MICROMATERIALS AND NANOMATERIALS

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IMPRESSUM
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editorial office:
Fraunhofer Institute IZM Berlin
Micro Materials Center
Gustav-Meyer-Allee 25, D–13355 Berlin
phone: +49 (0)30 46403-200
fax: +49 (0)30 46403-211
e-mail: bernd.michel@izm.fraunhofer.de
homepage: www.micromaterialscenter.com
editor: B. Michel, Berlin
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Preface

Der Automobilbau erwartet in den nächsten Jahren deutliche Innovationen durch eine immer breitere Nutzung der modernen Technologien wie Mikroelektronik, Mikrosystemtechnik und die Nanotechnologie. Insbesondere bei der Automobilsensorik werden Mikro- und Nanowerkstoffe eine große Rolle spielen. Im Bereich der Automobilelektronik geht der Trend zu höheren Temperaturen. Die Fortschritte der sogenannten Hochtemperaturelektronik sollen sich vor allem auch durch Kosteneinsparungen sowie durch eine bessere Nutzung des motornahen Fahrzeugraumes ausdrücken.

Mechatronik im Fahrzeug ist ein wichtiger Trend zur Verbindung von Mechanik, Elektronik und Informatik. Die Mikromechatronik und Nanomechatronik als besonders innovative Forschungsdisziplinen werden in Verbindung mit modernen Lösungen der Mikrosystemtechnik, z.B. auch des Electronic Packaging, zu ganz neuen Lösungen im Automobilbereich führen. Im Rahmen der Zulieferermesse Z2003 (Automotive Suppliers Conference) wird hierzu erstmals eine bedeutende wissenschaftliche Veranstaltung – die MicroCar 2003 – Automobilhersteller, die Elektronikindustrie und zahlreiche Spezialisten aus Hochschulen und Forschungseinrichtungen in Leipzig zusammenführen, um die neuen Möglichkeiten des Einsatzes von Mikro- und Nanowerkstoffen in der Automobilindustrie zu diskutieren.

In 50 Vorträgen wird über neueste Forschungsergebnisse sowie aktuelle Trends der Mikro- und Nanotechnologien für die Anwendungen im Automobil berichtet. Der vorliegende Band 2 der neuen Publikationsreihe Micromaterials and Nanomaterials des Fraunhofer Micro Materials Center Berlin (MMCB) enthält die Abstracts dieser wissenschaftlichen Veranstaltung.

Prof. Dr. Bernd Michel
Chairman MicroCar 2003

In the years to come, the automotive industry is expecting to see breath-taking innovations thanks to an ever broader use of modern technologies, such as microelectronics, microsystem technology and nanotechnology. Particularly with automobile sensors, micro and nanomaterials will have an important role to play. In the area of automotive electronics, the trend is towards high-temperature applications, and the progress made here is expected to lead to more cost-efficiency as well as a more optimised utilisation of assembly spaces close to the engine.

Mechatronics for automotive applications is another important trend, combining mechanics, electronics and information technology. Micro- and nanomechatronics, particularly innovative research disciplines, will help create, in combination with advanced solutions from microsystem technologies, e.g. the electronic packaging, a range of entirely new developments in automobiles. Under the umbrella of the Automotive Suppliers Fair Z2003, it is happening for the very first time now that a momentous scientific conference, such as the MicroCar 2003, brings together representatives from car manufacturers and the electronics industry, as well as a large number of experts from technical colleges, universities and research institutes to discuss the new potentials and possibilities presented by the use of micro and nanomaterials in Leipzig.

With the presentation of 50 papers, speakers will inform about their latest research results as well as current trends in micro and nanotechnologies for automotives. This issue, no. 2 of the new publications series Micromaterials and Nanomaterials of the Fraunhofer Micro Materials Center Berlin (MMCB), is publishing the abstracts of this scientific event.

Prof. Dr. Bernd Michel
Chairman MicroCar 2003

Conference

MicroCar 2003

Micro Materials, Nano Materials for Automotives
LEIPZIG (D), June 26, 2003

Dominating trends and developments
for micro and nano materials / micro and nanotechnologies
with a focus on automotives and mechanical engineering

This conference is a scientific event initiated and organised by members from industry, predominantly the automotive industry, the state of Saxony and several professional societies and associations.

When: 26 June 2003
Where: Neue Messe Leipzig, Congress Center
Host: Z2003 Suppliers Fair

Chairman: Scientific chair and responsible for the organisation is Prof. Dr. Bernd Michel from the Fraunhofer Institute IZM Berlin, Germany (e-mail: bernd.michel@izm.fraunhofer.de)
Responsible: Fraunhofer-Institute for Reliability and Microintegration (IZM) Berlin, Micro Materials Center Berlin (MMCB)

Schedule: 09:00 – 13.00 Morning Plenary Session
Talks and presentations from academia and industry
13:30 – 17:00 Afternoon Session of Workshops
Five parallel workshops of cutting-edge topics

Program Committee

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Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V.,
Europäisches Netzwerk für Hochtemperaturelektronik (HITEN),
Fraunhofer Micro Materials Center Berlin (MMCB),
U.K. Faraday Partnership in Automotive and Aerospace Materials (Advance),
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Innovationsteam Mikrotechnik der Deutschen Bank AG,
Chemnitzer Werkstoffmechanik GmbH,
Sächsischer Verein für Mechanik e.V.,
Silicon Saxony e.V.

Plenum I

Chairmen:
Michel, B. (Fraunhofer IZM Berlin)
Senske, W. (DaimlerChrysler AG, Frankfurt)
Fukuda, T. (Univ. Nagoya / IEEE Nanotechnology Council New York)

Speakers:
9:00 Rößler, M. (Saxon State Minister of Research and Culture)
Research on micro- und nanotechnologies in Saxony
9:10 Frech, R., Michael, U., Steiner, M. (Porsche AG Stuttgart)
Trends in automotives - Challenges to research and technology
9:35 Fukuda, T. (Univ. Nagoya / IEEE Nanotechnology Council New York)
Current and future trends in nanotechnology
10:00 Wolfgang E. (Siemens AG, München)
Reliable power electronics for automotive industry
10:25 Pongratz, S. (Motorola Corporate Labs Wiesbaden)
Microsystem technology and their application
10:50 Zschech, E. (AMD Saxony GmbH Dresden)
Advanced materials for high performance microprocessors

Plenum II

Chairmen:
Wolfgang, E. (Siemens AG, München)
Fecht, H.-J. (Universität Ulm / Forschungszentrum Karlsruhe)
Schneider, G. (Robert Bosch GmbH Stuttgart)

Speakers:
11:20 W. Wondrak, W. Senske, R. Thompson (DaimlerChrysler), R. Viancino (CRF Fiat)
Requirements on high-temperature electronics for automotive industry
11:45 Eisele, U., Schneider, G. (Robert Bosch GmbH Stuttgart)
Ceramic microstructures and nanostructures for automotives
12:10 Gessner, T. (TU Chemnitz)
Materials- and technology aspects of Silicon micromechanics for application in the automotive industry
12:35 Bock, K.-H. (Fraunhofer IZM München)
Polytronics for automotive applications

1
High Temperature Electronics in Automotives

New materials and materials compounds, new techniques in electronic packaging, as well as low-cost and reliable automotive electronics.
Chaired by the GMM Dept. of Electronic Engineering (Head: K.-D. Lang) and their Technical Commitee for „Electronic Packaging".
By participation of the European Network for High Temperature Electronics (HITEN), and under cooperation with the UK Faraday Partnership in Automotive and Aerospace Materials (ADVANCE).

Chairmen:
Lang, K.-D. (GMM Frankfurt / IZM Berlin)
Albrecht, J. (Siemens AG Berlin)

Speakers:
13:30 Wilde, J. (Albert-Ludwigs-Universität Freiburg)
Mechatronics in automobile – the high temperature problem for the packaging
13:55 Ferber, A., Schneider-Ramelow, M. (Fraunhofer IZM Berlin)
Interaction of thick wire bonding quality und vibration technique during the assembly of power modules
14:20 Zapf, J. (Siemens AG München)
Substrates for high temperature applications
14:45 Kempe, W. (DaimlerChrysler AG Frankfurt)
Packaging of high temperature components for use in automotives

15:20 Tiederle, V. (RMCtech GmbH Sindelfingen)
Test and qualification of components for high temperature applications
15:45 Hauck, T. (Motorola GmbH, München)
Power Gold - an interconnection technology for high temperature electronics
16:10 Riepl, T., Lugert, G. (Siemens VDO Automotive AG, Regensburg)
Reliable high temperature electronics at competitive costs – a contradiction ?
16:35 Kaulfersch, E.[1,2], Vogel, J.[2], Kieselstein, E.[3] ([1] Fraunhofer IZM Berlin, [2] AMIC GmbH Berlin, [3] Chemnitzer Werkstoffmechanik GmbH)
Fluidic power modules for power electronics and stacked modules

2
Micro Materials, Nano Materials for Automotive Applications

Microelectronics and microsystem technologies in the hot seat with modern materials science.
By participation of the VDI/VDE-Gesellschaft Mikroelektronik, Mikro- und Feinwerktechnik and the VDI/VDE-Technologiezentrum Informationstechnik as well as several technical committees of GMM.

Chairmen:
Dötzel, W. (TU Chemnitz)
Werner, M. (Deutsche Bank AG Berlin)

Speakers:

13:30 Leson, A. (Fraunhofer IWS Dresden)
Nanotechnology competence center Ultrathin functional layers – Perspectives for the automotive industry

13:55 Schiller, W.A., Rabe, T. (Bundesanstalt für Materialforschung und -prüfung, Berlin)
LTCC-ceramics in the automobile

14:20 Katzer, D.[1], Petzold, M.[1], Graf, J.[2], Bagdahn, J.[1] ([1] Fraunhofer IWM Halle, [2] Robert Bosch GmbH Stuttgart)
Automotive Silicon MEMS - Test and design for reliability

14:45 Wiemer, M., Frömel, J., Gessner, T. (Fraunhofer IZM Chemnitz), Nowack, B., Südkamp, W., Peschka, A. (Aktiv Sensor GmbH, Stahnsdorf), Petzold, M., Bagdahn, J. (Fraunhofer IWM Halle)
Evaluation of low temperature bonding interconnects for pressure sensors in automobile technology

15:20 Scheel, W., Wittke, K., Nowottnick, M. (Fraunhofer IZM Berlin und ZVE Oberpfaffenhofen)
New solutions with high temperature stable lead interconnects for electronic components

15:45 Gottfried, K.[1], Kaufmann, C.[2], Hoffmann, R.[2], Wiemer, M.[1], Gessner, T.[1,2] ([1] Fraunhofer IZM Chemnitz, [2] TU Chemnitz)
Temperature-stable metallisation and interconnect systems for sensor applications in automobiles

16:10 Keller, J., Michel, B. (Fraunhofer IZM Berlin)
Nanomechanics for electronic components in the automobile

16:35 Walter, H. (Fraunhofer IZM Berlin), Grellmann, W. (Martin-Luther-Universität Halle/Merseburg), Seidler, S. (Universität Wien), Michel, B. (Fraunhofer IZM Berlin)
Challenges of advanced mechanical micro testing techniques

3
Mechatronics and Micromechatronics in Automotives

Mechanical engineering and electronics in concert with information technologies.
By participation of departments of the Bavarian Competence Network for Mechatronics (BKM).

Chairmen:
Ansorge, F. (IZM Oberpfaffenhofen)
Specks, W. (Volkswagen AG Wolfsburg)

Speakers:

13:30 Kress, R. (Audi AG Ingolstadt)
Mechatronics and micro system technology from the viewpoint of an automobile producer

13:55 Specks, W. (Volkswagen AG Wolfsburg)
Requirements for electronic technologies for future automobile systems

14:20 Seubert, T. (Hella KG Lippstadt)
Mechatronics in automotives - challenges and solutions by the example of driving assistance systems

14:45 Lugert, G., Riepl, T. (Siemens VDO Automotive AG, Regensburg), Ingenbleek, R. (ZF Friedrichshafen)
Modular high temperature mechatronics for gear box applications

15:20 Teepe, G. (Motorola GmbH, München)
Open architectures in in concert with with electronics

15:45 Ansorge, F. (Fraunhofer IZM Oberpfaffenhofen)
Design, assembly and packaging of mechatronic systems using von rapid prototyping processes

16:10 Kunzmann, J. (TU Chemnitz), Scheidling, M. (Teleflex-Morse GmbH, Heiligenhaus), Kade, I., Knorr, A. (TU Chemnitz)
Concepts of multi-functional structures for electronic gas pedals

16:35 Auersperg, J. (Fraunhofer IZM Berlin), Erdl, H. (BMW AG München), Wolter, J. (Fraunhofer IZM München), Rümmler, N. (Amitronics GmbH Seefeld)
Micro mirror applications in the automobile

4
Micro and Nano Measuring Techniques – Advanced Techniques for Automotive Applications

Nanotechnologies: Will NanoCar be the car of the future?
By participation of DVM - Deutscher Verband für Materialforschung und -prüfung e.V. Berlin and the Micro Materials Center Berlin (MMCB).

Chairmen:
Dost, M. (CWM GmbH Chemnitz)
Wolter, K.-J. (TU Dresden)

Speakers:
13:30 Simons, G., Dual, J. (ETH Eidgenössische Techn. Hochschule Zürich)
Analysis of fracture surface of thin Copper foils
13:55 Vogel, D., Michel, B. (Fraunhofer IZM)
nanoDAC – Method for reliability analysis on micro- and nanoscale
14:20 Weiss, B., Zimprich, P. (Universität Wien)
New developments in non-contact strain measurement using laser-speckle correlation techniques
14:45 Dost, M. (Chemnitzer Werkstoffmechanik GmbH Chemnitz)
LongLife – Optical measuring techniques for reliability evaluation of MEMS

15:20 Kühnert, R. (image instruments GmbH Chemnitz)
Finite-Elemente based microdeformation measurement
15:45 Villain, J. (FH Augsburg)
Structure formation in small lead volumina
Uhlig, C.[2], Kahle, O.[2], Wienecke, B.[2], Bauer, M.[1,2]
([1] BTU Cottbus, [2] Fraunhofer IZM Teltow)
16:10 **Optical Crack Tracing - An automatised, simply applicable and precise measurement technique for fracture toughness of polymers**
16:35 Schmucker, U., Zubtsov, M., Böhme, T. (Fraunhofer IFF Magdeburg)
Extension of application possibilities of AFMs

5
Applications in Microsystem Technologies for Automotives and their Suppliers

Modular microsystem technologies, microfluidics, miniaturisation, micro sensors and -actuators, and IT for automotives.

