

# Sensor Systems

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In 2005 and 2006 several new devices have been designed and realized within the ZMNS for various projects.

To be able to determine corrosive components in engine oils, a novel sensor consisting of thin-film strips (e.g. made of copper), featuring different thicknesses deposited on a glass substrate has been developed in cooperation with the AC<sup>2</sup>T. Over 100 sensors were manufactured and successfully tested.

The thermal conductivity of insulating oil yields important information about the oil's ageing and consequently about the condition of oil-filled high-voltage power transformers. In the frame of a FFF project in cooperation with the Graf Group, thermal conductivity sensors featuring chromium heating elements and germanium thermistors both on closed membrane structures and on spatially separated micro-bridges have been fabricated. The thermal conductivity of transformer oil and several others fluids was determined. The experimental results were implemented in a doctoral thesis and presented in a couple of publications.

In cooperation with TU Delft, a new particle sensor chip has been designed for combined optical and impedance measurements on single cells. Fabrication alternatives for compensation of parasitic substrate coupling have been investigated.

In the course of a "lab-on-chip" project, a silicon-based prototype requiring an external heating for PCR (Polymerase Chain Reaction) has been realized. Further, thin film nano-scale (500 nm conductor path width and 500 nm gap) interdigital electrodes arrays composed of Cr and Au have been realized. The arrays were deposited on thermally oxidized silicon wafers. The usability of the chips for DNA detection is currently investigated in cooperation with ARC-Research.

Miniaturized rheometric devices, featuring in-plane oscillating micromachined silicon nitride bridges which are driven by the Lorentz force, have been designed and fabricated. The micro-bridges have been characterized by means of optical and electrical measurements. The devices show different modes of vibration, suitable for sensing of density and viscosity of liquids. This project is supported by FWF.

A system-capable flow sensor was developed in the course of an FWF project in cooperation with the *Forschungsstelle für Integrierte Sensorsysteme* (Austrian Academy of Sciences). Nine different sensor configurations consisting of thin film germanium thermistors and chromium heaters placed on a 1.3 µm thick silicon nitride membrane (anisotropic etching of Silicon) were designed and manufactured. The properties of the sensor devices are currently investigated.

The research has led to 44 publications in scientific journals and international conference proceedings.

## Research Activities

### Sensors for the Properties of Liquids

- G. Fercher *et al.*: Contactless Conductivity Measurement of Ion Concentrations in Solutions (*page 373*)
- A. Jachimowicz *et al.*: Bridge-Based Microsensor for Determining the Thermal Properties of Liquids (*page 379*)
- C. Riesch *et al.*: Measurement of Liquid Properties with Resonant Cantilevers (*page 385*)

### Particle Sensors

- G. Hairer *et al.*: A Non Coaxial Sheath Flow Device for Micrometer Sample Stream Profiles (*page 391*)
- S. Kostner *et al.*: On-chip Cytometric Detection of Single Biological Cells Using Integrated Photodiodes (*page 397*)
- S. Kostner *et al.*: Particle and Cell Detection using a DVD Pickup Head (*page 401*)

### Biosensors

- G. Hairer *et al.*: PCR Microsystem for Fast Cycling (*page 405*)

### Thermal Flow Sensors

- F. Keplinger *et al.*: Sensitive Measurement of Flow Velocity and Flow Direction Using a Circular Thermistor Array (*page 411*)
- J. Schalko *et al.*: Advanced Thermal Flow Sensors (*page 417*)

## Project Information

### Project Manager

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### Project Group

Last Name	First Name	Status	Remarks
Agoston	Attila	Ph.D. student	
Avian	Jürgen	student	
Beigelbeck	Roman	student	
Cerimovic	Samir	Ph.D. student	
Fercher	Georg	Ph.D. student	
Graschopf	Dieter	student	
Hairer	Gabriel	Ph.D. student	
Jachimowicz	Artur	Senior researcher	
Jakoby	Bernhard	Associate Prof	
Keplinger	Franz	assistant Prof	
Kostner	Stefan	Ph.D. student	Univ. Ass.
Kuntner	Jochen	Ph.D. student	
Pärr	Günther	student	
Pirker	Ewald	technician	
Riesch	Christian	Ph.D. student	
Rogler	Gerhard	technician	
Schalko	Johannes	postdoc	
Stangl	Günther	technician	
Svasek	Edeltraud	technician	
Svasek	Peter	technician	
Talic	Almir	Ph.D. student	
Vellekoop	Michiel J.	full professor	
Zoppel	Sandra	Ph.D. student	

### Books and Contributions to Books

1. J. Nieuwenhuis:  
*"Microsystems for Particle Analysis"*;  
 Institute of Sensors and Actuator Systems, Vienna, Austria, 2005, ISBN: 3-85465-014-0; 103 S.

