Final Program

51st IEEE HOLM Conference on Electrical Contacts 2005

26-28 September 2005

ALONG WITH THE

Intensive Course on Electrical Contacts

23-25 September 2005

Holiday Inn Chicago City Center
Chicago, IL

Sponsored By:
The Components, Packaging, and Manufacturing Technology Society of the IEEE

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Purpose

The Holm conference provides a forum for the presentation and discussion of the latest developments in the field of electric contacts and the application of recent advances in materials and processes in electrical electronic and telecommunications equipment. Also, the Contact Course provides training to engineers for a solid foundation in electrical contact principles and practice. This year the conference and the intensive course will be run consecutively to allow participants to attend both.

For Whom

Practicing designers, engineers, physicists and research scientists – those new to the field and those experienced.

The 2005 Holm Conference will include excellent papers from North America, Europe and Asia authored and presented by some of the outstanding technical people in this field. Additionally, the conference enables attendees to discuss personally with authors either additional details concerning their work or any subject related to the author's field of expertise.

Background

The Holm Conference began in 1953 as a forum for the discussion of electrical contact phenomena and related fields. In 1968, the conference was named the Holm Conference in honor of Dr. Ragnar Holm. Dr. Holm, whose contributions to the field of electrical contacts spanned 50 years and forms the foundation of the electrical contacts field, was the inspiration and guide of the Conference from its inception until his death is 1970.

In 1985, IEEE Society started sponsoring the conference as recognition of its importance in the field of electrical engineering.

Intensive Electrical Course on Contacts

September 23 to 25, 2005

Holiday Inn Chicago City Centre
Chicago, IL

Dr. P.G. Slade,
Course Director, Arcing & Power Contacts

Dr. R.S. Timsit,
Contact Fundamentals & Connectors

The 2005 Intensive Course has been completed revised to reflect recent needs in understanding very low contact force phenomena and the effects of high frequency currents. While doing this, the Course still covers the broad range of electrical contact situations, which are listed below:

- Making contact and surface finish effects
- Making connections and connector design [low and high current]
- Switching contacts ac and dc design considerations [low and high current]
- Contact materials for connectors and for switching contacts
- Contact finishes
- Contact failure mechanisms and how to analyses them
- Corrosion and the effects of ambient environments

The Course includes class problem-solving exercises so that participants will learn how the Course material can be applied. A participant in this Course will thus leave the sessions with a thorough and broad knowledge of the subject. Our teaching approach will allow practicing engineers to use detailed knowledge of contact technology to resolve their own practical design problems.

COURSE AGENDA

Day 1

Morning

- Contact Fundamentals

Afternoon

- The Electric Arc

Evening

- Q & A Session

Day 2

Morning

- Contact Materials for Arcing Contacts
- Non Arcing Power and Non-Permanent Power Connectors
- Electronic Connectors and Metallic Coatings

Afternoon

- Switching Contact Guidelines
- Connector Design Guidelines

Evening

- Q & A Session

Day 3

Morning

- Introduction to Tarnishing and Corrosion
- Experimental Evaluation of Corrosion

Afternoon

- Experimental Evaluation of Corrosion (continued)
- Corrosion and Power Arcing Contacts and Connectors

Registration

All Participants are encouraged to pre-register to avoid lines at the conference and to obtain the discounted fee.

CONFERENCE	Prior To 8/12/2005	After 8/12/2005
IEEE Member	$550	$600
Non-Member	$600	$650
Student	$200	$250
INTENSIVE COURSE		
IEEE Member	$1050	$1250
Non-Member	$1100	$1300
INTENSIVE COURSE (with 3 or more from the same organization)		
IEEE Member	$975	$1175
Non-Member	$1025	$1225
INTENSIVE COURSE (if also registering for the conference)		
IEEE Member	$900	$1100
Non-Member	$950	$1150

(Plus registration fee for conference)

Please Note: The Intensive Course is subject to a sufficient number of participants registering by 12 August. If there is not enough advance registration, the course will be cancelled on 12 August and persons registered will have their course fee refunded.

Registration Hours

Sunday, 25 September	3:00 p.m. – 6:00 p.m.
Monday, 26 September	7:30 a.m. – 5:00 p.m.
Tuesday, 27 September	8:00 a.m. – 5:00 p.m.
Wednesday, 28 September	8:00 a.m. – 11:00 a.m.

