

# **26th International Conference on Electrical Contacts 2012**

**(ICEC 2012)**

**IET Conference Publications 605**

**Beijing, China  
14-17 May 2012**

**ISBN: 978-1-62276-313-9**

**Printed from e-media with permission by:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571



**Some format issues inherent in the e-media version may also appear in this print version.**

Copyright© (2012) by the Institution of Engineering and Technology  
All rights reserved.

Printed by Curran Associates, Inc. (2012)

For permission requests, please contact the Institution of Engineering and Technology  
at the address below.

Institution of Engineering and Technology  
P. O. Box 96  
Stevenage, Hertfordshire  
U.K. SG1 2SD

Phone: 01-441-438-767-328-328  
Fax: 01-441-438-767-328-375

[www.theiet.org](http://www.theiet.org)

**Additional copies of this publication are available from:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: 845-758-0400  
Fax: 845-758-2634  
Email: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

# TABLE OF CONTENTS

<b>RF Current Produced from DC Electrical Arcing</b> .....	1
<i>J.J. Shea, C.J. Luebke, K.L. Parker</i>	
<b>Investigations on Material Structural Changes on Electrical Joints at High Contact Temperature</b> .....	7
<i>S. Schlegel, S. Grossmann, M. Lakner, T. Schoenemann</i>	
<b>Contact Spot Temperature and the Temperature of External Surfaces in an Electrical Connection</b> .....	12
<i>C. Wilson, G. McIntosh, R.S. Timsit</i>	
<b>A Study of Switching Time and Light Emission During Carbon Contact Separation</b> .....	18
<i>J. Praquin, J. Rivenc, C. Gautherot, N. Ben Jemaa, E. Carvou, J.B.A. Mitchell, R. El Abdi</i>	
<b>DC-Arc Blowing Under Pulsed Magnetic Field</b> .....	23
<i>A. Vassa, E. Carvou, S. Rivoirard, L. Doublet, C. Bourda, N. Ben Jemaa, D. Givord</i>	
<b>Experimental Study on Arc Duration Under External Transverse Magnetic Fields in a DC 580V Circuit</b> .....	30
<i>Liu Yun, Li Zhenbiao, Wang Ke, Wang Ronghua</i>	
<b>Breaking Performance of a Circuit Breaker Influenced by a Permanent Magnetic Field at DC Voltages Up to 450 V</b> .....	35
<i>T. Schrank, E.-D. Wilkening, M. Kurrat, F. Gerdinand, P. Meckler</i>	
<b>Arc Quenching Performance Due to Ablation: Comparison Between Four Common Polymers</b> .....	41
<i>E. Jonsson, M. Runde, G. Dominguez, A. Friberg, E. Johansson</i>	
<b>The Role of Organic Compounds in Simulation of Dust Environments for Electric Contacts</b> .....	45
<i>Zhou Yilin, Lv Yang, Liu Libiao</i>	