Chairmen:
Krüger, S. (VDI/VDE-IT Teltow)
Vogel, J. (AMIC GmbH Berlin)

Speakers:
13:30 Krüger, S. (VDI/VDE-Technologiezentrum Informationstechnik GmbH Teltow)
Micro system technology for the automotive industry (Trends)
13:55 Großer, V. (Fraunhofer IZM Berlin)
Match-X – methodology and „box of bricks“ for modular microsystems
14:20 Binder, W. (Binder Electronik GmbH Sinsheim)
Design, assembly and and qualification of modular microsystems in 3D-BGA technology
14:45 Jerems, F., Rachui, D., Fröhlich, E., Proft, M. (Valeo Switches & Sensors GmbH Bietigheim-Bissingen)
Sensors for advanced driving assistance systems

15:20 Hiller, K. (TU Chemnitz)
State-of-the-art and application capability of special kinetic sensors for automotives
15:45 Rümmler, N., Schnitzer, R. (Amitronics GmbH Seefeld)
Vibration analysis of microcomponents using laser vibrometry
16:10 Löbner, B., Weiß, U. (TU Chemnitz)
Airbag fire elements based on Hafnium hydride
16:35 Claessen, R. (SuNyx Surface Nanotechnologies GmbH Köln)
Durable, self-cleaning coatings in optical quality for for automotive applications

Trends in the Automotive Industry – Demands on Research and Technology

Trends im Automobilbau – Anforderungen an Forschung und Technologie

Frech, R., Michael, U., Steiner, M.
Dr. Ing. h.c. F. Porsche Aktiengesellschaft, Weissach

The automotive industry is challenged by continuously increasing demands on the intelligent use of materials. Micro and nano technologies and materials offer great potential to meet those challenges.

Many developments originating from this field are well established in the automotive industry and more will follow. A demanding basic research in institutes and universities promotes the knowledge of technologies and materials on micro and nano scales. This knowledge has to be turned into ideas finally yielding successful products. A key role for this task belongs to the automotive suppliers. As system suppliers they very often possess a high level of technical expertise. This is especially valid for electrical and electronic applications, microsystems technology and mechatronics where synergies with other industries exist.

For car manufacturers the most important result of a new development is the improvement of their product. The aim with the highest priority for Porsche is the satisfaction of the customers demand for innovative and also highly reliable cars. New technologies have to fit to the character of Porsche cars and their efficacy has to be proven before these technologies are transferred into Porsche products. If these criteria are fulfilled the potential of micro and nano materials can be fully exploited.

Contact:
Rolf Frech, Dr. Ing. h.c. F. Porsche Aktiengesellschaft, Entwicklung,
Porschestraße, 71287 Weissach, Germany
e-mail:

Trends in Nanotechnologies – Recent Nanorobotic Technologies –

Fukuda, T., Arai, F., and Dong, L.X.
Dept. of Micro System Engr., Nagoya University, Japan

Nanotechnology is a strategic branch of science and engineering for the new century; one that will fundamentally restructure the current technologies. The nanoscale world is governed by mesoscopic sciences, which is different from either the macro scale or the atomic one. Applications of nanotechnology may involve almost every aspects of our life.

The emerging field of nanorobotics will serve as a common fundamental technology for the exploration of the nano world by filling up the gap between top-down and bottom-up strategies for nanotechnology and may lead to the appearance of molecular assembler. Nanorobotic manipulation is the first step in the advancement of nanorobotic technologies.

The well-defined geometries, exceptional mechanical properties, and extraordinary electric characteristics, among other outstanding physical properties, of carbon nanotubes (CNTs) qualify them to be the most important nano materials discovered by so far and promise them for many potential applications, especially in nanoelectronics, nanoelectromechanical systems (NEMS), and other nanosystems. Nanorobotic manipulation is a significant enabling technology for bring such materials into nano devices and system. By highlighting the recent progress on nanorobotic technologies, nanorobotic manipulations of CNTs, in situ nanoinstrumentation of nano materials in free space, nanofabrications of and/or with CNTs, mechanochemistry-based nanorobotic assembly are demonstrated.

Contact:
Prof Dr Toshio Fukuda, Dept. of Micro System Engng., Nagoya University,
Furo-cho, Chikusa-ku, Nagoya 464-8603, Japan
e-mail: fukuda@mein.nagoya-u.ac.jp

Reliable Power Electronics for Automotive Applications

Zuverlässige Leistungselektronik für die Automobiltechnik

Wolfgang, E.
Siemens AG, Corporate Technology, Power Electronics, Munich

Power electronics will become increasingly important in future automobiles. This applies to vehicles powered by internal combustion engines as well as by fuel-cell and hybrid-electric drives.
The main driving forces of this trend are: reduction of CO2, replacement of mechanical by electrical parts to save volume and weight as well as lower costs. Many power electronics applications require near-engine mounting locations: this represents a great challenge, particularly as regards reliability.

A concept is presented for assuring reliability despite the high operating temperatures and vibrations involved. It is based on built-in reliability and virtual qualification. The inputs are the mission profile, i.e. the stress to which the individual parts of the power electronics system are exposed during their operating life, and the system description. The reliability is secured in three steps: simulation and verification of components and joinings, reliability risk analysis and accelerated testing. The behavior is simulated with respect to the electrical and mechanical systems, EMC, cooling and reliability.

Examples of how the integrated starter generator and DC/DC converter operate demonstrate the procedure used to assure reliability.

Contact:
Prof Dr Eckhard Wolfgang, Siemens AG, Corporate Technology, Power Electronics,
Otto-Hahn-Ring 6, 81730 Munich, Germany
e-mail: eckhard.wolfgang@siemens.com

MicroSystem Technology (MST) and their Application

Mikrosystemtechnik und ihre Anwendungen

Pongratz, S.
Motorola Advanced Technology Center – Europe, Motorola GmbH

MicroSystem Technologies enabling intelligent miniaturized monolithic and/or hybrid integrated systems that may include sensing, processing and actuating device utilizing electronic, mechatronics, microfluidic, thermonic, and photonic functions.

Automotive, Information Technology and Telecommunication, as well as Health/Biotech and Instrumentation are the main areas of application for MicroSystem Technologies.

Market Opportunities are:
- Sensor systems and modules for automotive applications
- Multiband and multimode mobile phones requiring more components and functions
- Micro-scale fuel cells for portable applications
- Emerging life science fluidic based devices and environmental monitors

The situation and trends in the specified fields will be illustrated in more detail with special emphasize towards automotive applications.

Contact:
Dr. Siegfried Pongratz, Motorola GmbH, Dept. MATC-Europe
Hagenauer Strasse 44, 65203 Wiesbaden, Germany
e-mail: siegfried.pongratz@motorola.com

New Materials for High-Performance Microprocessors

Neue Materialien für leistungsstarke Mikroprozessoren

Zschech, E.
AMD Saxony LLC & Co. KG, Dresden/Germany

The International Technology Roadmap for Semiconductors (ITRS) is a successful global cooperation that presents an industry-wide consensus on the "best current estimate" of the future research and development needs of semiconductor technology out to a 15-year horizon. Currently, high-performance microprocessors (HP-MPUs) are driving the continuous shrinking of metal-oxide-semiconductor (MOS) feature sizes and of on-chip interconnect dimensions. The scaling down of the HP-MPU physical gate length follows a two-year cycle with a scaling factor of 0.7 until 2005 and switches to a three-year cycle thereafter, leading to 10 nm gates in 2016. The device geometries for application specific integrated circuits (ASICs) follow those of the HP-MPUs with a delay of two years. The traditional down-scaling of MOS transistors and interconnect structures leads to performance limitations that have to be overcome by the introduction of new materials. Microprocessor and ASIC applications are pushing material innovations in the gate stack and in interconnect structures, which result in new and exciting challenges to materials scientists!

The manufacturing technologies of HP-MPUs and of automotive electronics like microcontrollers and sensors have a high synergy potential. The know-how transfer from leading-edge microprocessor manufacturers - including development and implementation of advanced thin film materials - is beneficial for automotive electronics manufacturers today and will be even more important for future vehicles with a significantly higher content of electronic components and with new electronic systems. In this talk, material transitions that are necessary to improve the product performance and to maintain the product reliability of HP-MPUs are highlighted. Particularly, the reduction of gate leakage currents by the implementation of high-k materials (at first oxynitrides, followed by metal oxides) for gate dielectrics in MOS transistors is discussed. Performance and reliability aspects that require the integration of high-conductivity interconnect and of low-k insulating materials and, in longer term, more sophisticated interconnect concepts including innovative materials are presented.

Contact:
Dr. Ehrenfried Zschech, AMD Saxony LLC & Co. KG,
P.O., Box 11 01 10, D-01330 Dresden, Germany
e-mail: ehrenfried.zschech@amd.com

Requirements on High-Temperature Electronics for Automotive Industry

Anforderungen an Hochtemperaturelektronik im Automobilbau

Wondrak, W.[1], *Senske, W.*[1], *Thompson, R.*[2], *Groppo, R.*[3], *Viancino, R.*[3]
[1] DaimlerChrysler AG, Research and Technology, Dept. E/E Hardware, Frankfurt am Main, Germany
[2] DaimlerChrysler Corporation, Huntsville Electronics, Huntsville, USA
[3] Centro Ricerche Fiat, Orbassano, Italy

The need for higher integration density, together with the fact that electronic modules and functions are continuing to be integrated into "smart" devices, leads inevitably to higher ambient operating temperatures in automotive applications. This feeds the demand for high-temperature electronic system solutions.

This paper will discuss the trends envisioned for the automotive industry as mechatronic controllers become more prevalent. Technical challenges and qualification issues associated with marketing automobiles with these devices will be discussed.

Special emphasis will be given to application examples and requirements, semiconductor devices, passive devices, packaging & assembly, and reliability assessment.

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Contact:
Dr. Wolfgang Wondrak, DaimlerChrysler AG, Research Electronics and Mechatronics, Dept. E/E System Hardware, ‘
Goldsteinstrasse 235, 60528 Frankfurt am Main, Germany
e-mail: wolfgang.wondrak@daimlerchrysler.com

Ceramic Micro-Systems and Nanoscale Microstructures for Automotive Technology

Keramische Mikrostrukturen und Nanogefüge für die Fahrzeugtechnik

Ulrich Eisele, Gerhard Schneider
Robert Bosch GmbH, Corporate Division Research and Development – Materials, Stuttgart

Bosch is a leading company to introduce silicon based microsystems into automotive technology for sensing and other applications. In this presentation, we try to evaluate the chances of ceramic microsystems in the future. Possible concepts, benefits and limitations are discussed. Special attention is given to ceramic multilayer structures which already have a significant technical importance.
In a second part we show the current state to build ceramic multilayers from nanoscale powders. Some of the processing issues are shown and possible benefits for other microsystems in general are discussed.

Contact:
Dr. Ulrich Eisele & Prof. Dr. Gerhard Schneider, Robert Bosch GmbH, Dept. FV/FLW, Postfach 10 60 50, 70049 Stuttgart, Germany
e-mail: ulrich.eisele@de.bosch.com

Materials and Technology Issues of Si-Micromachining for Automotive Applications

Werkstoff- und Technologieaspekte der Silizium-Mikromechanik für Anwendungen in der Automobilindustrie

Thomas Gessner
Chemnitz University of Technology, Center of Microtechnologies, Chemnitz, and Fraunhofer Institute of Reliability and Microintegration, Berlin/Chemnitz, Germany

New technology and material approaches are necessary in order to fulfil the requirements of MEMS devices for automotive applications. Especially the integration with microelectronics, reliability aspects, manufacturing costs and device properties are challenging issues recently and in the future. Based on the introduction of different Simicromachining technologies some advanced technology approaches will be discussed like wafer bonding at low temperatures (Silicon Fusion Bonding[1]), the fabrication of Air gap Insulated Microstructures (AIM)[2] and specific interconnect and wiring concepts at higher temperatures.
A special Air gap Insulated Microstructure will be described. The AIM consists of a spring mass system and is driven by comb fingers. Forces up to 200 µN (5,100 times larger than the weight of the structure) act onto the seismic mass to realize a displacement of 18 µm. Several structures have been investigated in order to determine and optimize the technology depending characteristics of the microstructure. Tests of the long-term behaviour, thermal stability and shock resistance identifies the AIM-Technology as an attractive technology for the production of low cost High Aspect Ratio Microstructures (HARMs).
Furthermore within this paper we present novel optical devices which are mounted using low temperature Si direct bonding. The application of low temperature bonding allows the connection of MEMS wafer directly onto an electric wafer. Additionally, some materials properties and challenges of device metallization at high temperatures will be reflected.

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Contact:
Prof. Dr. T. Geßner, Chemnitz University of Technology, Center for Microtechnologies, 09107 Chemnitz, Germany
e-mail: thomas.gessner@izm.fraunhofer.de

Polytronics for Automotive Applications

Polytronic shows some advantages for automotive applications, but does it stand the corresponding reliability requirements?

Polytronic für Automobilanwendungen

Bock K.
Fraunhofer Institute IZM, Dept. Polytronic Systems, Munich

Small portable and automotive systems drive the increasing demand on methods for miniaturized and flat as well as flexible system packaging. Polytronic systems base on components and technologies for the manufacturing of thin and flexible systems at the lowest possible price for ubiquitous electronic systems and ambient intelligence. From a variety of possible realisations the combination of components and integration technologies is carefully developed or respectively selected in order to best fitting the requirements of each individual customer application regarding functionality, price and manufacturability.
This opens a wide spectrum from lowest-cost single-use electronics up to possible high-functionality communication an automotive systems applications. Wafer thinning technology has been advanced down to a residual thickness of 20µm and below. Because of low height, low topography of assembled chips and mechanical flexibility enable the integration in thin and bendable systems and even in vertically stacked systems. Increased fracture resistance of the ICs and better yield of silicon real estate is reached by replacing the sawing process by a dicing-by-thinning process. Polymer material based assembly processes in a reel-to-reel production system allow for high through-put. The bonding of thin-chips by precise dosed polymer adhesives as well as screen printing of polymer paste directly on the substrate and IC enable low cost applications. Polymer based active components like device related functional polymer layers and functional active and passive polymer components are combined with thin silicon chips for integration in flexible systems low-cost production processes based on a reel to reel fabrication environment recently opened at IZM.
The spectrum of applications for thin, flexible polytronic systems is extremely broad. It ranges from relatively simple uses such as passive transponders in labels to indicators combined with electronics consisting of nothing but polymer elements, right up to complex implantable microsystems. The scope of possible applications for future products in the fields of Information and Communication Technology, automotive environment, medicine and lifestyle is practically unlimited. Advantages are simplified processing, cost reduction, flexible, clinging on to any surface, very low weight, mass reduced systems.