Registration payments: Checks are to be made out to the IEEE HOLM in U.S. funds. Visa, MasterCard, American Express, Diners Club, Discover and wire transfers are also accepted. Please mail your payment along with the enclosed registration form to:

IEEE Holm Conference
IEEE Conference Management Services
445 Hoes Lane
Piscataway, NJ 08854
Or fax to +1 732 465 6447

For additional information please contact Holm Registrar, at +1 732 562 3870, via fax to +1 732 465 6447, or email: j.lambert@ieee.org

Conference registration includes admission to technical sessions, Welcome Reception, refreshment breaks, awards luncheon, and printed book of Technical Proceedings.

Welcome Reception

All conference attendees are invited to register early and attend a welcome reception on Sunday, 25 September from 4:00 p.m. – 6:00 p.m. at the Holiday Inn Chicago-City Centre.

Hotel

The conference this year meets in Chicago, IL at the Holiday Inn Chicago-City Centre Hotel where meeting facilities are well suited to the Conference Sessions and other activities. The hotel is offering special rates of $169.00 US dollars single/double occupancy to conference attendees. Rates are subject to applicable state, local and occupancy taxes: approximately 14.9%. To make a reservation please call the Holiday Inn Chicago-City Centre Hotel at +1 312 787 6100 and identify yourself as part of the IEEE Holm Conference on Electrical Contacts in order to receive the special group rate. The special rate is valid until 3 September 2005, reservations received after this date are subject to space and availability.

Check in time: 3:00 p.m. Check out time: 12:00 p.m.

Travel Arrangements

Please contact the IEEE Travel Services Department at 1 800 TRY IEEE (1 800 879 4333) or +1 732 562 5387 if calling from outside the US to obtain negotiated airfares on Continental, United Airlines and American Airlines.

Local Transportation

Holiday Inn Chicago-City Centre, 300 East Ohio Street, Chicago, IL 60611

Transportation From Airports

Taxis:
Cost is $40 from O'Hare International (ORD), 45-60 minute ride, $30 from Midway (MDW), 30-35 minute drive.

There is also a Continental Air Express Shuttle available to and from both airports with the following fees: $24 one way and $44 round trip from O'Hare International Airport, $19 one way and $34 round trip from Midway Airport

Driving:
If you are arriving by your own transportation and you wish to park at the Holiday Inn Chicago-Centre Hotel daily parking at $28/day and self parking at $28 per 24 hours.

Driving Directions from North, South & East via Rt I-90/94: Exit at Ohio St. East, two blocks past Michigan Ave. from West.

Follow signs to Rt I-94 North Wisconsin then exit at Ohio St. East to hotel.

The Holiday Inn Chicago-City Centre location puts you in the heart of Chicago where you'll experience Chicago's vibrant business climate, dazzling cultural institutions and exceptional natural beauty.

Situated in Streeterville, one of Chicago's most affluent neighborhoods, the **Chicago City Centre** is an award winning hotel with unmatched premium services and amenities. Just outside the hotel doors, where the Magnificent Mile's world class shops and restaurants beckon, and an easy walk takes you to **Navy Pier** with its popular recreational pleasures. The **Chicago City Centre** is conveniently located 2 blocks east of Michigan Ave and 6 blocks from **Millennium Park**, located at the north end of **Grant Park**. The hotel offers: High-speed internet service throughout the hotel, 24-hour room service, a world class fitness facility, indoor and outdoor pools, tennis courts and 4 restaurants.

Mystic Blue Cruise at Navy Pier

Please join us for a three (3) hour reception and dinner cruise along Lake Michigan and explore every deck on the newly remodeled sleek silvery-blue 600 passenger vessel built specifically for cruising the Chicago Skyline. The atmosphere is casual yet contemporary. The service is great. The view is amazing. Imagine the beautiful Chicago Skyline as it reaches for miles North and South with the lake resting at its feet.

Mystic Blue Cruise will travel south along the lake shore, past the Adler Planetarium, North to Evanston, then returns south to Navy Pier. All the while, offering unmatched views of our world-famous skyline, from the Sears Tower to the John Hancock to the Museum Campus, Aon Center and more.

