. Peter Raynes, 1994
Tatsuo Uchida, 1994
Hideaki Kawakami, 1996
Günter Baur, 1997
James L. Fergason, 1997
Shoichi Matsumoto, 1999
Terry J. Scheffer, 1999
William Doane, 2000
Eiji Kaneko, 2000
Shin-Tson Wu, 2001
Kei-Hsiung Yang, 2001
Philip J. Bos, 2002
Shohei Naemura, 2002
Katsumi Kondo, 2004
Anthony Lowe, 2004
Masataka Matsuura, 2004
Adi Abileah, 2005
Gregory Crawford, 2005
Hoi-Sing Kwok, 2005
Paul Drzaic, 2005
Deng-Ke Yang, 2007
Kenji Okamoto, 2007
Vladimir Chigrinov, 2008
Seung Hee Lee, 2008
Sung Tae Shin, 2011
Hiap L. Ong, 2012
Hiroyuki Mori, 2013
Källi Kälintär, 2013
Victor Belyaev, 2014
Hidefumi Yoshida, 2015
In Byeong Kang, 2016
Sin-Doo Lee, 2017
Mary Lou Jepsen, 2018
Seok-Lyul Lee, 2018
Shihchang (James) Chang, 2019
Yi-Pai Huang, 2019
Tomokazu Shiga, 2019
Takahiro Ishinabe, 2020
Ruiqing (Ray) Ma, 2022
Ian Underwood, 2022

SID SPECIAL RECOGNITION AWARD
George H. Heilmeier, 1975
C. J. Gerritsma, 1978
Paul M. Alt, 1980
Dwight W. Berreman, 1987
Eiji Kaneko, 1987
Jürgen Nehring, 1987
E. Peter Raynes, 1987
Martin Schadt, 1987
Akio Sasaki, 1988
Terry J. Scheffer, 1987
Noel A. Clark, 1989
Sven T. Lagerwall, 1989
Karel Kuijk, 1992
Birendra Bahadur, 1993
Tatsuo Uchida, 1994
Satoshi Okazaki, 1995
Georg Weber, 1997
Bernhard Scheuble, 1997
Rudolph Kiefer, 1998
Katsumi Kondo, 1998
Joseph A. Castellano, 2000
Shohei Naemura, 2000
Shin-Tson Wu, 2001
Haruhiko Okumura, 2004
Hiap Ong, 2005
Deng-Ke Yang, 2005
Alex Henzen, 2007
Sang Soo Kim, 2007
Hiroyuki Mori, 2008
Hirotsugu Kikuchi, 2009
T.N. Ruckmongathan, 2009
Michio Kitamura, 2010
Hyun Chul Choi, 2011
Takahiro Ishinabe, 2011
Kyeong Hyeon Kim, 2011
Hyang Yul Kim, 2012
Seung Hee Lee, 2012
Seok-Lyul Lee, 2012
In-Byeong Kang, 2013
Hidefumi Yoshida, 2013
Mark Spitzer, 2014
Jun Ho Song, 2015
Byeongkoo Kim, 2015
Yasuhiro Koike, 2015
Akihiro Tagaya, 2015
Chang Ho Oh, 2016
Emi Yamamoto, 2016
Masaki Hasegawa, 2017
Kenichiro Masaoka, 2017
Jae-Hoon Kim, 2018
Yasushi Tomioka, 2018
Noboru Kunimatsu, 2018
Chiwoo Kim, 2019
Mamoru Furuta, 2021
XUE DONG, 2021
Kentaro Okuyama, 2022

Image Generation

1964 **RCA** Guest-Host (Heilmeier) mode

1966 **RCA** Dynamic Scattering Mode

1967 **RCA** Room temp, apolar Schiff base mixtures developed

1967 **DEMUS** Concept of eutectic mixure formulation is published

1968 **RCA** Demonstrates their LCD technologies

1969 **HOECHST** MBBA - 1st room temperature single component LC

1970 Schadt & Helfrich start collaboration on field effects at Roche and file Swiss TN patent

1970 Fergason independently conceives TN and files US TN patent later bought by Roche

1970 Demus apolar esters

1970 **HOECHST** Room temp azoxy compounds

1971 **SCHIEKEL & FAHRENSCHON, KAHN** Vertical alignment LCs

1971-1973 **ROCHE** First commercial alkyl cyano Schiff base and cyano ester TN mixtures

1972 **BELL LABS** Berremann uses 4x4 matrix to model LCD configurations

1972 Raynes eliminates reverse twist and tilt domains in TN

1972 **GOOCH & TARRY** 1st and 2nd TN minimum understood

1972 Stable biphenyl liquid crystals by Gray, Harrison and Nash

1973 Demus alkyl-alkoxy cyclohexane esters

1973 Soref proposed transverse field effect (similar to IPS) LCD

1974 Commcercial production of biphenyl mixtures (E7, E8 etc) BDH

1974 **BELL LABS** White-Taylor cholesteric guest-host display

1975 Meyer discovers ferroelectric LCs

1976 **ROCHE** 1.5 volt pyrimidine TN mixtures

1976 **MERCK** Cyano-phenyl cyclohexanes and their mixtures

1980 **BELL LABS** Kmetz proposed single polarizer TN display

1980 **CLARK & LAGERWELL** Surface Stabilized Ferroelectric LCD

1980 **ROCHE** Alkenyl LCs enabling large STN mux ratios and short TFT response

1980s **MERCK, CHISSO** Fluorinated, TFT-TN compatible LCs

1981 **BELL LABS** Berreman-Heffner 360 bistable cell

1982 **RSRE** Waters and Raynes Supertwisted guest-host mode

1983 **BROWN BOVERI** Developed STN display

1984 **TEKTRONIX** Bos proposed pi-cell

1987 **SEIKO-EPSON** Developed DSTN

1988 **SHARP & SEIKO-EPSON** Stretched retarder film compensated STN developed

1990 **MERCK** Difluoro substituted materials with large negative dielectric anisotropy