2. F. Keplinger:  
"Disposable Ion-Selective Electrodes";  
in: "Encyclopedia of Sensors", American Scientific Publishers, 2006, ISBN: 1-58883-058-6, S. 369 - 393.

## Publications in Reviewed Journals

1. A. Agoston, F. Keplinger, B. Jakoby:  
"Evaluation of a vibrating micromachined cantilever sensor for measuring the viscosity of complex organic liquids";  
Sensors and Actuators A, 123-124 (2005), S. 82 - 86.
2. A. Agoston, C. Ötsch, B. Jakoby:  
"Viscosity sensors for engine oil condition monitoring - Application and interpretation of results";  
Sensors and Actuators A, 121 (2005), S. 327 - 332.
3. B. Jakoby, G. Art, J. Bastemeijer:  
"Novel Analog Readout Electronics for Microacoustic Thickness Shear-Mode Sensors";  
IEEE Sensors Journal, 5 (2005), 5; S. 1106 - 1111.
4. B. Jakoby, F.P. Klingner, P. Svasek:  
"A novel microacoustic viscosity sensor providing integrated sample temperature control";  
Sensors and Actuators A, 123-124 (2005), S. 274 - 280.
5. B. Jakoby, M. Vellekoop:  
"Miniaturized Sensors for Monitoring and Physical Chemosensor Applications";  
Geophysical Research Abstracts (GRA), 7 (2005), 07930.
6. F. Keplinger, R. Beigelbeck, R. Fasching, S. Kvasnica:  
"Miniaturized Cantilever Device with a Broad Measurement Area to Determine Two Orthogonal Magnetic Flux Density Components";  
Geophysical Research Abstracts (GRA), 7 (2005), 11086.
7. J. Kuntner, R. Chabicovsky, B. Jakoby:  
"Sensing the thermal conductivity of deteriorated mineral oils using a hot-film microsensors";  
Sensors and Actuators A, 123-124 (2005), S. 397 - 402.
8. J. Kuntner, R. Chabicovsky, F. Kohl, B. Jakoby:  
"Applicability of Thermal Conductivity Sensing for Condition Monitoring";  
Geophysical Research Abstracts (GRA), 7 (2005), 11087.
9. J. Kuntner, G. Stangl, B. Jakoby:  
"Characterizing the Rheological Behavior of Oil-Based Liquids: Microacoustic Sensors Versus Rotational Viscometers";  
IEEE Sensors Journal, 5 (2005), 5; S. 850 - 856.
10. S. Kvasnica, P. Adamek, P. Spatenka:  
"Imaging of Unbalanced Magnetron DC Discharge";  
IEEE Transactions on Plasma Science, 33 (2005), 2; S. 364 - 365.
11. M. Mannsberger, A. Kukovecz, A. Georgakilas, J. Rechthaler, J. Schalko, F. Hasi, G. Allmaier, M. Prato, H. Kuzmany:  
"Thermal Stripping of Supramolecular Structures: C60 Nanorods";  
Journal of Nanoscience and Nanotechnology, 5 (2005), 2; S. 198 - 203.

12. J. Nieuwenhuis, A. Jachimowicz, P. Svasek, M. Vellekoop:  
“*Optimization of Microfluidic Particle Sorters Based on Dielectrophoresis*”;  
IEEE Sensors Journal, 5 (2005), 5; S. 810 - 816. E. Hofer, F. Keplinger, T. Thurner,  
T. Wiener, D. Sanchez-Quintana, v. Climent, G. Plank: “A new floating sensor array  
to detect electric near fields of beating heart preparations”; Biosensors &  
Bioelectronics, 21 (2006), S. 2232 - 2239.
13. N. Kaun, S. Kulka, J. Frank, U. Schade, M. Vellekoop, M. Harasek, B. Lendl:  
“*Towards biochemical reaction monitoring using FT-IR synchrotron radiation*”;  
Analyst, 131 (2006), S. 489 - 494.
14. N. Kaun, M. Vellekoop, B. Lendl:  
“Time-Resolved Fourier Transform Infrared Spectroscopy of Chemical Reactions in  
Solution Using a Focal Plane Array Detector”;  
Applied Spectroscopy, 60 (2006), 11; S. 1273 - 1278.
15. S. Zoppel, M. Farsari, R. Merz, J. Zehetner, G. Stangl, G.A. Reider, C. Fotakis:  
“*Laser micro machining of 3C-SiC single crystals*”;  
Microelectronic Engineering, 83 (2006), S. 1400 - 1402.