$75.00 per person, including tax and gratuity
3 Course buffet meal including two drink tickets per person

Please register early as attendance is limited

Mystic Blue Cruises is located on the South Side of Navy Pier just East of Riva's Restaurant. The pier is at 600 E. Grand Avenue

For more information regarding Mystic Blue Cruises please go to: www.mysticbluecruises.com

IEEE Holm Conference Ragnar Holm Scientific Achievement Award Nomination Guidelines

History: The Ragnar Holm Scientific Achievement Award was created by the 1971 Holm Conference Steering Committee in honor of the memory of Dr. Ragnar Holm, the founder of the modern science of electrical contacts. This award is to be granted to the living scientist or engineer who has made significant contributions to the theory or practice of electrical contacts, or for work in related technologies which is directly applicable to contacts. In considering a person's work and selecting a recipient preference will be given for: a.) Nominees that have made contributions to the technology over many years, b.) the originality and scientific importance of contributions, and c.) achievements that have found a high degree of practice. Provided worthy candidates are found, the Award will be granted annually.

Eligibility: Any person may be nominated for this award regardless of IEEE membership. Members of IEEE Holm Awards and Nomination Committee are not eligible to be considered for the award while serving on these committees. Nominations are not accepted for persons deceased. Candidates must have made contributions to the electrical contact field for a period spanning at least ten years.

Nominator Eligibility: Any person may nominate a candidate for this award, with the following exception: members of the award committee.

Nomination Support Materials:

Endorsers: At least two letters of endorsement are required. One is from the nominator and the others are from the endorsers selected by the nominator. Endorsers should be in a position to substantiate the candidate's contributions by providing explicit detail from personal knowledge. The nominator is responsible for submission of the letters of endorsement.

Candidate Personal Data/Education/Work: "Name", provide complete name of candidate, not initials. "Personal", provide date of birth, and citizenship. "Education", list year and exact degree of institute. "Society Membership", list various professional society affiliations. Under society activities list officers and major committee work. "Professional History", list present occupation followed by previous career experiences. Indicate positions held, years, and briefly explain each responsibility.

Technical Accomplishments: “Technical Publications”, such as books, papers, reports, and standards are to be listed in chronological order giving author’s names, title, book, journal, or proceedings. “Patents”, should be listed by date, number, title, and country of origin. Documentation authentication “Development of Products or processes”, may be listed for items not covered by patents. “Technical Presentations”, such as keynote addresses or courses developed by the candidate should also be listed.

Significant Contributions: Describe the candidate’s outstanding contributions in terms of specific items. Provide a short paragraph to each one including a general description of the item, the degree of originality and creativity, and importance of the work to the electrical contact field and the time period over which the contribution was made. Also state cases of examples of practices which were developed or modified through contributions of the candidate.

Forward Nominations To: IEEE Holm Nominations Committee, c/o IEEE Holm Conference Administrator, 445 Hoes Lane, Piscataway, NJ 08854 USA

Nominations Deadline: November 15, 2005

Holm 2006

The 52nd IEEE Holm Conference on Electrical Contacts will be held 24-29 September 2006 at the Delta Centre-Ville, Montreal, Quebec, Canada

Prospective authors should submit a brief abstract (200 words maximum) in English, in word or pdf format before December 15, 2005 to the IEEE Conference eXpress website:

http://www.ieee.org/conferencepublishing

Conference ID: Enter “holm06”
(Please use lowercase)

Important Dates

December 15, 2005	Abstract Deadline
February 15, 2006	Notification of Acceptance
April 17, 2006	Completed Paper Deadline
September 24, 2006	Conference Begins

Correspondence Address
IEEE Conference Management Services
50th IEEE Holm Conference (2004)
445 Hoes Lane
Piscataway, NJ 08854
Tel: +1 800 810 4333 or +1 732 562 3870
Fax: +1 732 465 6447
Email: j.lambert@ieee.org

Holm Web site:
www.ewh.ieee.org/soc/cpmt/tc1/

Morton Antler Lecture

The Morton Antler Lecture is an annual lecture given at the IEEE Holm Conference on a topic of special interest to the electrical contact community. This lecture series was established in honor of Dr. Morton Antler, a long time member of the Holm Steering Committee and participant in the Holm Conference. Dr. Antler was a distinguished scientist and lecturer in the fields of electrical contacts, tribology, corrosion, and electrodeposition.