<b>Study on Electrical Contact Performance of Circuit Breaker Terminals in the Environment Containing SO<sub>2</sub></b> .....	50
<i>Lu Jianguo, Wang Jingqin, Wang Lili, Liu Lin, Guan Ruiliang, Yu Xiaofeng, Zhao Sheng</i>	
<b>Experimental and Numerical Studies of Surface Contamination and Degradation of Aluminium Contacts in Primary Aluminium Smelters</b> .....	55
<i>D. Molenaar, D. Gunasegaram, T. Kilpatrick</i>	
<b>Study on the Reliability Test of Automotive Relays Under Temperature Cycling Condition</b> .....	61
<i>Luo Yanyan, Meng Fanbin, Liu Baoli, Li Wenjun, Zhang Yuanlei</i>	
<b>Electrical Behaviour of the Wheel-Rail Contact</b> .....	67
<i>F. Houzé, H. Chollet, P. Teste, X. Lorang, F. Loete, R. Andlauer, S. Debuquoi, F. Lerdu, M. Antoni</i>	
<b>Study on Wear Mechanisms of Copper Impregnated C/C Composite Under Electrical Current</b> .....	73
<i>Y. Kubota, S. Nagasaka, T. Miyauchi</i>	
<b>Applicability of Cu-Mo Multilayers Material in Sliding Contacts of DC Mine Transportation System</b> .....	78
<i>B. Miedzinski, M. Habrych, J. Wandzio, N. Grechanyuk</i>	
<b>Research of Temperature Rise on the Contact Surface in the Sliding Electric Contact</b> .....	82
<i>Hui Lichuan, Chen Zhonghua</i>	
<b>Wear and Electrical Properties of Slip Rings</b> .....	86
<i>C. Holzapfel</i>	
<b>Survey of the Electrical Apparatus Reliability Developments in China</b> .....	91
<i>Lu Jianguo, Wang Jingqin, Luo Yanyan</i>	
<b>Reliability of Hermetically Sealed Miniature Relays in Silicone-Rich Environments</b> .....	98
<i>C. Schrank</i>	
<b>Study on the Reliability Test and Failure Analysis of Automotive Relays at High Temperature</b> .....	105
<i>Luo Yanyan, Lu Jianguo, Meng Fanbin, Li Chunxia, Liu Zhijun</i>	
<b>A 'Universal' Life-Test System for Electromechanical Relays</b> .....	110
<i>B.J. Frost, S.J. Hobday</i>	
<b>Degradation Failure Model of Electromagnetic Relay</b> .....	116
<i>Ye Xuerong, Ma Yue, Meng Hang, Zhai Guofu</i>	
<b>Experimental and Numerical Studies of a Multi-Leaf Clamped Lap Joint Design for Aluminium Bus Bar Applications</b> .....	124
<i>D. Molenaar, T. Kilpatrick, D. Gunasegaram</i>	
<b>Modelling of Spring Type Electrical Contacts</b> .....	130
<i>O. Aitken, J.-A. Rodriguez, P. Vinson</i>	
<b>Optimal Design and Analysis System of AC Solenoid Valve</b> .....	134
<i>Xu Zhihong, Lin Shuyi, Cheng Zhuyuan</i>	
<b>Experimental and Simulated Force-Displacement Relations Under Cyclic Bending Deformation of Copper-Based Spring Materials</b> .....	142
<i>Y. Hattori, K. Furukawa, H. Hamasaki, F. Yoshida</i>	