Contact:
Dr.-Ing. K. Bock, Fraunhofer IZM, Dept. Polytronic Systems,
Hansastr. 27d, 80686 München, Germany
e-mail: bock@izm-m.fraunhofer.de

Automotive Mechatronics – High-Temperature Applications Will Challenge Packaging and Interconnection Technologies

Mechatronik im Kfz – die Hochtemperatur-Herausforderung an die Aufbau- und Verbindungstechnik

Wilde, J. and the members of the GMM FA5.5
IMTEK Institute of Microsystem Technology, University of Freiburg, Laboratory for Assembly and Packaging

The development of automobile E/E-architectures exhibits several mega-trends: Among these are mechatronic integration, on-site-distributed and intelligent systems and an increasing use of sensors. As a result, elec-tronic systems will have to operate at higher temperatures, with more power dissipation and in smaller compartments while customers require still more reliable systems. Although several years ago there was much effort aiming at operating temperatures of up to 500 °C a parallel trend was more successfully directed towards temperatures of 200 °C, e.g. based on semiconductors utilizing the SOI-technology (silicon-on-insulator). For commercial application of such components, it will be necessary that modules, printed-circuit-board assemblies as well as com-plete mechatronic components will be suited for high temperatures. In order to reach this goal assembly, packaging and interconnection tech-nologies will be the key processes.
In this work we will discuss the question of high-temperature electronics under two aspects: On innovative application examples, we will firstly demonstrate why mechatronic integration of power electronics and actua-tors will have an impact on the thermal management of automotive E/E systems. Also we will discuss the physical basis for this dependency. These aspects will be supplemented by examples of high-temperature specifications.
In the second part of this work, we will concentrate on the individual manufacturing processes for assembly, packaging and interconnection. Also we regard the utilized materials and their capability to withstand high-temperature applications up to 250 °C. In detail soldering and adhe-sive bonding for components mounting, wire-bonding and flip-chip-technology for electrical interconnections as well as housing techno-lo-gies we will be evaluated. Among the materials high-power/high-tem-perature substrates as well as passive components are regarded.
As in the case of present-days high-temperature electronics there is only a small margin for further temperature increase, a last part of the presen-tation is aimed at qualification processes and reliability testing of elec-tronics operating under high thermal loads.

Contact:
Prof. Dr. Juergen Wilde, IMTEK AVT,
Georges-Koehler-Allee 103, 79110 Freiburg, Germany
e-mail: wilde@imtek.de

Interaction Between Quality of Heavy Wire Interconnections and Mechanical Vibration During Bonding of Power-Modules

Wechselwirkung von Dickdraht-Bondqualität und Schwingungstechnik beim Aufbau von Powermodulen

Ferber, A., Schneider-Ramelow, M.
Fraunhofer Institute IZM Berlin, Dept. Chip Interconnection Technologies

The number of electrical devices used in cars rises steadily. Therefore the electrical energy which has to be provided rises, too, especially because more applications are based on high operating currents.

To carry high loads assembly of bare die power-modules with heavy wire bonding (wire diameter > 150 µm) is getting increasingly important. In automotive applications these modules are often embedded in injection molded polymer packages with integrated connection leads. During wire bonding, the wire is welded to the substrate by vertically applying force and ultrasonic (US) vibration. This energy is necessary to get the atomic interconnection and therefore welding between wire and metallization material.

One of the major problems while contacting the connector pads is caused by undesired vibration of the embedded leadframe bond pads, resulting from the US energy of the bonding process. The value of these parasitic vibrations can be affected by a variety of factors (shrink of polymer, disadvantageous pad dimensions, etc.) and it usually decreases the quality of bond interconnection significantly.

By application of laser vibrational measurement it is possible to detect and evaluate such undesired bond pad vibrations. In this presentation a correlation between the measured amount of vibration and the quality of the bonded contact will be discussed. Furthermore, in qualifying the exact amount of evolving vibrations, the improvements resulting from varying the production parameters of the package are measurable. And as a further benefit recommendations for a high quality power module packaging process can be expressed.

Contact:
Dr. Martin Schneider-Ramelow, Fraunhofer IZM, Dept. Chip Interconnection Technologies, Gustav-Meyer-Allee 25, 13355 Berlin, Germany
e-mail: schneidr@izm.fraunhofer.de

Substrates for High-Temparature Applications Siemens AG, Corporate Technology, Design to Prototype

Substrate für Hochtemperaturanwendungen in der Siemens AG

P. Demmer
Siemens AG, Corporate Technology, Material and Manufacturing,Design to Prototype

The demands on the heat resistance of base materials for printed circuit boards (PCB) are constantly rising. The reasons are higher miniaturization and components with increasing power. In automotive electronic systems PCBs are positioned in the engine compartment with temperatures over 150 °C. We also see an increasing market for high temperature applications up to 200 °C in the military and aircraft industry. The intense heat radiation for a long time imposes high thermal stresses on the base material. New leadfree solders with higher melting temperatures and the future need for halogenfree materials are pushing the evaluation of new base-materials with significantly improved thermo-mechanical stability.

The focus of this presentation is the comparison and qualification of substrates with high thermal stability and halogen-free materials.

Contact:
Dr. Peter Demmer, Siemens AG, Corporate Technology, Design to Prototype,
Otto-Hahn-Ring 6, 81730 Munich, Germany
e-mail: peter.demmer@siemens.com

Electronic Packaging with High-temperature Components for Automotive Applications

Aufbautechnik für Hochtemperatur-Baugruppen zum Automotive-Einsatz

Wolfgang Kempe
DaimlerChrysler AG, Research and Technology, Frankfurt (Main), Germany

In order to realize electronic packaging techniques at high-temperatures, the replacement of lead-containing solders, which have so far been used, by solders with higher melting points is not enough. Production processes need to be overhauled and adapted entirely.

Currently, solders on tin-silver-copper (SnAgCu) basis are being used in the fabrication of high-temperature components for their melting point at 216 °C. Crucial for the realization of such techniques however are the components whose thermal properties limit their use to soldering processes within a certain temperature range. For the time being, this limit is given with 250° C.

Mass production of automotive electronics will continue to use organic circuit boards. Although some materials with higher glass transition temperature (Tg) are already available, the long-term reliability of these has not been verified yet. The manufacturing process itself will be a continuation of current techniques, though on a higher level, and it is assumed that selective soldering will replace wave soldering. This way, a reduced process window for the prevention of damage to component elements and circuit boards will lead to an even more sophisticated surface mount technology (SMT) than there is today.

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Contact:
Wolfgang Kempe, DaimlerChrysler AG, Research and Technology,
Goldsteinstr. 235, D-60528 Frankfurt (Main), Germany,
e-mail: wolfgang.kempe@daimlerchrysler.com

Testing and Qualification of Components for High-temperature Applications

Erprobung und Qualifikation von Baugruppen für Hochtemperatur-Anwendungen

Viktor Tiederle
RMCtech GmbH, Sindelfingen

There are a number of automotive applications that high-temperature electronics are important for. To name but one, sensors and actuators are frequently installed in locations where the specific physical dimensions must be measured.

Traditionally used methods for the qualification of components do not apply here. They require a much elevated temperature so that the long running times, such as 6,000 hrs, could be performed in a fast-motion like mode. This method is not advisable for high-temperature applications, as technological limits are soon met with and do not permit conclusions to be drawn by analogy.

To escape this dilemma, it is necessary to extend one's evaluations into early developing stages and to treat later qualification processes as investigations with complementary character.

This paper describes a systematic methodology for the proof of the reliability of components under sustained continuous operation, consuming only relatively little more time and working even where technological limits are reached.

Contact:
Dr. Viktor Tiederle, RMCtech GmbH, Sindelfingen
Kolumbusstr. 2, 71063 Sindelfingen, Germany
e-mail: viktor.tiederle@mbtech-group.com

Power Gold - An Interconnection Technology for High Temperature Electronics

Power Gold – eine Verbindungstechnologie für Hochtemperaturelektronik

James J. Wang, Torsten Hauck***
* Motorola Inc, SPS - SMARTMOS‘ Technology Center
** Motorola GmbH, SPS - DigitalDNA‘ Laboratories

Automotive is requesting engine control IC to operate in 145 °C ambient. Power Gold technology allows ICs to operate hotter. Package Theta-jc remains the same; nevertheless, power increases when silicon junctions operate at 175 °C. Since more heat dissipates from molded package and across FR4 board with ICs at 175 °C Tj-max instead of 125 °C or 150 °C, Power Au enhances power. Continuous, reliable 175 °C Tj-max operation is achieved with Power Gold. Top silicon metallization and wire bond pads are gold. Electroplated gold process integrates with wafer flow having aluminum interconnect layers underneath the top Power Gold layer. Thick Power Gold carries current, minimizes electromigration through aluminum bus and provides oxide free gold pad for gold wire bonding. Both gold ball bonding speed and ball shear strength improve with gold pads over conventional aluminum bond pads. Gold to gold single metal joints are impervious to halides and do not corrode at high temperature. Mold compound adheres to rough gold surface and power package survives MSL1 preconditioning and autoclave without delamination over die surface. Power Gold allows SMARTMOS™ to survive 4,000 hours of high temperature bake at 190 °C and 1,500 cycles of air to air temperature cycling from -65 °C to 175 °C. Power Gold cost for 8" wafers is comparable to one layer of aluminum plus ILD. Introduction of Power Gold onto ICs improves reliability of packaging such that 175 °C Tj-max operation is now feasible.

Contact:
James J. Wang, Motorola SPS – SMARTMOS’ Technology Center, MOTOROLA INC.,
2100 E. Elliot Road, Tempe, AZ 85284, USA
e-mail: James.J.Wang@motorola.com

Reliable High Temperature Electronics at Competitive Cost – a Contradiction?

Zuverlässige Hochtemperaturelektronik zu wettbewerbsfähigen Kosten – ein Widerspruch?

Riepl, T., Lugert, G.
Siemens VDO Automotive AG, Regensburg

Cars are rapidly evolving from purely mechanical to complex and electronically controlled systems. Moreover, European carmakers are seeking to substantially reduce wiring and assembly costs. In particular, engine/transmission units will be treated as fully tested and calibrated items – including electronics, sensors, air intake and wiring – ready for delivery to the vehicle assembly plant. This asks for electronics, which can be mounted on the engine/transmission unit. These electronics have to survive long-term operation in a harsh environment, where humidity, vibration and, most of all, high temperatures will impact reliability. As the market will not accept premium prices, there is a substantial challenge for designers to provide technologically innovative and cost-efficient solutions.

In fact there is already one technology used in automotive for high temprature applications, the hybrid or micro-hybrid technology, which is basically bare die assembly on ceramic substrates. The disadvantages of this technology are:

- relative high price compared to standard SMT
- KGD (known good die) issue together with allocation topics for bare dice
- slow development cycles

The proposed approach is to extend the temperature limits of SMT to cover most HT applications with a cost competitive technology, which is close to standard development and manufacturing processes. The following work is ongoing:

- bulk silicon devices: optimisation of process and design, accompanied by detailed characterisation of the relevant devices in the critical temperature range in order to find hidden potential
- study of SOI (silicon on insulator) as high temperature alternative and bench-mark regarding area reduction vs. higher cost per area compare to bulk Si
- component packaging: improved adhesion promotors and elimination of bromine flame retardants, which promote HT related failure of Au wires
- organic substrates: prevention of barrel cracks by base materials with adapted CTEz and improvement of board level reliability by reduction of CTExy; additional: improved thermal conductivity
- improved reliability of solder joints by reduced mechanical load (i.e. additional mechanical fixing) and investigation of lead-free solders regarding HT reliability with special focus on intermetallics formation
- reliability methodology: new methods to tailor qualification programs to a given application by mission profiling and to reduce qualification time

The presentation will outline the contribution of the European project HOTCAR.

Contact:
Dr. Thomas Riepl, Siemens VDO AG, SV P ED T IC,
P.O.Box 10 09 43, 93009 Regensburg, Germany
e-mail: thomas.riepl@siemens.com

Fluidic Power Modules for Power Electronics and Stacked Modules

Fluidische Kühlmodule für Hochleistungselektronik und gestackte Module

Kaulfersch, E.[1,2], *Vogel, J.*[2], *Kieselstein, E.*[3]
[1] Fraunhofer Institut für Zuverlässigkeit und Mikrointegration IZM, Berlin,
[2] AMIC Angewandte Mikro-Messtechnik GmbH, Berlin,
[3] Chemnitzer Werkstoffmechanik GmbH, Chemnitz

Cooling of power electronics equipment in automotive applications in general has to cope with low temperature differences between the junction and the coolant. Forced convection needs powerful fans which themselves may be consuming large amounts of power. Therefore, the limited overall power budget requires intelligent cooling concepts that could include electronics cooling integrated into the engine cooling circuit.
The tied interval between the tolerable temperatures for e.g. IGBT converters and the coolant can only be used, if cooling modules with a very low thermal resistance are available. Power converter chips therefore can be placed directly onto DCB coated AlN substrates. With a pin fin structure on the backside, they can be used as covers of a cooler box. Weight and cost aspects force the cooling modules to be designed as sandwiches of AlN covers and appropriate GFK bodies. Gaskets and seals have to show a high reliability and must be flexible enough to withstand the motions caused by CTE mismatch and pressure.
To proof the reliability of the cooling module, a measurement technique basing on a MicroDAC deformation measurement system has been applied for monitoring the inflating with operation pressure. To have the appropriate design tools and parameters available for generating tailored products, FE simulations have been performed and tuned according to the measurement results. For improvement of the efficiency of the pin fin plates, a pin fin heat pipe concept will be presented.