2005 Morton Antler Lecture

The Evolution of Arc Fault Circuit Interrupters

By John A. Wafer
Vice President and Chief Technology Officer
EATON Electrical Group
Pennsylvania, USA

John Wafer has overall research and development and functional engineering responsibilities for the Electrical Group of Eaton Corporation. The Group's products and solutions are used in residential, commercial, industrial, mining, utility and Navy electrical systems. He is a native of Ireland and is a Physics graduate of Dublin University, Trinity College with B.A. and M.A. degrees. He began his career with Westinghouse Electric Corporation at their Research Laboratories in Pittsburgh, Pennsylvania. He progressed through engineering and technical management positions at both the Laboratories and Divisions, and in 1981 he started a Technology and Quality Center. He joined Eaton Corporation in 1994 when it acquired the Distribution and Control Business Unit from Westinghouse. He has 39 years of experience in the electrical industry having worked on low through medium voltage electrical distribution and control products including circuit breakers, contactors, transformers, motors, and associated electromagnetic and electronic devices and systems. He holds more than 50 patents, and in 2001 the Pittsburgh Intellectual Property Law Association recognized him as "Inventor of the Year". He has been involved in forums and committees associated with certification and standards bodies such as UL and CSA, and he has been active at the National Electrical Manufacturers Association (NEMA) for 25 years. He has served on the NEMA board and has held numerous chairs including Division 5, LVDE, and 5AB. He received the NEMA Kite & Key award in 2001. His professional memberships include IEEE, NFPA, and IAEI.

The 51st IEEE Holm Conference on Electrical Contacts Contributors

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University of Rennes

University of Southampton

University of Tokyo

Technical Program

Monday, September 26, 2005

8:00 a.m.

INTRODUCTION and OPENING REMARKS

Henry Czajkowski, 2005 Holm Conference Chair

8:10 a.m. – 9:10 a.m.

Holm Award

Contact Contamination and Arc Interactions, Gerald Witter, Chugai USA, Inc. IL

Arc Discharge and Contact Reliability in Switching and Commutating Contacts
Koichiro Sawa, Keio University, Japan

9:10 a.m. – 9:30 a.m.

Coffee Break

9:30 a.m. – 11:10 a.m.

Arcing Materials

Chair: Thomas Schoepf
Co-Chair: Bill Balme

1.1 **Contact Erosion of Ag/SnO_2/In_2O_3 Made by Internal Oxidation and Powder Metallurgy**
Chi Leung, Eric Streicher, Dennis Fitzgerald, Justin Cook, AMI DODUCO

1.2 **Occurrence of SiO_2 on the Contact Surface and its Dependence of Electrode in Silicon Vapor**
Terutaka Tamai, Hyogo University of Teacher Education, Japan

1.3 **The Effect of Silver Compostition and Additives on Switching Characteristics of Silver Tin Oxide Type Contacts for Automotive Inductive Loads**
Z.K. Chen, G. Witter, Chugai USA, Inc

1.4 **Substitution of Silver/Cadmium oxide in High Voltage Disconnectors**
Christian Bernauer, Torsten Kuntze, Ruhrtal Hochspannungsgerate, Germany, Volker Behrens, Thomas Honig, AMI DODUCO GmbH, Germany

1.5 **High Temperature Resistant Galvanic Deposited Gold Layers for Switching Contacts**
Werner Johler, Tyco Electronics AXICOM

11:10 a.m. – 11:20 a.m.

Break

11:20 a.m. – 12:20 p.m.

Power

Chair: John Shea
Co-Chair: Chi Leung

2.1 **Asynchronous Modular Contactor with Intelligent Motor Control Applications**
Xin Zhou, Lian Zou, Engelbert Hetzmannseder, Eaton Corporation, USA

2.2 **Modeling and Management of Microshocks under High Voltage Transmission Lines**
Aruna Gunatilake, S.M. Rowland, Z.D. Wang, N.L. Allen, The University of Manchester, United Kingdom

2.3 **Effect of Short Circuit Current Duration on the Welding of Closed Contacts in Vacuum**
Paul G. Slade, Erik D. Taylor, Richard E. Haskins, Jr., Eaton Electrical, USA

12:20 p.m. 1:40 p.m.