<b>Modeling Study of the Amount of Wear in Sliding Electric Contact .....</b>	<b>146</b>
<i>Chen Zhonghua, Hui Lichuan, Wang Tiejun, Guo Fengyi</i>	
<b>Contact Behavior of Electrical Vehicle-Battery Junction Box Under High Shorting and Breaking Current .....</b>	<b>151</b>
<i>E. Carvou, N. Ben Jema, B. Mitchell, C. Gautherot, J. Rivenc, L. Colchen</i>	
<b>New Contacting Solutions for High Voltage ZnO Varistors .....</b>	<b>156</b>
<i>A. Oberg, B. Stridh, R. Osterlund, L. Pettersson, A. Andersson, P. Hidman, P. Frejd</i>	
<b>Study on Detection Technology of the Contact Pressure on the Electrical Contacts of Relays .....</b>	<b>161</b>
<i>Wang Biao, Luo Yanyan, Zhang Yuanlei, Zhang Xiaojun</i>	
<b>Test Stand for Testing Contacts of Switches in a Fixed Household Electrical Installations .....</b>	<b>165</b>
<i>P. Borkowski, E. Walczuk</i>	
<b>Study on Digital Controller of Multi-Task Interleaving Parallel BUCK Modules .....</b>	<b>171</b>
<i>Li Xinfu, Zhou Yunhong, Fan Jianbo, Fan Haoliang</i>	
<b>A Correlation of Silver Tin Indium Oxide-Copper Composite Rivet Interface Bond Quality and Switching Endurance Life in DC Relays .....</b>	<b>174</b>
<i>Z.K. Chen, G.J. Witter</i>	
<b>Influence of Electromagnetic Pulse on Electromagnetic Relay by Using Equivalent Circuit Model .....</b>	<b>180</b>
<i>Li Bing, Yang Wenying, Peng Fei, Zhai Guofu</i>	
<b>Progress in Fabrication Technology of Silver-Based Contact Materials with Particular Account of the Ag-Re and Ag-SnO<sub>2</sub>Bi<sub>2</sub>O<sub>3</sub> Composites .....</b>	<b>186</b>
<i>S. Ksiezarek, M. Woch, D. Kolacz, M. Kamińska, P. Borkowski, E. Walczuk</i>	
<b>Advanced Silver-Tin Oxide Contact Materials for Relay Application .....</b>	<b>194</b>
<i>T. Mützel, R. Niederreuther</i>	
<b>Research on Uncertainty of Bounce Time for Electromagnetic Relay and Its Application in Operating Reliability Estimation .....</b>	<b>200</b>
<i>Yao Fang, Li Zhigang, Wu Yachao, Yao Cuiping</i>	
<b>Quantification of the Electrical Contact Endurance of Thin Plated Silver Coatings Subjected to Fretting Wear: Influence of Coating Thickness .....</b>	<b>205</b>
<i>P. Jędrzejczyk, S. Fouvry, O. Alquier</i>	
<b>Fretting Property of Asymmetrical Metal Contact Pairs .....</b>	<b>213</b>
<i>Lin Xueyan, Luo Guoping, Xu Liangjun</i>	
<b>Influence of Contact Interface Composition on the Electrical and Tribological Properties of Nickel Electrodeposits During Fretting Tests .....</b>	<b>221</b>
<i>S. Noël, D. Alamarguy, L. Baraton, P. Laurat</i>	
<b>Detailed Analysis of Contact Resistance of Fretting Corrosion Track for the Tin Plated Contacts .....</b>	<b>228</b>
<i>Y. Shibata, S. Oohira, S. Masui, S. Sawada, K. Iida, T. Tamai, Y. Hattori</i>	
<b>Electrical and Mechanical Lives of Ag/C and Ag/WC/C Contacts .....</b>	<b>233</b>
<i>Chi Leung, D. Harman, L. Doublet, C. Bourda, YuSheng Cui, Lifu Hu</i>	
<b>Influence of Voltage on Electrode Mass Change of AgNi Contacts for Electromagnetic Contactors: Relativity of Contact Resistance and Arc Mode .....</b>	<b>240</b>
<i>K. Yoshida, K. Sawa</i>	
<b>Simplification of the Arc Splitting Process in Numerical Gas Flow Simulations .....</b>	<b>245</b>
<i>J. Riss, M. Lindmayer, M. Kurrat</i>	
<b>Arc Characteristics on Dissymmetric Contact Pair of Ag Based Materials at Slowly Breaking .....</b>	<b>250</b>
<i>K. Miyanaga, Y. Kayano, H. Inoue, T. Takagi</i>	
<b>Numerical Simulation of Arc Motion During Interruption Process of Low-Voltage Circuit Breakers .....</b>	<b>255</b>
<i>Chen Degui, Li Xingwen, Ji Liang, Zhou Xin</i>	
<b>Manifold Decomposition Processes of Silicone Vapor and Electrical Contact Failure .....</b>	<b>261</b>
<i>T. Tamai, S. Sawada, Y. Hattori</i>	
<b>Influence of Coatings on Contact Resistance .....</b>	<b>267</b>
<i>Lu Ningyi, Jiang Changliu, Chen Jun</i>	
<b>Contact Resistance Characteristics of Relays Operated in Vapors Evaporated from Non-Silicone-Type Acryl-Based Polymeric Products Cured in Various Manners .....</b>	<b>272</b>
<i>M. Hasegawa, N. Kobayashi, Y. Kohno, H. Ando</i>	
<b>Study on Static Arc Behaviors in a Relay Considering Influence of the Silver Vapor .....</b>	<b>277</b>
<i>Zhou Xue, Qi Le, Liu Bo, Zhai Guofu</i>	
<b>New Technology of Modification of Reed Switch Contact Surfaces with the Usage of Ion-Plasma Nitriding .....</b>	<b>284</b>
<i>K.A. Arushanov, S.M. Karabanov, I.A. Zeltser, R.M. Maizels, E.N. Moos</i>	
<b>Detection and Formation Process of Overheated Electrical Joints Due to Faulty Connections .....</b>	<b>288</b>
<i>Xin Zhou, T. Schoepf</i>	