Contact:
Dr. Eberhard Kaulfersch, Fraunhofer IZM,
Gustav-Meyer-Allee 25, 13355 Berlin, Germany
e-mail: eberhard.kaulfersch@izm.fraunhofer.de

Nanotechnology Center of Competence for Ultrathin Functional Films – Perspectives for the Automotive Industry

Nanotechnologie-Kompetenzzentrum Ultradünne funktionale Schichten – Perspektiven für den Automobilbau

Leson, Andreas
Fraunhofer Institute for Material and Beam Technology (IWS), Dresden

Nanotechnology is going to become one of the key technologies of the 21th century. Despite the fact that nanotechnology is still in its infancy numerous examples of products already exist. Ultrathin films are a key element of nanotechnology. Their applications extend from the microelectronics and optics to medical science and sensor elements as well as to wear protection layers.
Nanotechnology is also going to have a great impact on the automotive industry. Ultrathin layers are already in use in order to improve wear resistance and to decrease friction. Nanoparticles are found in modern tires and will be used in intelligent paints. Antireflective coatings, sun protection glazing as well as nanocomposites for the production of light and stiff exterior parts are other applications which are reviewed. Moreover an outlook on possible future applications of nanotechnology in the automotive industry will be given.
In order to consequently explore the industrial application possibilities of nanotechnology 49 enterprises, 10 university institutes, 22 research establishments as well as 5 organizations focused their know-how and joined to a network, which is recognized and sponsored by the Federal Ministry for Education and Research as a national center of competence in the field of nanotechnology. The structure and the activities of this network which has a strong regional focus on Saxony and is coordinated by Fraunhofer IWS will be addressed.

Contact:
Dr Andreas Leson, Fraunhofer Institute for Material and Beam Technology Dresden,
Winterbergstrasse 28, 01277 Dresden, Germany
e-mail: andreas.leson@iws.fraunhofer.de

Low Temperature Co-fired Ceramics (LTCC) in Automobiles

LTCC-Keramik im Automobil

Schiller, Wolfgang A.; Rabe, Torsten
Federal Institute for Materials Research and Testing (BAM), Berlin,
Division "Materials Technology of Advanced Ceramics and Composites"

Demands of automotive industry on efficiency and reliability of electronics constantly increase. Electronic components located in many places of the motor car are exposed to high temperatures (> 150 °C), frequent temperature variations, high accelerating forces (> 60 g), and aggressive ambient conditions. Examples are:

- Electronics in exhaust systems up to 800 °C (e.g. l sensor);
- Electronics in engine compartment up to 200 °C and 60 g (e.g. transmission control unit);
- Electronics at wheels up to 300 °C (e.g. steer/brake by-wire);
- Electronics in passenger cell up to 85 °C (e.g. safety systems).

The driving forces of automotive electronics are:

- Progress of IC development and packaging technology (Current development directions are the increase of the level of integration, the miniaturization, the integration of passive components and the "System in package" concept.);
- Strict environment regulations and safety demands (Smart sensors combined with electronic control units (ECU) are necessary);
- Introduction of the mechatronics concept (ECUs are attached to the mechanical systems, which have to be controlled);
- Increasing comfort and safety demands of car drivers without cost raising.

The LTCC technology offers great potentials for development of automotive electronics according to the above-mentioned demands and driving forces, especially by

- "System in package" solutions for compact, robust and temperature-stable modules for ECUs (ECU coupling more frequently with mechatronic or by-wire solution)
- Integration of sensors and actors in the modules

LTCC modules are chemically resistant and hermetically dense. Contrary to PCB on polymer basis they show no water absorption. LTCC modules possess high stressability against both thermal and mechanical loads, so they can be used also above 150 °C and 40 g. Furthermore the high thermal shock resistance caused by low thermal expansion and low Young module promotes the broad field of applications of LTCC modules in automobiles.

The engine management system by mechatronic transmission control and the ABS/ESP controlling represent the highest challenges on car electronics at present. Therefore these examples based on current LTCC developments by company BOSCH are subject of the lecture.

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Contact:
Dr. W. A. Schiller, BAM, Division V.4,
12200 Berlin, Germany
e-mail: wolfgang.schiller@bam.de

Automotive Silicon MEMS: Test and Design for Reliability

Mikrosysteme im Automobil: Prüfung und Sicherung der Zuverlässigkeit

D. Katzer[1], J. Bagdahn[1] , M. Petzold[1], J. Graf [2] and R. Müller-Fiedler[2]
1 Fraunhofer Institute for Mechanics of Materials, Halle (Saale)
2 Robert Bosch GmbH, Stuttgart

The fabrication of micro electromechanical systems (MEMS) for automotive applications, such as acceleration sensors, pressure sensors or yaw rate sensors, is presently in most cases based on single crystalline or polycrystalline silicon materials. In particular, micromechanical devices can be produced using either bulk micromachining techniques, surface micromachining techniques or a combination of both.

In this paper, examples for automotive silicon MEMS will be presented and the future potential will be discussed. For automotive applications, particular attention has to be paid to the mechanical reliability of both the miniaturized Si components well as the bonded joints. As a consequence, the strength and the lifetime have to be accordingly addressed both for the system design and layout during the development stage and for quality assessment during fabrication.

Testing methods, experimental results and design concepts will be presented which can be applied for strength prediction, design optimization, quality assessment and failure analysis of mechanically loaded silicon MEMS. Special attention is paid to the influence of defects and etched notches on the strength properties of single crystalline and polycrystalline silicon, the failure behavior of silicon structures during shock loading and the reliability of wafer-bonded interfaces. For both bulk and surface micromachined components, results of lifetime measurements on mechanically long-term loaded components will be presented and the potential of fracture mechanics-based lifetime models for reliability considerations will be discussed.

Contact:
Dr. Matthias Petzold, Fraunhofer IWM Halle,
Heideallee 19, 06120 Halle (Saale), Germany
e-mail: petzold@iwmh.fraunhofer.de

Evaluation of a Low Temperature Wafer Bonding Process for Pressure Sensors Used in Automotive Industry

Bewertung von Niedertemperaturbondverfahren für Drucksensoren in der Automobiltechnik

Wiemer, M.[1], *Frömel, J.*[1], *Gessner T.*[1], *Nowak, B.*[2], *Südkamp, W.*[2], *Peschka, A.*[2], *Bagdahn, J.*[3], *Petzold, M.*[3]
[1] Fraunhofer Institute Reliability and Microintegration, Department Micro Devices and Equipment, Chemnitz, Germany;
[2] Aktiv Sensor GmbH, Stahnsdorf, Germany
[3] Fraunhofer Institute for Mechanics of Materials, Halle, Germany

Wafer bonding technologies are used for the fabrication and packaging of micro mechanical devices in bulk and surface micro machining. A special low temperature bond process was integrated into the technological process flow to package a pressure sensor fabricated by Aktiv Sensor GmbH.

In the paper a low temperature bonding process used with an oxygen plasma pretreatment followed by 400 °C anneal will be explained and the results of infrared transmission as well as the measured bond strengths of the prepared test wafers will be plotted. During the development of this bonding process it was shown that it is possible to reach bond strength between 1.8 J/m^2 and 2.4 J/m^2 depending on the annealing time.

As an application for the low temperature wafer bonding process a novel absolute dual range pressure sensor designed for brake by wire systems will be presented. Below 30 bar the sensitivity is about 4mV/bar and above the changing point until 250 bar the sensitivity is about 0.5 mV/bar, which is suitable for measuring the pressure needed for braking. Silicon direct bonding process was chosen for bonding the base, because accuracy for the adaptation of the small gap between base and the center boss of at least 20 nm is needed. Because of the danger of bonding the center boss to the substrate, anodic glass bonding could not be used.

Two different bonding conditions will be compared. In the first case, an unprocessed silicon wafer was bonded with the pressure sensor wafer using an oxygen plasma pre treatment followed by an 800 °C anneal for 5 h. In the second case the gap was integrated in the base, which was bonded using oxygen plasma pre treatment, followed by an 400 °C anneal for 5 h.

Contact:
Dr. M. Wiemer, Fraunhofer Institute Reliability and Microintegration,
Department Micro Devices and Equipment,
Reichenhainer Strasse 88, 09126 Chemnitz, Germany
e-mail: wiemer@che.izm.fhg.de

New Solutions with High-Temperature-Resistant Solder Joints for Electronic Assemblies

Neue Lösungen mit hochtemperaturbeständigen Lötverbindungen für elektronische Baugruppen

W. Scheel, K. Wittke, M. Nowottnick
Fraunhofer Institute IZM, Dept. Board Interconnection Technologies, Berlin and Oberpfaffenhofen

The application of electronic assemblies is moving more and more in the "high temperature" range. For instance the automotive industry needs electronic units near the engine with 150 °C operating temperature and more. Because these temperatures are to high for common standard solder joints, the development of new materials and technologies is required. For the temperature region up to 150 °C the use of special "reacting solders", a mixture of different alloys, is possible. During the soldering process the powder mixture can react and form a strengthened solder joint, with a higher melting point and improved thermomechanical properties.

The situation for operating temperatures higher than 200 °C is completely different. For these applications normally solder alloys with a high lead content are preferred. Lead-free solder alloys with comparable melting temperatures are not announced today. A new alternative can be the combination of adhesive joints with solder joints, whereas the mechanical function will be realized mainly by the adhesive. In contrast the solder joints can operate even in the liquid state, whereby the mechanical stress in the components hardly disappears. Low melting solder alloys are preferred especially for such "liquid solder joints". First applications for this new joining technology are under test today.

Contact:
Dr. Mathias Nowottnick, Fraunhofer IZM, Dept. Board Interconnection Technologies,
Gustav-Meyer-Allee 25, 13355 Berlin, Germany
e-mail: nowottnick@izm.fraunhofer.de

Temperature Stable Metallization and Interconnect Systems for Car Sensor Applications

Temperaturstabile Metallisierungs- und Anschlußsysteme für Sensoranwendungen im Kraftfahrzeug

Gottfried, K.[1], *Kaufmann, C.*[2], *Hoffmann, R.*[2], *Wiemer, M.*[1], *Gessner, T.*[1,2]
[1] Fraunhofer Institute IZM Chemnitz, Dept. Microdevices & Equipment
[2] Chemnitz University of Technology, Center for Microtechnologies

Nowadays, cars are equipped with a high number of micro sensors for a more comfortable driving and to improve the safety of the inmates as well as of the other road users. Due to the car specific environment, for some of these sensors a functionality at elevated temperatures is desired and necessary. Especially on-engine and in-exhaust applications offer a strong need for high temperature stable sensors.
The fabrication of temperature stable micro devices requires materials with a pertinent thermal and thermodynamic stability. During the past, remarkable efforts have been made concerning substrate materials. Today, various substrates like SiC, GaN, GaAs, and SOI are available for that purpose. In contrast to this, the interconnect and wiring system is still an unsolved problem in many cases. Problems like oxidation and corrosion of the metal layers as well as an interdiffusion of the complete material stack rising up with increasing temperature.

The contribution will give a short report about the activities of FhG-IZM, Department Microdevices and Equipment, on that field. Main topics are:
- to figure out, what are the crucial problems of interconnect and wiring systems for temperature loaded microsystems
- to discuss the ability and the limits of currently used concepts and materials for that purpose
- to present examples for temperature stable metallization systems based on two specific applications

Contact:
Knut Gottfried, Fraunhofer IZM, Dept. Micro Devices and Equipment,
Reichenhainer Str. 88, 09126 Chemnitz, Germany
e-mail: Knut.Gottfried@che.izm.fhg.de

Nanomechanics for Electronics in Automotive Applications

Nanomechanik für Elektronikkomponenten im Automobil

Keller, J.[1], *Michel, B.*[2]
[1] Brandenburgische Technische Universität Cottbus, Lehrstuhl Polymermaterialien, Cottbus
[2] Fraunhofer Institute IZM Berlin, Dept. Mechanical Reliability and Micro Materials, Berlin

As more electronics are applied in harsh under-hood environments, new concepts on thermal management have to be developed. In such a harsh environment with high temperature gradients, high humidity and corrosion the thermal, electrical, and mechanical reliability of sensitive circuitry have to be ensured on a high quality level. The approach for enhancement of reliability of such systems has to be based on system-, component- but also on the material-level. For the design of corresponding micro and nanomaterials underfills and adhesives of newly developed but also well-established polymers can be modified with nanoscaled fillers. The applied fillers are e.g. SiO_2 based nanoparticles for toughening reasons or carbon nanotubes to increase thermal or electrical conductivity.

For the successful design of micro and nanomaterials the employed characterization methods have to be based on a combination of experimental and computational approaches. The authors developed a powerful experimental technique for micro and nano scaled strain field measurement the so-called nanoDAC method (nano Deformation Analysis by Correlation). With this method which is based on the comparison of SPM images by cross correlation algorithm the characterization of strain fields of thermo-mechanically loaded specimens can be performed on bulk materials and on devices i.e. microelectronic components or MEMS. The characterization and evaluation of micro and nano cracks or defects, thin layers and material interfaces can be achieved with the nanoDAC approach.

By varying material properties or constitutive material models in a parameterized finite element model the measured strain field data of a thermo-mechanical deformation can be fitted to an appropriate material model. In the future this technique can be extended to a mesoscale type of simulation in the sense of the combination of finite element analysis and molecular modeling giving the potential of verifying nanomechanical material models.

Contact:
Dipl.-Ing. Jürgen Keller, BTU Cottbus, Lehrstuhl Polymermaterialien,
Universitätsplatz 3-4, 03044 Cottbus, Germany
e-mail: juergen.keller@nanoreliability.com

Challenges of Advanced Mechanical Micro Testing Techniques

Möglichkeiten moderner mechanischer Mikroprüftechniken

Walter, H.[1], *Grellmann, W.*[2], *Seidler S.*[3], *Michel, B.*[1]
[1] Fraunhofer Institute IZM Berlin, Dept. Mechanical Reliability and Micro Materials, Berlin
[2] Martin-Luther University Halle-Wittenberg, Halle
[3] Vienna University of Technology, Vienna

The development of small-sized (micro) devices (e.g. in automotives, micro-electronics) has significantly increased the demand for more accurate measurements of mechanical materials properties. In the case of micro-electronic applications, a complex material behaviour occurs due to different mechanical and thermal properties throughout the sandwich (e.g. package), which can influence the mechanical and thermal reliability as well as the life time. The produced residual stresses and material inhomogeneities as well as high thermal gradients cause local defects such as cracks in the sandwich structure.