Lunch on Your Own

1:40 p.m. – 3020 p.m.

Connector Fretting A

Chair: Milenko Braunovic
Co-Chair: Ed Smith

3.1 **Intermittency Events in Bio-Compatible Electrical Contact**
J.W. McBride, University of Southampton, UK, C. Maul, TaiCaan Technologies Ltd., UK

3.2 **The Influence of Contact Interface Characteristis on Vibration-Induces Fretting Degradation**
George T. Flowers, Fei Xie, Michael Bozack, Roland Horvath, Auburn University, USA, Bretton I. Rickett, Robert D. Malucci, Molex, Inc. USA

3.3 **Displacement Measurements at the Connector Contact Interface Employing a Novel Thick Film Sensor**
Liza Lam, John W. McBride, Chrisitan Maul, John K. Atkinson, University of Southampton, United Kingdom

3.4 **Vibration-Induced Deterioration of Tin-Coated Connectors Studied by Using a Force Controlled Fretting Bench-Test**
Tag Hammam, KIMAB, Sweden, Asa Kassman-Rudolphi, Uppsala University, Sweden, Per Lundstrom, Outokumpu Fabrication Technologies, Sweden

3:00 p.m. – 3:20 p.m.
Coffee Break

3:20 p.m. – 4:40 p.m.
Connector Corrosion A
Chair: Nourdeeine Benjamaa
Co-Chair: Brett Rickett

4.1 **Lubrication of Electrical Contacts**
Bella Chudnovsky, Schneider Electric, USA

4.2 **Inspection of the Contaminants at Failed Connector Contacts**
Cuifeng Feng, Beijing University of Posts & Telecommunications, China, Ji Gao Zhang, Nokia Corporation, Finland

4.3 **On the Spontaneous Growth of Soft Metallic Whiskers**
E.N. Hoffman, M.W. Barsoum, W. Wang, R.D. Doherty, A. Zavaliangos, Drexel University, USA

4.4 **The "Selective" Deposition of Particles on Electric Contact and Their Effects on Contact Failure**
Jinshun Gao, Beijing University of Posts & Telecommuncations, China

6:00 p.m.
Social – Mystic Blue Cruise Tour at Chicago Navy Pier

Tuesday, September 27, 2005

8:00 a.m. – 9:20 a.m.

Arc Interruption

Chair: Werner Rieder
Co-Chair: Xin Zhou

5.1 **Cathode Spot Behavior on Tungsten-Copper Contacts in Vacuum and the Effect on Erosion**
Erik D. Taylor, Eaton Electrical, USA

5.2 **Time-coordinated Non-arcing Breaking Operation of Reed Switches for Higher Current**
Noboru Wakatsuki, Yu Yonezawa, Ishinomaki Senshu University, Japan

5.3 **The Influence of Load and Contact Material on the Tangential Separation Force of Low Current Switching Contacts**
Alexander R. Neuhaus, Andreas Hammerschmid, Thomas Felkel, Marthin Reichart, AC^{2}T Research GmbH, Austria, Werner F. Rieder, Vienna University of Technology, Austria

5.4 **An Investigation for the Method of Lifetime Prediction of Ag-Ni Contacts for Electromagnetic Contactor**
Yosuke Kawakami, Keio University, Japan

9:20 a.m. – 9:40 a.m.

Coffee Break

9:40 a.m. – 10:20 a.m.

Morton Antler Lecture
The Evolution of Arc Fault Circuit Interrupters

John A. Wafer, Chief Technology Officer, Eaton Electrical, Eaton Corporation, PA, USA

10:40a.m.-11:00a.m.

Break

11:00am – 12:00p.m.

Safety

Chair: Henry Czajkowski
Co-Chair: Erik Taylor

6.1 **Performance Classification for Electrical Connections Using ASTM B868**
J. Aronstein, Consulting Engineer, USA

6.2 **Conditions for Series Arcing Phenomena in PVC Wiring**
John J. Shea, Eaton Corporation, USA

12:00 p.m. – 1:30 p.m.