<b>Transformer Fault Diagnosis Based on IAFSA and Rough Set</b> .....	296
<i>Chen Xiaoqing, Liu Juemin, Huang Yingwei, Fu Bo</i>	
<b>Wavelet Analysis for the Fault Detection in Electrical Connectors</b> .....	301
<i>Zhang Hao, Gao Jinchun, Yu Cuiping, Chen Chen</i>	
<b>Study on Acquiring Key Performance Parameters and Comprehensive Performance Degradation Model of Relays</b> .....	306
<i>Wang Jia, Yao Fang, Li Zhigang</i>	
<b>Numerical Analysis of the Electric Arc Simulation Using Ansys CFX</b> .....	311
<i>B. Barbu, A. Iturregi, F. Berger, E. Torres</i>	
<b>Method for Calculation of Contact Resistance and Finite Element Simulation of Contact Temperature Rise Based on Rough Surface Contact Model</b> .....	317
<i>Wang Shujuan, Hu Fang, Su Bonan, Zhai Guofu</i>	
<b>The Effect of Serrations on the Electrical Contacts in Contactors</b> .....	322
<i>E. Johansson, M. Johansson, L. Eriksson, P. Isberg</i>	
<b>Constriction Current Behavior of Oxide Film Effect Observed by Using LED Wafer</b> .....	326
<i>S. Sawada, S. Tsukiji, T. Tamai, Y. Hattori</i>	
<b>Nanoscale Particles Modified Gold Plating for Electrical Contacts</b> .....	331
<i>Song Jian, C. Koch, Wang Liangliang</i>	
<b>Lifetime of Cold-Sprayed Electrical Contacts</b> .....	338
<i>G. Rolland, Y. Zeralli, V. Guipont, M. Jeandin, S. Hardy, L. Doublet, C. Bourda</i>	
<b>Ag/(SnO<sub>2</sub>)<sub>12</sub> Electrical Contact Material with Fibre-Like Arrangement of Reinforcing Nanoparticles: Preparation, Formation Mechanism and Properties</b> .....	346
<i>C. Lawson, Shen Qianhong, Zhu Shenmin, Li Hongyun, Mu Chengfa, Wu Xinhe, Chen Xiaotong, Qi Gengxin, He Qing, Qiao Xiuqing, Fan Xianpin, Yang Hui</i>	
<b>Fine Transfer in Electrical Switching Contacts Using Gold Coated Carbon-Nanotubes</b> .....	353
<i>J.W. McBride, L. Jiang, C. Chianrabutra</i>	
<b>Magnetically Controlled MEMS Switches with Nanoscale Contact Coatings</b> .....	359
<i>S.M. Karabanov, A.S. Karabanov, D.V. Suvorov, B. Grappe, C. Coutier, H. Sibuet, B.N. Sazhin</i>	
<b>The Investigation on the Production Process of AgSnO<sub>2</sub> Contact Materials by AgSn Alloy Powder Pre-Oxidation</b> .....	362
<i>Liu Liqiang, Yan Xiaofang, Weng Wei, Xie Jifeng, Zheng Ning</i>	
<b>Contact Surface Condition Effect on Contact Resistance and Improving Methods</b> .....	368
<i>Bai Xiaoping, Li Guowei, Weng Wei, Zhang Mingjiang, Lin Wanhuan, Zhu Libing, Zhang Yaping</i>	
<b>Degradation Phenomena of Electrical Contacts Using Hammering Oscillating Mechanism and Micro-sliding Mechanism: Oscillating Amplitude, Natural Frequency and Damping Ratio Caused by the Mechanisms</b> .....	375
<i>S.-I. Wada, K. Sawa</i>	
<b>Study on Electrical Contact Properties of Ag-SnO<sub>2</sub> Contact Material</b> .....	382
<i>Meng Fanbin, Wang Weitao, Zhang Ning, Chen Xueguang</i>	
<b>Investigation of Thermal and Mechanical Stresses of Arcing Contacts in Circuit Breakers</b> .....	386
<i>C. Fnineche, O. Aitken</i>	
<b>Experimental Investigation on Parameters of Switches Contacts</b> .....	390
<i>T. Elbekri, L. Chaàbane</i>	
<b>Influence of Generated Organic Gas on Contact Resistance for Relay</b> .....	393
<i>Li Ying, K. Kubono, S. Takano, Y. Kurata, S. Aoki, H. Saso</i>	
<b>Influence of Attachment Quality on the Performance of Arcing Electrical Contacts</b> .....	398
<i>An Guojian, G. Horn</i>	
<b>Research on Optimization Method of High-Frequency Relay's RF Capability Based on Orthogonal Experiment</b> .....	402
<i>Xu Le, Chen Guofeng, Song Jiangzhu, Zhai Guofu</i>	
<b>Study on the Arc Property of AgSnO<sub>2</sub> Contact Material</b> .....	406
<i>Wang Haitao, Wang Huihui</i>	
<b>Investigation on Friction Coefficient Evolution for Thin-Gold Layer Contacts</b> .....	411
<i>H. Essone-Obame, L. Cretinon, B. Cousin, N. Ben Jemaa, E. Carvou, R. El Abdi</i>	
<b>The Connector Life Test System Design</b> .....	417
<i>Lu Na, X.Y. Jiang, L.J. Xu, Y.S. Li</i>	
<b>Effect of Resistance at Contact Boundary of Loose Connector on Electromagnetic Radiation</b> .....	422
<i>K. Matsuda, Y.-I. Hayashi, T. Mizuki, H. Sone</i>	
<b>Investigation of Electrical Properties and Morphology of Several Contact Materials After Cyclic Damp-Heat and Sliding</b> .....	426
<i>Kong Zhigang, Huang Ruoyu, Xu Liangjun</i>	