Originally a tool for structural analysis, the Finie element (FE)-analysis has also gained in importance in design support for different components. The thermal and/or mechanical behaviour can be analysed numerically without having real prototypes. For the prediction of reliability, the knowledge of material properties is required. Without the ability to measure such material properties, the potential of this simulation tool is strongly restricted. But conventional test methods on standard test specimens lead to a disagreement between test results and real properties on micro scales. Testing of small specimens has therefore become necessary creating a new class of test methods and has led to new developments.

This paper reviews recent developments in advanced micro testing technologies, particularly in the context of mechanical test methodologies, and attempts a review of the problems of size effect or failure scaling.

Contact:
Dipl.-Ing. H. Walter, Fraunhofer IZM, Dept. Micro Materials Center Berlin,
Gustav-Meyer-Allee 25, 13355 Berlin, Germany
e-mail: hans.walter@izm.fraunhofer.de

Mechatronics and Micro System Technology from the Viewpoint of a Car Manufacturer

Mechatronik und Mikrosystemtechnik aus Sicht des Automobilherstellers

Kress, R.
AUDI AG, Ingolstadt, Germany

Today, 90 per cent of automotive innovations are predominantly motivated by electronics. At the same time, the new systems are subject to continually increasing cost pressure, while devices and functions are rapidly becoming part of the standard car equipment. A further challenge is provided by the fact that numbers of functions are on the increase, while development cycles decrease, complexity grows, buyer trends tend towards greater individualisation, and widening the range of models becomes imperative. Simultaneously, it remains important to further enhance levels of quality.

Available electronics architectures are defined by features such as multiple, individually conceptualised, component-specific control devices. Individual elements, bus-systems and bus-logs form a highly complex, component-group optimised network. This trend is characterised by being highly labour, time and cost intensive during development, while benefiting from little occasion for multiple use.

A high number of conventional control devices and growing demands by the new electronics systems concurrently lead to new package issues, which can only be solved by escaping into assembly spaces where ambient conditions are less favourable.

Experiences such as these have given rise to the investigation of an optimised electronics architecture, taking all economic as well as technical requirements into account, which will be able - by the help of mechatronics - to produce a highly compatible (not limited to any one production series), modular construction system.

Contact:
Dr.-Ing. Richard Kreß, AUDI AG,
85045 Ingolstadt, Germany
e-mail: richard.kress@audi.de

Requirements on Electronics Technologies for Future Automotive Systems

Anforderungen an Elektroniktechnologien für zukünftige Automobilsysteme

Specks, Will
Konzernforschung Elektroniksysteme, Volkswagen AG, Wolfsburg

The next generation of automotive electronics is strongly driven by infotainment and safety systems. The challenge for the automotive industry is that many of the newly required technologies are driven by computer, communication, and consumer products and follow much shorter life cycles than the car.

The major fields of application in infotainment are the human machine interface, seamless and wireless connectivity, mobile communication, and in-car entertainment. The human-machine interface will contain a growing number and size of displays per car, some of them being organic light emitting displays or electrically configurable surfaces as e.g. electronic ink. Wireless connectivity and mobile communication will create a market for GSM, Bluetooth, wireless LAN, and GPS electronics in cars. Future software-based entertainment and navigation requires large memory and high-speed processors. The infotainment system will apply modern software and network techniques as known from the computer, communication, and consumer electronics.

For safety electronics a growing field of application are collision mitigation or even collision avoidance features. Some key success factors for these features are vehicle surround sensors based on radar, laser, video or ultrasonic sensors. Those sensors act as “electronic eyes” scanning the environment and providing image signals to powerful computing platforms. They extract assumptions about the detected objects and compose a picture of the environment by sensor fusion techniques. Safety will further be enhanced by active lighting systems using more and more semiconductor or electro luminescent materials.

Contact:
Dr. Will Specks, Konzernforschung Elektroniksysteme (1776), Volkswagen AG,
D-38436 Wolfsburg, Germany
e-mail: will.specks@volkswagen.de

Mechatronics in Automotive Requests and Solutions for Driver Assistance Systems

Mechatronik im Automobil
Anforderungen und Lösungen am Beispiel von Fahrerassistenzsystemen

Seubert, T.
Director Advanced Development, Hella KG, Lippstadt, Germany

The trend in automotive electronic systems goes towards increasing functionality in convenience and safety applications while reducing at the same time energy consumption, emissions, costs, risks and time to market. This has lead to developing even more miniaturised electronics, designed for specific applications, distributed all over the car in inconvenient places. This could only be achieved by integrating electronics, mechanics and other physical applications as well as software and complex decision making into so called mechatronic modules.

At the same time, ambiance constraints to mechatronic modules have become more and more challenging: shocks up to 1,500 g, temperature up to 170 °C, water tightness …

The trend towards mechatronics is characterized by multi-functional integration, miniaturisation, the reduction of the number of all interconnections and by using the most reliable interconnection technologies available. Some technologies and the underlying development process is illustrated in the presentation.

The results are shown on some innovative driver assistance products such as
- Infrared Adaptive Cruise Control and Emergency Brake
- Camera based Lane Departure Warning

Contact:
Dr. Tilmann Seubert, Hella KG, Advanced Development,
Beckumer Straße 130, 59552 Lippstadt, Germany
e-mail: Tilmann.Seubert@Hella.com

Modular High Temperature Mechatronics for Transmission Control

Modulare Hochtemperaturmechatronik für Getriebe-Anwendungen

Lugert, G., Riepl, T.[1], *Ingenbleek, R.*[2]
[1] Siemens VDO Automotive AG, Regensburg
[2] ZF Friedrichshafen AG

In the recent years, mechatronic concepts allowed to increase reliability of elec-tronic control devices and at the same time to reduce cost. One remarkable example is the mechatronic integration of an electronic transmission control, sensors and actuators to one single assembly module, finally mounted inside the gearbox. The market introduction of this approach was enabled by highest sys-tem integration and design optimisation to the specific applications. As high temperature capability and long term reliability are mandatory for any device mounted inside a transmission system, innovative microsystem technologies have to be applied. These technologies come along with relative high initial cost and therefore require a high annual production to be competitive.

After the successful market introduction of some very specific applications, a broad market penetration is the next step. Target is to find concepts which are on one hand competitive for smaller production volumes and on the other hand flexible enough to fit to a platform of transmission controls with a high total vol-ume, split into alternative versions with different geometry and functionality. On top of that, temperature and lifetime require-ments are increasing. This implies the need for a modular approach to mechatronics for harsh environment.

Existing technologies for mechatronic integration lack either modularity or high temperature capability. A national consortium, funded by BMBF is working on a project called HTM, split into the following work packages:

- Modular high temperature microelectronics
- High temperature capable sensors
- Modular housing concept for harsh environment
- Modular interfaces for harsh environment

The presentation will first outline the variety of applications to be covered by the modular mechatronic concept. Based on that, the overall task is separated into single work packages. Actual activities are focussed on the conceptional design for a modular solution. Some first results will be presented together with an outlook on the next steps to be done.

Contact:
Dr. Thomas Riepl, Siemens VDO AG, SV P ED T IC,
P.O. Box 10 09 43, 93009 Regensburg, Germany
e-mail: thomas.riepl@siemens.com

Open Architectures Pressured by Industry Conflicts

Offene Architekturen im Spannungsfeld der Elektronik

Gerd Teepe
Strategy and Advanced Systems Labs, Motorola GmbH, München

Automotive electronics is positioned in the tension zone of conflicting requirements:

- Speed of innovation: electronics innovates at Gordon Moore's pace, where integration density doubles every 18 months. In opposition to this, car model innovation cycles are 4 to 6 years.
- Logistics flexibility: Semiconductors take 60 days in average to produce, in contrast to this, a car assembles within hours.
- Quality in cars is assured through lengthy test routines and a rugged quality process with excellent results, but inflexible structures. The true quality level of electronics is determined at design time through its process. More flexibility at 0-ppm failure is required urgently.
- Spare part availability: New cost effective semiconductor processes replace the old ones within a few years. The car requires spare parts for a life time of about 25 years or more.

Consequential architectural changes are required to solve these massive divergence problems between industries. The proposed solution is based on the mechatronics concept. Especially applicable for sensors and actuators, these must cope with the new architecture and operate in an increasingly networked environment.

The advent of the LIN- and FlexRay-based networking systems brings a new view to vehicle electronics architecture, where system integration, diagnostics and serviceability is given priority over the more traditional view on networks, characterised by transmission bandwidth and latency time. In fact new requirements such as composability, real-time behaviour and fault-tolerance are becoming primary criteria. Electronics design must support seamless integration into the software and hardware architecture of the vehicle, assuring by constrution the required production flexibility and highest quality standards.

Contact:
Dr.-Ing. Gerd Teepe, Motorola GmbH,
Schatzbogen 7, 81829 Munich, Germany
e-mail: gerd.teepe@motorola.com

Design, Assembly and Packaging of Mechatronic Systems by Support of Rapid Protoyping Process

Design, Assembly und Packaging mechatronischer Systeme unter dem Einsatz von Rapid Prototyping Prozessen

Frank Ansorge, Jörg Wolter, Christian Rebholz, Herbert Reichl
Fraunhofer IZM, Mikro-Mechatronik Zentrum, Oberpfaffenhofen

Airbags, navigation systems, chassis controls, radar distance control - the number of systems of microelectronics and micro systems in cars is high and constantly rising. In parallel increasing electronics and software reduces the former mechanics or give an additional benefit to the mechanics in order to achieve optimum system functionality to electrical consumer.
The most electrical consumers are interlinked to mechanical reactions. Mechatronics offers a maximum functionality by the linkage of sensor technology, actuators, signal processing and robust interfaces to the customer. Optimized reliability, excellent economy of mechatronic systems are the base to "Design for Quality" and "Design for Reliability". Mechatronic modules are defined as mechanical components or functionalities, electronic components with intelligence by software. The optimum performance concerning total functionality with minimization of the expenditure and thus a minimum of the system costs requires suitable development tools, deep understanding for functional rapid prototyping and according packaging processes, to achieve novel solutions.
The most important developments for micro mechatronic are part of industry like mechanical engineering, the automobile industry, the medical technology and the robotics. It is shown, how functional rapid prototyping can accelerate and improve the development processes of the electronic packaging. This rounded up by a view of the procedures of the assembly of electronic, optical and mechanical components of the mechatronic subsystem. A substantial procedure is the housing of the assembled systems into optimized packages to withstand harsh environmental conditions. All process descriptions will be supported by detailed technological information and functionality demonstrating sub-modules.
Development conditions for micro mechatronic systems are described, whereby the focus is based on applications in the automotive engineering. The lecture is completed by pointing out interfaces to adapt these new processes efficiently into own developments with a minimum of own efforts.

Contact:
Frank Ansorge, Fraunhofer IZM, Mikro-Mechatronik Zentrum,
Argelsrieder Feld 6, 82234 Oberpfaffenhofen, Germany
e-mail: ansorge@mmz.izm.fraunhofer.de

Multi-feature Design of Electronic Throttle Controls

Multifunktionale Strukturkonzepte für elektronische Gaspedale

Köhler, E.[1]; Kunzmann, J.[1]; Scheidling, M.[2]; Kade, I.[1]; Knorr, A.[1]
[1] Chemnitz University of Technology, Institute of Applied Design and Plastics Technology, Chemnitz GER
[2] TeleflexMorse, Heiligenhaus GER

Control-by-wire systems were gaining more and more importance in automotive during the last years. Current solutions are usually based on a replacement of mechanical signal connections by electronic signal transmission. The signal generating sensors are mostly placed on the maintained and not widely altered pedals or controls. Most widely distributed and large-scale manufactured are so called electronic throttle controls as accelerator pedals regulating engine revolutions.
Those ETC-systems are assembled differentially, consisting of standard design components, assembled by standard off-the-shelf connecting components to subassemblies and complemented with rotational sensors of different designs and working modes. But for a smooth, definite and long-term stable performance high effort concerning assembly and positioning has to be accepted.
Starting with a thorough analysis of current and future pedal features and using the disadvantages of current systems as starting points for optimization, several feasibility proposals were designed. Additionally, the electronic signal can be generated without much wear. Even an electronic signal balancing concerning IDLE and WOT is possible.
Therewith, advanced opportunities for a driver-adapted hysteresis became realizable. Additionally, feedback-reactions resp. feedback-modules could be integrated. Such feedback systems refer to known ideas of dynamic distance control or external speed or cruise control.
Additionally, available systems were compared with the developed to quantify advantages concerning weight and costs.

Contact:
Prof. Dr.-Ing. habil. E. Köhler, TU Chemnitz,
Institut Allgemeiner Maschinenbau und Kunststofftechnik,
Reichenhainer Strasse 70/D131, 09126 Chemnitz, Germany
e-mail: eberhard.koehler@mb.tu-chemnitz.de

Micromirror Applications in Automobile

Mikroschwingspiegelanwendungen im Automobil

J. Wolter[1], J. Auersperg[2], H. Erdl[3], N. Rümmler[4], F. Ansorge[1], H. Reichl[2]
[1] Fraunhofer IZM Development Center for Micromechatronics and System Integration, Oberpfaffenhofen
[2] Fraunhofer Institute IZM Berlin, Dept. Mechanical Reliability and Micro Materials, Berlin
[3] BMW AG Forschungs- und Ingenieurzentrum, München
[4] AMITRONICS Angewandte Mikromechatronik GmbH, Seefeld

Nowadays, the automotive sector emerged to a high innovated segment for the integration of new technologies and subsystems. Short development periods for automotive applications enable a fast launch but demands also for fast development processes for new systems. During the last years the share of electronics as well as optoelectronics devices in automobiles grows very fast. They offer on the one hand a wide range of new functions and on the other hand several advantages in contrast to conventional system solutions. A very special optical system is a micromirror application. The paper presents an overview on fields of applications of "micromirror"-devices in automotive systems. Micromirror devices, presently used in display systems for projection purposes and as cross-bar switching devices in telecommunication are MEMS devices that use the advantages of both, IC and mechanical system technologies. A typical system currently targeted for the projection market is the DMD (digital mirror device) from Texas Instruments which consists of an array of up to 1,280 × 1,024 rotatable aluminium mirrors.