Awards Luncheon

Ragnar Holm Scientific Achievement Award

Mr. Gerald Witter, Chugai USA

Dr. Morton Antler Lecture

Mr. John A. Wafer, Eaton Electrical

2004 IEEE Holm Conference Erle Shobert Prize Paper Award

Roland Timsit

for “Electrical Conduction through Small Contact Spots”

1:30 p.m. – 2:50 p.m.

Connector Fretting B

Chair: Roland Timsit
Co-Chair: Z.K. Chen

7.1 **Rating Power Connectors Using Voltage Drop**
Robert D. Malucci, Frank R. Ruffino, Molex Inc, USA

7.2 **Micro Motion at the Failed Contact Interfaces**
Zhanping He, Liangjun Xi, Beijing University of Posts & Telecommunications, China

7.3 **Effect of Fretting Slip Amplitude on the Friction Behavior of Electrical Contact Materials**
D. Gagnon, Hydro Quebec IREQ, Quebec, Canada, M. Braunovic, MB Interface, Canada, J. Masounave, Ecole de technologies Superieure, Canada

7.4 **The Fretting Characteristics of Intrinsically Conducting Polymer Contacts**
Liza Lam, John W. McBride, Jonathan Swingler, University of Southampton, UK

2:50 p.m. – 3:10 p.m.
Coffee Break

3:10 p.m. – 4:30 p.m.
Modeling
Chair: John McBride
Co-Chair: Richard Moore

8.1 **Application of the Finite-Element Analysis for the Calculation of an Insulation Displacement Process**
Stefan Joregens, Hennig Taschke, LumbergConnect GmbH & Co. KG, Germany

8.2 **Deflection Analysis of Spring Connector**
A. Elmanfalouti, R. El Abdi, M. Buisson, N. Benjemaa, Unniversity of Rennes 1, France

8.3 **A Model for Life Time Evaluation of Closed Electrical Contacts**
M. Braunovic, MB Interface, Canada, V. V. Izmailov, M.V. Novoselova, Tver State University of Technology, Russia

8.4 **A Mechanical, Electrical, Thermal Coupled-field Simulation of a Sphere-plane Electrical Contact**
A. Monnier, R. Meyer, P. Teste, Universites Paris VI et Paris XI, France, B. Froidurot, C. Jarrige, Schneider Electric, France

4:30 p.m. – 4:40 p.m.
Break

4:40 p.m. – 5:40 p.m.
Connector Corrosion B
Chair: Jigao Zhang
Co-Chair: Ed Smith

9.1 **Pore Corrosion Model for Gold-Plated Copper-Contacts**
A.C. Sun, H,K. Moffat, D. G. Enos, C.S. Glauner, Sandia National Laboratories, NM, USA

9.2 **Electrochemical Migration of Land Grid Array Sockets under Highly Accelerated Stress Conditions**
S. Yang, Ji Wu, Michael Pecht, University of Maryland, USA

9.3 **Multi-Scale Study of the Electrical Properties of Organic Layers Grafted on Gold Surfaces**
S. Noel, Alamarguy, N. Lecaude, O. Schneegans, LGEP, France, L. Tristani, FCI, France

5:45 p.m.

TC1 Meeting

Chair: Gerald Witter

Wednesday, September 28, 2005

8:20 a.m. – 10:00 a.m.

MEMS

Chair: Koichiro Sawa
Co-Chair: Bob Malucci

10.1 **The Effects of Surface Contamination on Resistance Degradation of Hot-Switched Low-Force MEMS Electrical Contacts**
Daniel J. Dickrell III, Michael T. Dugger, Sandia National Laboratories

10.2 **Micro Phenomena in Low Contact-Force Probing on Aluminum**
Kenichi Kataoka, Tokyo Electron AT Ltd., Japan, toshihiro Itoh, Tadatomo Suga, The University of Tokyo, Japan

10.3 **Finite Element Analysis of Magnetic Structure for Micro-Electro-Mechanical Relays**
Wanbin Ren, Guofu Zhai, Qiya Wang, Harbin Institute of Technology, China, Desheng Li, Beijing University of Technology, China

9:20 a.m. – 10:00 a.m.

Invited Speaker:
Prof. Timothy Fisher, Purdue University

Enhanced Interfacial Transport using Carbon Nanotube Arrays

10:00 a.m. – 10:20 a.m.