1990-2000 **MERCK, CHISSO** Many types of LC mixtures got perfected for TFT applications

1991 **IBM** Yang demostrates multidomain TN

1992 Baur et al present IPS mode

1993 **KSU/KDI** Cholesteric bistable reflective display

1993 **TOHOKU UNIVERSITY** Uchida proposed OCB mode

1993 **IBM** Lien demonstrated multi-domain homeotrophic (VA) LCD

1995 **HITACHI** Presents IPS display

1995 **HUGHES & SHARP** Single-polarizer reflective modes for low power and LCOS

1996 **HUGHES** Wu proposed MTN mode LCD

1996 E-ink Displays

1997 **FUJITSU** MVA mode LCDs

1998 **HYDIS** Lee develops FFS LCDs

2002 **KIKUCHI** Polymer-stabilized bluephase LC Concept

2004 **TOSHIBA MATSUSHITA** OCB Mode 32" TV Panels from

2008 **SAMSUNG** Polymer-stabilized bluephase LCD

2014 **MERCK KGAA** Next-generation FFS technologies 15% higher transmittance than conventional FFS

Liquid Crystal Materials

1960's

1970's

1980's

1990's

2000's

2010's

Manufacturing Milestones

1970-1975 - Hermetic glass frit sealing, SiO alignment, and vacuum fill cell fabrication - High temp. process* - Rubbed Polyimide (PI) alignment*

1972 **JANNING** develops alignment by oblique evaporation*

1975 - Low temp. drop fill cell frabrication (thermoplastic gasket, PVA alignment) - Batch processing* - Distributed glass fiber spacers* - Ion barrier layer on soda lime glass*

1975-1980 PI alignment, epoxy seal, vacuum fill based low temp. batch process (7"-14" mothers glass)

1985 **CORNING** "Touched polished" no alkali flat glass

1985 Pixilated color filters for color displays

1991 **GIBBONS ET AL** publish LC photo-alignment

1990-2000 LCD materials, processes and equipment for large area AM LCD manufacturing got perfected.

1992 Schadt et al. develop stable optical alignment and its patterning by LPP

1995 **3MV** BEF & DBEF multi-layer brightness enhancement films

1995-2005 LC mother glass sizes kept on increasing significantly (Gen. 3-8)

1995-2000 LC photo-alignment

1997 FujiFilm develops discotic wide view film for TFT-TN displays

1998 **SAMSUNG** PVA LCDs manufacturing

2001 LC (one) drop filling and cell mating in vacuum for large size LCDs

2009 Sharp's Generation 10 plant using photo-alignment

2018 **BOE** Gen 10.5 fabrication plant

Passive-Addressing Milestones

RCA CMOS technology developed

1973-1974 Kawakami and Alt-Pleshko independently develop optimized MUX drive

1975-1976 Low level intrinsic multiplexing applied in TN products

1979 Nehring & Kmetz publish "Ultimate limits for matrix addressing"

1987 **NITTO DENKO** Mechanically stretched optical retarder films

1988 Ruckmongathan publishes IHAT technique

1990 **CITIZEN WATCH CO.** "Frame response" found

1991 **INFOCUS/ ASAHI GLASS** MLA/MLS addressing independently

Product Milestones

1973 **SHARP** EL-805 pocket calculator using DSM

1973 **BROWN BOVERI** First commercial TN displays (Casio watches)

1973-1980 TN LCDs were introduced in clocks, calculators and numerous other applications

1975 **HUGHES** LC Light valves developed

1983 Monochrome TN panel used in Data General portable computer

1988 Monochrome STN panel for computer notebooks

1990 Stacked STN panels used in subtractive color or mode LCD projector color

1992 "Dual scan" color STN panels (notebook computers)

1992-1995 AMLCDs introduced in Notebook and Desktop computers.

1993 **KENT DISPLAY IND.** commercializes ChLCDs

1996-2006 Various types of LCDs (TN, IPS, MVA, OCB & Blue Phase) introduced in TVs, mobile phones and many other applications

2001 LCDs start gaining significant TV market from CRTs.

2002 CSTN cell phone displays with single-chip MLS drivers introduced

2004 LCD becomes the largest display techology

2005 **SHARP** announces 1,000,000:1 contrast on 37" FHD LCD monitor

2007-2010 3D LCD TVs

2010 **APPLE** Introduces the iPad based on FFS technology that has optical and power performance needed for the iPad, and iPhone displays

2010 LCDs constitute > 85% of all the display sales. CRTs are almost extinct.

2011 **AUO** 55-in. 4K ×2K 2-D/3-D switchable glasses-free LCD TV

2014 **GOOGLE** Google Glass AR system introduced using a LCOS display.

2016 **DIGILENS** Wins SID best in show award for a LC based wide field AR combiner

Contributors to this milestone chart

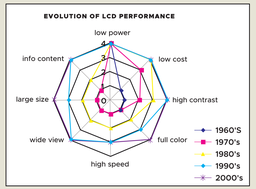
2003 - Allan Kmetz (architect) and others gratefully acknowledged

20110/12 Revision - Birendra Bahadur (chair), Allan Kmetz, Martin Schadt, Shin-Tson Wu

2022 - ST Wu, Phil Bos, Sri Peruvemba, Bob Raikes, Chris Chinnock, Ross Young, Bob O'Brien, Amer Malik, Russell Kempt

Charts designed by Michael Moreno

LCD performance improvements created new display markets



Copyright 2003 to 2022 Society for Information Display All rights reserved.