The use of micromirror technology in automotive applications will cause high demands concerning reliability of the final system. One main issue for the application field "automotive" will be the harsh environment. While current mirror-applications need to fulfill conventional specifications of home entertainment equipment (e.g. room temperature, no vibrations or other mechanical stress etc.) their application in automotive subsytems demands for temperature resistance (up to 150 °C), resistance against shock, vibration and other environmental influences.
Therefore, the contribution exhibits results of experimental as well as of numerical investigations that are suitable to make a DMD ready for several automotive applications. Special examinations deal with thermal problems (requirements for robust cooling systems), fatigue of the material under thermal and dynamic loading conditions and demonstrate the importance of individual solutions with respect to the field of application.

Contact:
Jörg Wolter, Fraunhofer IZM,
Argelsrieder Feld 6, 82234 Oberpfaffenhofen, Germany
e-mail: wolter@mmz.izm.fhg.de

Analysis of the Fracture Surfaces of Thin Copper Foils

Analyse der Bruchflächen dünner Kupferfolien

Simons, G., Dual, J.
Swiss Federal Institute of Technology Zurich (ETHZ), Institute of Mechanical Systems - Mechanics, Zurich, Switzerland

In an ongoing research project, the mechanical behavior of thin copper foils of various thicknesses (between 10 - 250 μm) is investigated. Tensile tests are performed with geometrically scaled samples accompanied by numerous analyses of the microstructure (e.g. texture, grain size). The general result of the tensile tests is the following: The thinner a foil the lower is its strain at fracture.

For the explanation of this result, the analysis of the fracture surfaces is useful as many facts of the deformation mechanisms can be deduced, e.g. the type of stress state. As the fracture surfaces of the samples are quite small (e.g. 20 μm × 400 μm), standard analysis methods can not always be used. Therefore, the applicability of the following measurement methods is investigated: AFM (atomic force microscope), EBSD (electronic backscatter diffraction), FIB (focused ion beam), optical and stylus profilometry, SEM (scanning electron microscope). Besides the results of these measurements (grain size and orientation, roughness of surfaces, size of plastic zone, stress state at fracture, type of fracture), the steps necessary for the preparation of the samples are given.

From these investigations it might be concluded that the small fracture strain of the copper foils is due to a change of the stress state in the presence of a small crack – the crack is supposed to originate from the surface as the samples are rough and not perfectly flat.

Contact:
Gerd Simons, CLA H25, Institute of Mechanical Systems,
Swiss Federal Institute of Technology Zurich (ETHZ),
CH-8092 Zurich, Switzerland
e-mail: simons@imes.mavt.ethz.ch

nanoDAC – A Method of Reliability Analysis for Micro and Nano Technology

nanoDAC – Verfahren zur Zuverlässigkeitsanalyse im Mikro- und Nanobereich

Vogel, D., Michel, B.
Fraunhofer Institute IZM Berlin, Dept. Mechanical Reliability and Micro Materials, Berlin

Recent advances in microtechnology and the development of new electronics and microsystem devices in automotive industry have led to a strong need in material characterization on a micro and nano scale. Moreover, complex structures and components are being tested, exposing them to standard accelerated tests in order to ensure reliability. Defects occurring due to thermal or mechanical material mismatches have to be analyzed by suitable methods. If they cannot be avoided completely, e.g. microcracks in materials or at interfaces, it is desirably to evaluate their impact on the life time profile of the component.
nanoDAC is an advanced deformation measurement method, which utilizes load state images captured by high resolution scanning electron or scanning probe microscopes. Displacement and strain fields are extracted by means of cross correlation algorithms applied to these images. As a result very local material response due to environmental impact or device exploitation can be analyzed. The nanoDAC measurement data can be used to optimize design and/or materials properties of components and devices by avoiding material fatigue or damage. Measuring strain fields, the tool is appropriate to validation of mechanical modeling for finite element analysis (FEA). Finally, nanoDAC displacement and strain measurement is a method suitable for the determination of material properties like e.g. CTE, Poisson, fracture mechanics values on unique specimens inaccessible by conventional testing equipment.
The presentation includes a brief introduction in the measurement technique, a view on the method's capability and the developed hard- and software for mechanical and thermal testing. Emphasis is made on the extension of the technique, originally developed for optical and scanning electron microscopy, to atomic force imaging. The application of the tools is illustrated by examples from electronics and microsystem packaging. It is shown how the nanoDAC method can be used to analyze microcracks and to determine fracture mechanics parameters from crack tip opening fields obtained from AFM scans. Furthermore, the investigation of thermally induced material deterioration on a sensor membrane with submicron layers is demonstrated.

Contact:
Dr. Dietmar Vogel, Fraunhofer IZM, Dept. Mechanical Reliability and Micro Materials,
Gustav-Meyer-Allee 25, 13355 Berlin, Germany
e-mail: dietmar.vogel@izm.fraunhofer.de

New Developments in Non-Contacting Strain Measurements Using Laser-Speckle-Correlation Techniques

Neue Entwicklungen in der berührungslosen Dehnungsmessung mit Laser-Speckle-Korrelationsverfahren

Weiss, B., Zimprich, P.
Institute of Materials Physics, University Vienna, Austria

Properties for materials as applied in microelectronics and microsystems packaging can differ significantly from those determined on bulk materials. These differences can be caused by changes in topology as in thin polymer layers, by the impact of manufacturing or by component specific aging. In addition, it is known, that physical properties of materials can change significantly, when the dimensions of the specimen become very small ("size-effect"). Therefore, the material properties cannot be deduced from data achieved from macrospecimens. Consequently, to increase the reliability of microelectronic components, it is frequently required to determine mechanical and thermal properties of the base material in its practical dimensions and the properties have to be measured directly on the components. For this purpose, standard testing equipment cannot be used.
A laser optical strain sensor for determination of thermal and mechanical strain, especially suitable for measurements on thin structures, will be presented. This method is based on the optical, non-contacting laser-speckle correlation technique using a new, very fast data acquisition procedure. The system was designed especially to determine temperature dependent mechanical properties (up to 800 °C) of thin structures like free-standing films (down to 1µm), foils, fibres, fibrebundels and bonding wires with typical dimensions of a few microns in thickness. A wide range of materials can be investigated, like metals, polymers, glasses, ceramics and multilayer-structures. No markings or preparation of the specimen surface is required. This technique is also suitable for the study of thermal strain behavior of packaging structures as used in microelectronic manufacturing. However, the system can also be applied to materials with various, non-standardized geometries.

Contact:
Prof. Dr. Brigitte Weiss, Institut für Materialphysik der Universität Wien,
Strudlhofgasse 4, A-1090 Wien, Austria
e-mail: weissb@ap.univie.ac.at

LONGLIFE – Optical Measuring Techniques for Reliability Evaluation of MEMS

LONGLIFE – Optische Messverfahren für die Zuverlässigkeitsbewertung von Mikrosystemen

Michael Dost, Eva Kieselstein, Thomas Winkler, Elke Noack
Chemnitzer Werkstoffmechanik GmbH, Chemnitz

The ask for high performance MEMS to ensure innovative and reliable solutions at low unit cost in automotive industry and other high-tech applications has led to growing activities in the development of micro materials with outstanding functional characteristics. The application of such materials in micro devices, which are implemented in technical systems with high risk categories (e.g. in automotive or aircraft environment) and high lifetime demands (15 to 20 years) requires exact knowledge about the reliability behavior of such materials during extremely long-lasting application periods. Unfortunately, the classical experimental and theoretical methods commonly used for reliability characterization – especially accelerated testing based on the Arrhenius model – are limited in their potential to deliver adequate results to such questions. The reason is, that (in opposite to conventional lifetime ranges of some years) in the high lifetime region physical processes are dominant in determining degradation and failure effects, which are modeled by this methods inadequately or at least with very poor accuracy. New approaches, like the so-called "physics-of-failure-approach" are needed to avoid serious technical and social consequences, which could arise from the contradiction between the implementation of new materials in high lifetime applications and the potential lack of knowledge about the long-term behavior of their properties, which could be described by the terminus "reliability gap".

The joint project LONGLIFE deals with the development of optical inspection techniques to investigate the thermo-mechanical properties and characteristics of micro materials and the physical mechanism of their change under the influence of typical application environments, that means, in the materials compounds of the MEMS. The presentation includes a survey of the contributions of the partners of the LONGLIFE project (mainly measurement and loading techniques by AMITRONICS Seefeld, BIAS Bremen, CWM Chemnitz, ETTEMEYER Elchingen, and practical application by R. BOSCH Stuttgart and GEMAC Chemnitz).

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Contact:
Dr. M. Dost, Chemnitzer Werkstoffmechanik GmbH,
Otto-Schmerbach-Str. 19, D-09117 Chemnitz, Germany
e-mail: dost@cwm-chemnitz.de

Finite-Element-based Micro Deformation Measurement

Finite-Elemente-basierte Mikroverformungsmessung

Kühnert, R., Meyer, R.
Image Instruments GmbH, Chemnitz

To carry out reliability assessments for electronic components and packages by means of numerical methods the exact knowledge of deformation behaviour and material parameters of involved materials and structures is essential. This is especially true in the case of micro- and nanoscaled structures due to the possible size-dependence of the thermomechanical micromaterial parameters.

One approach to bridge this gap, which was successfully demonstrated in many applications is to varify micromaterial parameters by means of deformation measurements in critical surface regions. For this purpose, e.g. Digital Image Correlation (DIC) techniques have been improved and adapted to be used in combination with Finite Element software by many research facilities in the last decade. Although a comparable precision of measurement and calculation results could be achieved, in most of these applications no optimized data interface was available for the integration of experimental results to the numerical computation algorithm.

Therefore, one main goal in the framework of the CRAFT cooperative research project High temperature Micromaterial Testing HiT was to develop and implement a finite-element-based DIC technique for micro deformation measurements based on the evaluation of micrograph series.

In contradiction to conventional image correlation, in ADASIM™ for each node point an irregular kernel geometry is used to track conformed pixel regions and to measure node displacements throughout the whole deformation process which is recorded as digital micrograph series.

The node positions themselves are imported as a finite element coordinate file whereas the kernel geometries are matched to the region inside the elements belonging to a certain material or structure. Thus, displacements can be evaluated directly at inner or outer material borders, interfaces or contacts. The use of identical meshes for both, measurement and computation enables the comparison of displacements inside the analyzed region and therefore to varify the used micromaterial parameters.

ADASIM™ primarily was developed for the evaluation of SEM micrographs but can be applied to digital image series from any source, if the requirement of conformed imaging inside the finite element regions is fulfilled.

Contact:
Dr. Rolf Kühnert, Image Instruments GmbH,
Annaberger Str. 240, 09125 Chemnitz, Germany
e-mail: kuehnert@image-instruments.com

Structures in Microsections of Small Solder Volumes

Gefügeausbildung in kleinen Lotvolumina

Villain, J.
University of Applied Sciences, Augsburg

In modern automotive electronics solder materials have to meet the following requirements: high temperature up to 180 °C, lead free solders and small solder volumes. Due to higher packaging density the feature size will be reduced by factor 0.7 and a doubling of devices/cm^2 will occur with each new product, that means every two to three years. That means the solder volume of the soldered joints decreases rapidly. Today the solder volume of a flip chip BGA (Ball Grid Array) with a ball diameter of 750 µm is 0.22 mm^3, the solder volume in 5 years with a ball diameter of 40 µm will be 0.000034 mm^3 !

The problems which are generated with small lead free solder joints are:

1 Small solder volumes are structured of layers of intermediate compounds which are the main part (about 80 to 90 %) in contrast to a mixture of intermediate compounds (about 10 to 30 %) combined with solder materials in conventional solder joints. Due to this structure the ductility decreases.
2 The amount of solved elements outside the thermodynamic equilibrium and the formation of low melting eutectics due to 3 or 4-component or even more complex systems and higher cooling rates lead to new phases with unknown material properties.
3 The influence of manufacturing parameters on the structure seems to be higher.

The growing of the intermediate compounds can not be determined any more by using the constitutional binary diagrams because three to six different elements act together. The mechanical behaviour of these phases in combination with the device and substrate metallization has to be determined for reality simulations of small solder volumes. First results of Vapour-Phase soldered components indicate the formation of intermediate compounds with three or four components.

Contact:
Prof. Dr. Jürgen Villain, University of Applied Sciences Augsburg,
Department of Electrical Engineering,
Baumgartnerstr. 16, D-86161 Augsburg, Germany;
e-mail: villain@lrz.uni-muenchen.de

Optical Crack Tracing – An Automated, Easy to Use and Accurate Method to Measure the Fracture Toughness of Polymers

„Optical Crack Tracing" – Die automatisierte, einfach durchführbare und genaue Messung der Bruchzähigkeit von Polymeren

Uhlig, C.[1], Kahle, O.[1], Wieneke, B.[2], Bauer, M.[1]
[1] Fraunhofer Institute IZM, Branch Lab Teltow
[2] LaVision GmbH, Göttingen

Crack formation and propagation is one of the major failure mechanisms, wherever the relatively brittle thermoset resins are used in electronic car components (e.g. adhesives, moulding resins). Typically, cracks grow from stress concentration sites (which always exists). Crack growth is often driven be either mechanical stresses (such as vibrations) or thermally induced stresses (cure stresses or thermal mismatches).
Development (synthesis or formulation) of improved thermoset resin materials for car electronics means testing of many important key properties, such as stability in hot and/or moist atmospheres, oil, adhesion, thermal expansion coefficient and Young's Modulus. Resistance to crack propagation, i.e. fracture toughness, is only one of these key properties.
Efficiency, i.e. the relationship of "meaningfulness" to costs of material testing is an important parameter to reduce time and costs of the development of new materials or new components. However, the current test practice to measure fracture toughness, recommended in A.S.T.M.-D5045 or ISO13586 standards, involves time-consuming and troublesome manual procedures; the lack of automation renders it complicate to train new technical staff in carrying out the fracture tests.
A new automatic optical method was developed to automatically measure crack propagation during the standard fracture toughness test. Thereby, fracture toughness is not only measured for crack initiation but also for crack propagation (i.e., the R-curve is measured).
In this paper, testing experience (of more than 1000 specimens) with this new method is reported and it is shown that great progress has been achieved regarding efficiency, ease of use, training time and effort, automation and, last but not least, accuracy.