Coffee Break

10:20 a.m. – 11:40 a.m.

Fundamentals

Chair: Paul Slade
Co-Chair: Philip Wingert

11.1 **Contact Resistance Characteristics of High Temperature Superconducting Bulk – Part IV**
Hiroyuki Fujita, Takuya Imaizumi, Koichiro Sawa, Keio University, Japan, Masaru Tomita, Railway Technical Research Institute, Japan, Naomichi Sakai, Izumi Hirabayashi, ISTEC-Superconductivity Research Laboratory, Japan, Masato Murakami, Shibaura Institute of Technology, Japan

11.2 **Synthesis and Characterization of Ti-Si-C Ternary Compounds for Electrical Contact Applications**
P. Eklund, J. Emmerlich, H. Hogberg, O. Wihelmsson, P. Isberg, P.O. A. Persson, U. Jansson, L. Hultman, Linkoping University, Sweden

11.3 **Equivalent Constriction Resistance Measured with the Low Dc Voltage Method under the Influence of Fritting Phenomena**
Eisuke Takano, Japan

11.4 **Multi-Spot Model Showing the Effects of Nano-Spot Sizes**
Robert D. Malucci, RD Malucci Consulting, USA

11:40 a.m. – 12:40 p.m.

Lunch

12:40 p.m. – 2:20 p.m.

Sliding

Chair: Werner Johler
Co-Chair: Steve Cole

12.1 **Development of the Lead-Free Brush Material for the High-Load Starter**
Ryoichi Honbo, Hiroyuki Wakabayashi, Youichi Murakami, Naruhiko Inayoshi, Kyoji Inukai, Takeshi Shimoyama, DENSO Corporation, Japan, Koichiro Sawa, Keio University, Japan, Maoki Morita, TRIS Incorporated Company, Japan

12.2 **Lont-Term High Resoultion Wear Studies of High Current Density Electrical Brushes**
Martin V.R. Skov Jensen, Vestas Wind Systems A/S and University of Aarhus, Denmark

12.3 **Degradation Process of a Sliding System with Au-plated Slip-ring and AgPd Brush for Power Supply**
Koichiro Sawa, Shingo Kakino, Takashi Shigemori, Yosuke Kawakami, Keio University, Japan, Kaoru Endo, Gun Ou, Hiroshi Hagino, Japan Servo Co., Ltd., Japan

12.4 **Characteristics of Carbon Flat Commutator for High-Inductance DC Motor Driving Automotive Fuel Pump**
Takashi Shigemori, Koichiro Sawa, Keio University, Japan

12.5 **Influence of Surface Roughness on Contact Voltage Drop of Sliding Contacts**
Takahiro Ueno, Nippon Institute of Technology, Japan

2:20 p.m. – 2:40 p.m.
Coffee Break

2:40 p.m. – 4:40 p.m.
Automotive
Chair: Jerry Witter
Co-Chair: George Drew

13.1 **An Arc Study at High DC Current Level in Automotive Applications**
D. Sallais, C. Bourda, D. Jeannot, Metalor Technologies, France, N. Benjemaa, E. Carvou, University of Rennes, France

13.2 **Consecutive Oberservations of the Relationship between Eroded Contact Surfaces and Motion of Breaking Arc at each Breaking Operation**
Junya Sekikawa, Takayoshi Kubono, Shizuoka University, Japan

13.3 **A Novel Concept Utilizing Conductive Polymers on Power Connectors During Hot Swapping in Live Modular Electronic Systems**
Trent Do, Teradyne Connection Systems, USA

13.4 **The Evolution of Contact Erosion during an Opening Operation at 42 V**
J. Swingler, A. Sumption, J.W. McBride, University of Southampton, United Kingdom

13.5 **Counter-Measures for Relay Failure Due to Dynamic Welding: A Robust Engineering Design**
Thomas Schoepf, Delphi Research Labs, USA

13.6 **Contact Heating by Long Arcing During Connector Disconnection**
M. Porte, J. Razafiarivelo, FCI Research Center, France, E. Carvou, N. Ben Jemaa, University of Rennes I, France

4:40 p.m.
End of Conference

Author Index

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along with the
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