<b>Design, Manufacture, Test and Reliability of Miniature Circuit Breaker</b> .....	430
<i>Bu Haomin, Zhang Lanjing, He Xiao</i>	
<b>Fault Analysis of Multi-DC Converter</b> .....	436
<i>Cui Yulong, Chai Wanli, Fan Haoliang, Fan Jianbo</i>	
<b>The Bayesian Analysis of Reliability of Zero-Failure Data</b> .....	439
<i>Jin Shaohua, Lu Jianguo, Wan Yanping, Sun Shuguang, Chen Xiuyin</i>	
<b>The Numerical Simulation and Reliability Analysis of Through-Hole Solder Joints</b> .....	443
<i>Wang Shujuan, Shao Xuejin, Xue Shengjun, Zhai Guofu</i>	
<b>Study of Guided Weapon Reliability Assessment Model Based on Bayes Method</b> .....	449
<i>Huang Jingde</i>	
<b>Study on Prior Information Fusion Method in Reliability Assessment for Low-Voltage Switchgear</b> .....	452
<i>Xu Shuyu, Zhang Liang, Wang Jingqin</i>	
<b>Study of Distribution Network Cable Faults Location Based on Wavelet Transform and Autocorrelation Analysis</b> .....	456
<i>Zhang Zhong</i>	
<b>Study on the Operational Reliability of AC Relay Based on the Impact from Electric Energy Quality</b> .....	459
<i>Yao Fang, Zhao Fa</i>	
<b>Study on the Comprehensive Test Technology of Circuit Breaker Mechanical Life and Its Accessories Based on Virtual Instrument</b> .....	465
<i>Li Wenhua, Yu Xiaoguang, Liu Jun, Yang Man, Zhao Sheng</i>	
<b>Study on Reliability for Automatic Transfer Switching Equipment</b> .....	471
<i>Lu Jianguo, Luo Yanyan, Li Wenhua, Zhao Sheng</i>	
<b>Reliability Analysis of Airport Lighting Aid System Based on Light Source Failure</b> .....	475
<i>Cao Sheng, Yang Wenying, Zhai Guofu</i>	
<b>Thermal Simulation of Small Capacity AC Contactor Based on ANSYS</b> .....	479
<i>Liu Guojin, Liu Haiqiang, Zheng Bin</i>	
<b>Evaluation and Forecast Method of AC Contactor Contacts Dynamic Response Based on Theory of Chaos</b> .....	484
<i>Yang Yijun, Su Xiuping, Cui Chunyan</i>	
<b>Testing Comparison of WS<sub>2</sub>-C and WS<sub>2</sub>-W Based Composite Materials of Low Speed Sliding Contacts</b> .....	487
<i>Y. Watanabe, M. Arai</i>	
<b>Morphological Wavelet Analysis for Low-Voltage Arc Fault</b> .....	492
<i>Zheng Xin, Xu Zhihong</i>	
<b>Investigations on Some Parameters Influencing the Current Commutation in the Circuit Breakers</b> .....	497
<i>C. Fnineche, O. Aitken</i>	
<b>Impact of Various Harsh Environmental Conditions on the Long Term Behavior of Electrical Joints</b> .....	502
<i>S. Dreier, S. Grossmann</i>	
<b>High-Speed Thermography of Fast Dynamic Processes on Electronic Switching Devices</b> .....	509
<i>P. Meckler, F. Gerdinand</i>	
<b>Author Index</b>	