Contact:
Christoph Uhlig, Fraunhofer IZM, Branch Lab Teltow,
Kantstraße 55, 14513 Teltow, Germany
e-mail: uhlig@epc.izm.fhg.de

Multimedia and Remote Working Capable SPM System

Erweiterung der Anwendungsmöglichkeiten für AFM's

Schmucker, U., Zubtsov, M., Böhme, T.
Fraunhofer Institute for Factory Operation and Automation, Dept. Automation, Magdeburg

Scanning probe microscopes (SPM) present completely new options for applications in the life science field. Not only do they make microscopic observation possible but specimen manipulation as well.

The IFF is developing new types of tools for the life science field on the basis of consequently expanding the possibilities of use of SPM (esp. scanning force and near field microscopes) by combining this with other technologies such as multimedia support, remote working, force feedback, manipulation and many more, previously not used in this field.

The multimedia expansions for SPMs make it possible to transmit sensor-actuator behavior (which the user knows from his/her macroscopic environment) to the user when manipulating objects in the submicroscopic world of his/her research subjects. By integrating a stereoscopic representation and haptic feedback in a scanning force microscope, structures in the submicroscopic world are made experiential for the user. Together with an interactive control, submicroscopic structures thus become sensible.

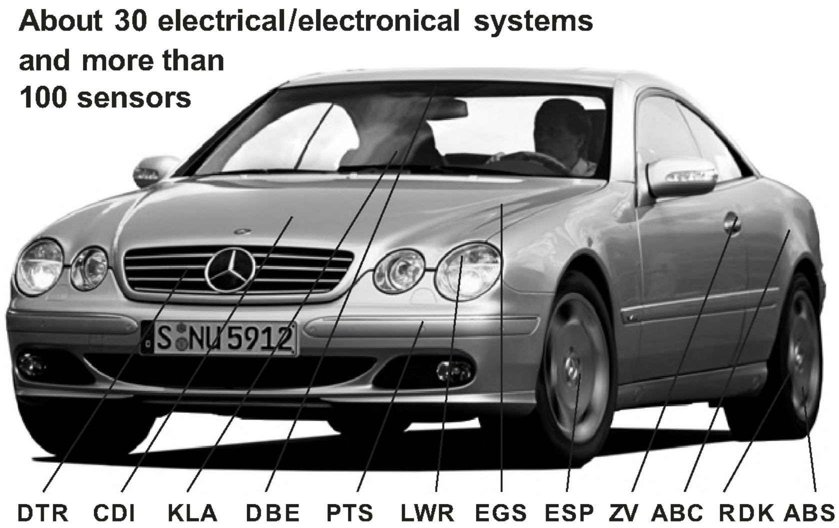
Contact:
Dr Ulrich Schmucker, Fraunhofer IFF, Dept. Automation Magdeburg,
Sandtorstr. 22, 39106 Magdeburg, Germany
e-mail: ulrich.schmucker@iff.fraunhofer.de

Microsystems Technology for Automotive (Trends)

Mikrosystemtechnik im Automobil

Krüger, S.
VDI/VDE-Technologiezentrum Informationstechnik GmbH Teltow

Demands on motor cars are steadily on the increase. Next to government regulations for higher safety standards, a decrease in fleet consumption and more environmentally-friendly engines, there is the customer's expectation to buy economical, individual and comfortable cars. Meeting these demands with the help of traditional, mechanical systems has been impossible for some time. A lot of functions can only be realised through extensive use of electronic components and software. The grown complexity of automotive car parts is exemplified by a number of up to 180 electronic engines, more than 50 control units, and several million lines of software code.
Modern cars understand, all the time better, how to monitor themselves, and where



System	Abb.	Sensors			
Distronic	DTR	3	Common-rail diesel injection	CDI	11
Electronic transmission control	EGS	9	Automatic climate control	KLA	13
Roof unit	DBE	7	Active body control	ABC	12
Automatic brake control	ABS	4	Tire pressure monitoring	RDK	11
Power lock	ZV	3	Electronic stability programme	ESP	14
Dynamic light regulation	LWR	6	Parktronic system	PTS	12

Figure: Sensor systems in automobiles (Source: DaimlerChrysler)

and when to adjust to a number of changes. So they can take in their environment and run identification processes. The basis for these functions are sensors, which, again, are often realised by microsystem technologies. Traditional examples are the application in pressure- and inertial sensors. 10 to 30 of these sensors are used in executive or premium end cars today. They operate cars' engine management, air bag or suspension systems. The technological senses of the car make for an entirely new quality of motoring.
Cost-efficient qualities especially, but also high flexibility and reliability of products have resulted in a broad application of microsystem technologies. Looking at current trends, at least three major tendencies can be observed. They are first applications in the areas of active safety systems with precrash-sensors, of wear sensors monitoring the condition of parts and fuels/lubricants, and of the fusion of sensors and data.
Thus, based on existing technologies, new concepts are leading to innovative automotive functions. Examples are anticipatory gear-box automats, dynamic navigation systems, active pedestrian protection, or telemetric diagnosis and warning applications.
The future of automobiles might become unspectacular: low petrol consumption, no environmental pollution, few accidents – and a car which adapts to the individual needs of its passengers. This paper presents current projects from industry and academia which have begun to prepare the way towards this vision.

Contact:
Sven Krueger, VDI-VDE Technologiezentrum Informationstechnik Teltow,
Rheinstr. 10B, 14513 Teltow, Germany
e-mail: krueger@vdivde-it.de

Match-X - A Methodology or Construction Kit for Modular Microsystems

Der Baukasten für Modulare Mikrosysteme

Großer, V.[1], *Vogel, J.*[2]
[1] Fraunhofer Institute IZM Berlin, Dept. Mechanical Reliability and Micro Materials, Berlin
[2] AMIC Angewandte Mikromesstechnik GmbH, Berlin

The modularisation of microelectronic products and microsystems has become more and more established over recent years. With the embedding of microsystems in an ever broader range of products, modular product and component families have become part and parcel of many a companies' catalogue. Until now though, the modularisation of micro components (such as sensors, actuators, and their drivers and signal transmitters) across firms and industries is still presenting problems to everyone concerned.

Match-X, a solution for modular microsystems, has been designed as a methodological tool for all kinds of firms and industries, enabling them to use standardised modules with high flexibility for their microsystems. This construction kit, as which it may be considered, was developed by the Fraunhofer institutes IZM and IPA, under coordination of a group of companies headed by the VDMA, and is now being marketed by the VDMA Match-X Community.

Additional or complementary activities are in the fields of modular micro-process technologies and modular micro-sensor technologies.

The paper describes the processes of development and manufacturing of new modular microsystems with Match-X, the tools that should be used and the hardware resources already available. Benefits and limits, as well as special features will be discussed in the paper.

Current application fields for these modular microsystems are
- development and test of new, complex systems (development kit)
- process measuring and control technology
- bus-compatible or autonomous microsensor systems
- miniaturised control elements for micromotors and actuators
- intelligent microfluidic components (valves, pumps etc.)

Contact:
Dr. Volker Großer, Fraunhofer IZM, Dept. Micro Materials Center Berlin,
Gustav-Meyer-Allee 25, D-13355 Berlin, Germany
e-mail: volker.grosser@izm.fraunhofer.de

Design, Assembly and Qualification of Modular Micro-Systems Build in 3D-BGA-Technology

Design, Aufbau und Qualifikation modularer Mikrosysteme in 3D-BGA-Technologie

Binder, W.[1], *Geiger, M.*[2]
[1] Management - Binder Elektronik GmbH, Sinsheim
[2] Research and development engineer – Binder Elektronik GmbH, Waldstetten

As a contract manufacturer Binder Elektronik develops and produces microelectronic components, modules and systems for modular microsystems in 3D-BGA-Technology according to customer specifications.

The mounting of two or more packages is possible with this stack up technology. The stack up 3D-BGAs are reliably components and flexibly to configure. These qualities make them especially suitable for developers, who have less space in their application and require the high performance of systems that can be combined.

Under consideration of the development-trends, the BGA-Technology was chosen as the electric connection technology of the 3D-BGA-Packages among each other. To manufacture these Packages the production processes based on the HDI-PCB-Technology with FR4 or similar materials are used. For the fast and advantageous assembly of 3D-BGA-Microsystems standard components such as SMD, BGA, COB and Flip-Chip can be used.

Existing 3D-BGA-Packages make the construction of different products for microsystem technology applications within a kit system possible. Measurements of the 3D-BGA-Packages of 12.5×12.5 mm^2 until 50.0×50.0 mm^2 are practicable.

The key benefits of these 3D-BGA-Packages are:

- Fast availability in small and middle quantities to market acceptable prices
- Decrease of the development time with simultaneous lowering of the development expenditure
- Fast adaptability at new components and technologies
- Easy to handle and low investment expenses for the processing of 3D-BGA-Packages
- Higher degree of miniaturization of complex microsystems
- Higher flexibility through the combination within the kit system
- Bus systems and central controls are unburdened

Contact:
Wolfgang Binder, Binder Elektronik GmbH,
Hauptstrasse 142, 74889 Sinsheim, Germany
e-mail: binder@binder-elektronik.de

Sensor for Modern Steering Assist Systems

Sensor für moderne Lenkhilfesysteme

Jerems, F., Rachui, D., Fröhlich, E., Proft, M.
Valeo Schalter und Sensoren GmbH, Bietigheim-Bissingen

Modern power steering systems in small and medium sized cars are increasingly of an electromechanical rather than hydraulic nature. Therefore an electronic steering effort sensor is necessary for the control algorithm. Many principles are known from industrial applications but only a few of them are suitable for automotive applications. The torque sensor presented here works on a magnetic principle where the magnetic flux path is modified by a torsion bar which is placed in the steering shaft. The magnetic field strength between two stators is a direct measure of the steering torque and is detected by two Hall sensors for the purpose of redundancy. This novel non-contact technology allows a simple and robust design.

The functional principle and the design will be presented as well as 3D magnetic field simulations enabling an optimization of the design.

Contact:
Dr. Frank Jerems, Dept. E1SY, Valeo Schalter und Sensoren GmbH,
Division Schalter und Detektionssysteme Zentraleuropa,
Laiernstr. 12, 74321 Bietigheim-Bissingen, Germany
e-mail: frank.jerems@valeo.com

Development of Special Kinetic Sensors and Their Application Potential for Automotive and Transportation Systems

Entwicklungsstand und Anwendungspotential spezieller kinetischer Sensoren für den Fahrzeugbau

Hiller, K.[1], *Bertz, A.*[1], *Dittrich, C.*[2], *Gessner, T.* [1,3]
[1] TU Chemnitz, Zentrum für Mikrotechnologien, Chemnitz
[2] GEMAC mbH, Chemnitz
[3] Fraunhofer Institute IZM Berlin, Dept. Micro Devices and Equipment, Chemnitz

Today, automotive and transportation systems are going to include a growing number of electronic systems and sensors. The increase of security and comfort as well as an effective and environment compatible use of the fuel are the driving forces of this trend. MST products such as microsensors are attractive because of their small size, low power consumtion and cost efficiency in combination with appropriate performance and reliability.

Micromachined kinetic sensors, such as acceleration sensors, inclination sensors and gyroscopes, have been integrated in automotive systems for several years. Mainly based on Silicon, both bulk and surface micromachining technologies have been established.

The paper describes the fabrication technology and sensor characteristics of bulk micromachined acceleration and inclination sensors developed in Chemnitz. Offering a high accuracy and stability, the inclination sensors are used for instance in transportation systems and elevators. Other possible applications in automotive systems are announced.

On the other hand, the Center of Microtechnologies is highly engaged in the development of self aligning high aspect ratio micromaching processes such as Air gap Insulated Microstructures (AIM). Based on standard single crystal silicon wafers, this technology offers the potential for a high volume fabrication of highly compact, but low cost of kinetic sensors. The properties and application related issues of this novel technology for automotive systems are discussed as well.

Contact:
Dr. Karla Hiller, Chemnitz University of Technology, Center of Microtechnologies,
09107 Chemnitz, Germany
e-mail: karla.hiller@zfm.tu-chemnitz.de

Vibration Analyses of Micro Assemblies by Means of Laservibrometry

Schwingungsanalysen an Mikrobauteilen mittels Laservibrometrie

Rümmler, N., Schnitzer, R.
AMITRONICS Angewandte Mikromechatronik GmbH, Seefeld / Munich

For a life time optimised construction the knowledge of dynamical assemblies load is one of the basic requirements. This fact is especially important for smart electronic structures and micro assemblies. To analyse the load vibration investigations and vibration tests are necessary. For such investigations of micro assemblies contactless working lasertechniques are used.
In the last few years experimental vibration analyses based on Scanning Laser Vibrometers have been established. By using of the scanning method the results of such analyses include beside natural frequencies and vibration amplitudes also mode shapes.
Because of the laser-focus diameter of 30 µm the vibrometer is qualified for vibration measurements of optical accessible assemblies with a size of minimal 30 µm.

The paper gives an overview about the principle of experimental vibration analyses especially for micro assemblies and shows like a Scanning Laser Vibrometer works.
Measuring results of different applications in the field of micro assemblies (circuit boards, micro connectors, sensors, microelectronic packages and micro mirrors) are discussed.
Based on the results structural modifications concerning a vibration optimization are inferable.

The results serve also for validation of FEM-models and as input data for numerical reliability investigations. The paper describes a special algorithm.

Contact:
Dr. Norbert Rümmler, AMITRONICS Angewandte Mikromechatronik GmbH,
An der Hartmühle 10, 82229 Seefeld, Germany
e-mail: info@amitronics.de

Airbag Igniter with Hafnium Hydride as Ignition Material

Airbag-Anzündelemente auf Basis von Hafniumhydrid

Loebner, B., Weiss, U.
Chemnitz University of Technology, Center for Microtechnologies, Chemnitz

Increasing number of airbags in a car causes new challenges on the wiring of igniters, especially in direction to a bus system. For such systems it is advantageously to integrate some electronics within the igniter and to have an ignition element that requires a very low ignition energy. A conventional bridge wire igniter requires about 3 mJ for ignition. With hafnium hydride as ignition material the energy can be lowered down to the range of 70 … 300 µJ.

Hafnium hydride is used as a thin film bridge on an insulating substrate. Manufacturing of the HfHx igniter bridge is done mainly with standard processes that are known from the semiconductor industry. The deposition of the bridge material was done by sputtering of hafnium, followed by a transformation to HfH_x in an H_2 atmosphere. Aluminium pads connecting the HfH_x bridge are used for wire bonding to the socket.

Igniter bridge design has been varied with several layouts and different processing parameters were prepared and evaluated in a first step without pyrotechnics. Main issues of characterization were the content of H in the HfH_x-layers, the firing energy and the long term stability. The characterization of the igniters with pyrotechnics was done in co-operation with partners. The results show the above-mentioned ignition energies and firing times below 300 µs.

The authors like to thank the involved partners of the research project:
G. Kordel/Dynamit Nobel, W. Schmid / NICO Pyrotechnik, T. Goernig / Continental TEMIC and H. Laucht / TRW Airbag Systems. The financial support of BMBF is kindly acknowledged.

Contact:
Dr. Bernd Loebner, Chemnitz University of Technology, Center for Microtechnologies,
09107 Chemnitz, Germany
e-mail: bernd.loebner@zfm.tu-chemnitz.de

Durable, Self-cleaning Coatings in Optical Quality for Automotive Applications

Stabile, selbstreinigende Beschichtungen in optischer Qualität für Anwendungen im Automobilbereich

Claessen, R.
SuNyx Surface Nanotechnologies GmbH, Cologne

Hydrophobic coatings for automotive glass have been under investigation of the automotive suppliers for a long time. The recent advent of self-cleaning glass in the architectural glass sector definitely reminded the decision makers that glass and similar surfaces sell better if they stay clean and shiny.

A novel concept for ultrahydrophobic coatings is presented, which overcomes current issues with self-cleaning glass coatings like limited durability and optical quality. Natural self-cleaning coatings exhibit three important features: intrinsic hydrophobicity, surface roughness and most importantly: self assembly of the surface chemistry with some measure of autoregeneration. We not only demonstrate the feasibility of this crucial property by biomimetic means, but combine it with high optical quality as well. By self-replenishment of the surface chemistry, lifetime in excess of a decade seems achievable. Additionally, a combinatorial approach to selection of materials supported by computer simulations speeds up the development process significantly. Overall, the next generation of self-cleaning coatings defeats teething troubles of this promising new market segment.

Contact:
Rolf Claessen, Ph.D., SuNyx Surface Nanotechnologies GmbH,
Stolberger Str. 370, 50933 Cologne, Germany
e-mail: rolf.claessen@sunyx.de

Micro Materials Center Berlin (MMCB)

B. Michel and T. Winkler

The competence center "Micro Materials Center Berlin" at the Fraunhofer IZM is one out of three German centers in the field of materials research for microtechnology which is funded by the BMBF (the German Federal Ministry for Research and Education) within its Strategic Program "New Materials for Key Technologies of the 21st Century". The two other centers are located at the University of Ulm and at the Research Center Karlsruhe. The project is guided by the project management organization NMT of PTJ Jülich. The MMCB started to work in summer 2000. There has been a lot of research activities in the recent years. The main goal of the MMCB is to carry out joint research projects with industry in the field of "Micromaterials Compounds and Reliability". The so-called thermal misfit problems which occurs at the interfaces between different materials with different thermo-mechanical behaviour may lead to considerable stresses and strains within the interconnection regions of microcomponents. More than 60 % of failure problems in microelectronics are related to these thermal misfit effects. To improve this situation an increase in advanced research activities directed towards reliability analysis and life-time evaluation of microcomponents and microsystems has to be achieved.

In the MMCB joint research projects with industry up to 6 million Euro will be carried out within four years to overcome or at least to reduce the existing reliability gap in microsystem technology applications. In the automotive industry, e.g. one challenge are the increasing requirements of the so-called high-temperature electronics which are most important for a further increase in microsystems applications in automotive industries. The reliability of advanced microelectronic packaging technologies has to be studied in more detail, taking into account creep, fatigue, vibration effects of new materials to establish the breakthrough of miniaturization in these kinds of 'high-tech' applications.

At the MMCB the following topics have been dealt with:

- Thermo-mechanical reliability evaluations of microcomponents in high-tech systems
- Development and simulation methods for the efficient design of small systems
- Nanomechanics testing techniques and simulation tools
- High temperature micromechatronics design and testing
- Thin-film technology for packaging solutions
- Ecological and economic analysis, evaluation and optimization of products and processes
- Fabrication of micro-mechatronic systems using encapsulation techniques
- Methods for the fabrication of high-performance systems (MEMS, MOMEMS, microsystems)
- Manufacturing and processing of advanced packages
- SMD-oriented materials, techniques and tool development, as well as auditive training
- Development and characterization of polymeric materials and composites
- Lead-free solders for packaging in high-temperature electronics for automotives

Recent MMCB activities

- SPIE San Diego 2002, MMCB presentation at the Nano- and Micromechanical Testing and Reliability Conference, March 2002 (Conference chairmanship, Plenary Lecture)
- EuroSIME Paris 2002, Technical Conference Chair, Invited Paper
- Materials Week Munich 2002, MMCB presentation, Invited Plenary Lecture
- DTIP Cannes, France, 2002, MMCB presentation, Conference Chair, Invited Plenary Lecture
- Nano 02 Washington, Invited Paper, Program Committee, Session Chair
- Materials in Electronic Packaging Braselton, USA, 2002, Technical Chair, MMCB presentation
- EPTC Singapore 2002, MMCB Tutorial, Invited Paper

NanoDAC – a new powerful method for crack evaluation in the micro-nano transition region

Cracks and fracture are very important for the reliability management in micro technology. The nanoDAC technique, developed at IZM is a very powerful means for the evaluation of near crack tip deformation fields. It enables to derive stress, strain and fracture quantities in the immediate vicinity of interfaces, interface layers, within tiny micro- and nanocomponents as well. By means of nanoDAC it is possible to determine stress intensity factors directly in an AFM (see **www.nanomechanics.biz**).

Announcement
and
CALL for PAPER

4th International Conference
on

Micro Materials and Nano Materials

MicroMat 2004

4-7 April, 2004
Berlin, Germany

Organizer:
IZM Fraunhofer Institute for Reliability and Microintegration
MMCB Micro Materials Center Berlin

In cooperation with:
VDI/VDE-IT VDI/VDE-Technologiezentrum Informationstechnik GmbH, Teltow
BAM Federal Institute for Materials Research and Testing, Berlin
DVM Deutscher Verband für Materialforschung und –prüfung e.V.
TU Technical University of Berlin

Technical organizer:
AMIC GmbH, Berlin

MAIN FIELDS OF THE CONFERENCE

- Micro materials research
- Micro materials testing
- Micro materials simulation
- Micro materials application
in microsystem technology, MEMS, NEMS.

Reflecting recent trends, special emphasis will be given to materials aspects of **nanomechanics and nanotechnology** applications.

ACTUAL INFORMATION
Regularly updated information on the conference will be available on
http://www.micromaterials.com

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E. REESE EPCOS GmbH Munich, D
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R. W. SIEGEL Rensselaer Polytech, Troy, USA
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E. SUHIR Bell Labs, Murray Hill, USA
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C.V. THOMPSON M.I.T. Cambridge, USA
W. TOTZAUER HTW Mittweida, D
R.R. TUMMALA Georgia Institute of Technology, Atlanta, USA
J. VILLAIN University of Augsburg (FH), D
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K.-J. WOLTER Technical University Dresden, D
W. WONDRAK DaimlerChrysler Frankfurt/M., D
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K. ZHANG Philips, Eindhoven, NL
T. WINKLER CWM Chemnitz, D (**Secretary**)

TOPICS

1. Experimental Characterization Techniques (Optical and Laser Techniques, Acoustic Methods, Thermography, Magnetic Testing, STM, AFM, UFM, microDAC, X-Ray Microscopy, Tomography)

2. Microdeformation Analysis (Digital Image Correlation, microDAC, nanoDAC, SEM Moiré, Micro Raman Spectroscopy)

3. Thermo-mechanical Simulation of Microcomponents and Microsystems

4. Thermal Characterization (Thermal Management, Electronics Cooling, Thermal Conductivity, Heat Transfer)

5. Nanomaterials – Nano Simulation and Testing

6. Downscaling of Material Properties, Interfacial Relations between Micromaterials and Nanomaterials

7. Stress and Strain in Thin Layers and Films

8. Advanced Mechanical Testing (Indentation Tests, DMA, Micro Tensile Testing, Internal Stress Analysis, ...)

9. Materials Parameters and Constitutive Behavior (Semiconductors, Ceramics, Polymers, Solders, Metallizations, Thin Films, and Special Combinations of Different Materials on Micro and Nano Scale)

10. Electronic Packaging Materials (for CSP, BGA, Flip Chip, COF, WL-CSP, ...)

11. Photonics and Optoelectronics Materials Issues

12. Materials Aspects of PCB and HDI-substrates

13. Interfaces and Interface Reactions

14. Interconnection and Assembly Technologies (Bonding, Bumping, Microsoldering, Microforming, Etching, Laser Treatment)

15. Ultraprecision Manufacturing of Micro and Nano Components

16. Simulation of Micro and Nano Materials (Simulation Tools, Design, Applications, Relations between Simulation and Experiment, Parametrized FE Models, Global vs. Local Modeling, Continuum vs. Lattice Modeling)

17. Micro and Nano Reliability

18. Crack and Fracture Problems (Crack Detection, Prediction and Prevention, Failure Criteria, Fracture Electronics)

19. Damage, Failure Modeling (e.g. Creep Damage, Damage Accumulation, Life Time)

20. Accelerated Testing

21. Probabilistic and Stochastic Methods

SPECIAL SESSIONS AND WORKSHOPS

1. Materials Aspects for Microfabrication and Modular Microsystem Technology

2. Nondestructive Testing of Micro Materials and Microcomponents

3. Micro- and NanoProbe Techniques

4. Materials for Micro Security and Homeland Security Applications

5. Micro Materials for Adaptronics

6. Polymeric Materials for Electronics (Polytronics)

7. Micro and Nano Materials for High Temperature Electronics

8. Software Tools for MST Applications and Databanks

9. Aspects of Recycling and Environmental Engineering

10. Micro Materials Special Applications in the Fields of
    - Sensors and Actuator Materials (MEMS, MOEMS, MoMEMS, NEMS, ...)
    - Automotive (Sensors, Airbag, ...)
    - Telecommunication
    - Medical and Biological Products
    - Harsh Environment
    - Consumer Electronics

11. Micro and Nano Materials in Education

During the MicroMat 2004 also the following special event will be held:

Berlin 6M Workshop on Micro Mechatronics – Micro Materials – Micro Mechanics

This workshop of the traditional 6M workshop series will be dedicated to the memoriam of Dr Andreas Schubert, one of the co-founders and co-organizer of MicroMat conference series, who died in 2003.

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O. WITTLER Technical University Berlin, D

CONTACT
Prof. Dr. B. Michel
Fraunhofer IZM, MicroMat 2004 Secretariat
Gustav-Meyer-Allee 25,
D-13355 Berlin, Germany
Phone +49 30 46403 – 200,
Fax +49 30 46403 – 211
e-mail bernd.michel@izm.fraunhofer.de

DATES

30 Sep. 2003	Submission of abstract
15 Dec. 2004	Notification of acceptance
31 Jan. 2004	Preliminary Program and Final Circular

LANGUAGE
The official language of the presentations is English. There is no translation of the presentations.

SPECIAL AWARDS
- Best paper awards (in different topics)
- Best poster award
- Special awards given by sponsoring societies and companies

CONFERENCE PUBLICATIONS
Abstracts will be handed out during the conference. Traditionally the conference proceedings will be published as a book as soon as possible after the conference. Additionally, selected papers will be published in special or regular issues of "Microsystem Technologies" and "Micromaterials and Nanomaterials".

POSTER SESSION
Following the very successfull poster presentations on the previous MicroMat conferences also on MicroMat 2004 special attention will be given to the poster exhibition.

CONFERENCE HOTEL
The new conference hotel NOVOTEL Berlin-Mitte is located in the city center of Berlin near the Potsdamer Platz and the Brandenburger Tor.

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Issue 2 (May 2003)
Micro Materials, Nano Materials for Automotives. (Ed. B. Michel) Abstracts of 50 papers presented at the Conference *"MicroCar 2003 – Micro Materials, Nano Materials for Automotives. Dominating trends and developments for micro and nano materials / micro and nanotechnologies with a focus on automotives and mechanical engineering"* held in Leipzig (D), June 26, 2003.

Issue 3 (August 2003)
Contributions of materials mechanics to electronic packaging.
Volume in memoriam to Dr Andreas Schubert.

Issue 4 (November 2003)
Fraunhofer IZM 1993 – 2003: Ten years excellence in electronic packaging.
Volume on the occasion of the tenth anniversary of IZM.

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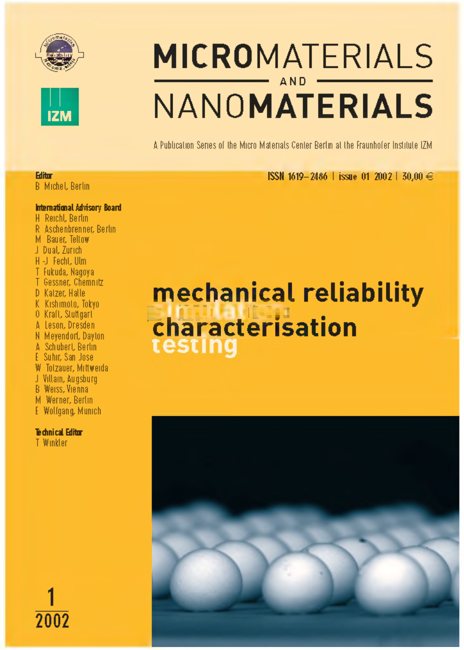

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