## Talks and Poster Presentations

1. A. Agoston, B. Jakoby:  
“*The Monitoring of Mechanical Aging of Engine Oil Using Microacoustic Viscosity  
Sensors*”;  
EUROSENSORS XIX, Barcelona, Spain; 11.09.2005 - 14.09.2005; in: “*Proceedings  
- Vol. 1 (M,T)*”, (2005), ISBN: 84-475-2984-3; 4 pages
2. A. Agoston, C. Ötsch, B. Jakoby:  
“*Application Aspects of Viscosity Sensors for Online Oil Condition Monitoring*”;  
12th International Conference (Sensors 2005), Nuremberg, Germany; 10.05.2005 -  
12.05.2005; in: “*Proceedings Volume I*”, (2005), p. 389 - 392.
3. R. Beigelbeck, F. Kohl, J. Kuntner, B. Jakoby:  
“*Heat Transfer Analysis of Micromachined Thermal Conductivity Sensors*”;  
IEEE International Conference on Emerging Technologies and Factory Automation  
(ETFA), Catania, Italy; 19.09.2005 - 22.09.2005; in: “*Proceedings of the ETFA  
2005*”, (2005), ISBN: 0-7803-9402-X; p. 977 - 983.
4. E. Hofer, F. Keplinger, T. Wiener, T. Thurner, G. Plank:  
“*Neue Sensoren zur Nahfeldmessung und Ermittlung von Mikrolatenzen der  
Erregungsausbreitung*”;  
Biomedizinische Technik, UMIT/Hall; 10.11.2005 - 12.11.2005; in:  
“*Wissenschaftliche Beiträge zur Jahrestagung 2005 - Biomedizinische Technik*”,  
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5. E. Hofer, T. Wiener, T. Thurner, F. Keplinger, P. Svasek, D. Sanchez-Quintana, v.  
Climent, A. Lueger, G. Plank:  
“*Cardiac Near Field Sensors - Technical Requirements and Validation Procedures*”;  
European Medical and Biological Engineering Conference, Prague, Czech Republic;  
20.11.2005 - 25.11.2005; in: “*Proceedings EMBEC '05*”, Vol. 11 (2005), ISSN: 1727-  
1983; 5 pages
6. B. Jakoby, E. Svasek:  
“*Ein miniaturisierter Viskositätssensor mit integrierter Temperierungsmöglichkeit*”;  
7. Dresdner Sensor-Symposium - Neue Herausforderungen und Anwendungen in  
der Sensortechnik, Dresden, D; 12.12.2005 - 14.12.2005; in: “*Tagungsband 7.  
Dresdner Sensor-Symposium*”, (2005), ISBN: 3-938863-29-3; p. 77 - 80.

7. F. Keplinger, R. Beigelbeck, H. Hauser:  
"Measurement of Two Orthogonal magnetic Flux Density Components with a Single Oscillating U-Shaped Micromachined Cantilever";  
12th International Conference (Sensors 2005), Nuremberg, Germany; 10.05.2005 - 12.05.2005; in: "Proceedings Volume I - Sensor 2005", (2005), p. 131 - 135.
8. F. Keplinger, R. Beigelbeck, F. Kohl, S. Kvasnica, A. Jachimowicz, B. Jakoby:  
"Frequency and Transient Analysis of Micromachined U-Shaped Cantilever Devices for Magnetic Field Measurement";  
13th European Conference on Solid-State Sensors, Actuators and Microsystems, Seoul, Korea; 05.06.2005 - 09.06.2005; in: "Digest of Technical Papers", (2005), ISBN: 0-7803-8994-8; p. 630 - 635.
9. F. Kohl, R. Beigelbeck, J. Schalko, A. Jachimowicz:  
"Towards System-Ready Flow Sensors";  
IEEE International Conference on Emerging Technologies and Factory Automation (ETFA), Catania, Italy; 19.09.2005 - 22.09.2005; in: "Proceedings of the ETFA 2005", (2005), ISBN: 0-7803-9402-X; p. 959 - 966.
10. S. Kostner, J. Nieuwenhuis, M. Vellekoop:  
"DEP Particle Separator with Adaptive Sensitivity";  
12th International Conference (Sensors 2005), Nuremberg, Germany; 10.05.2005 - 12.05.2005; in: "SENSOR 2005, 12th international Conference", Proceedings Volume I (2005), p. 261 - 265.
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"Online Oil condition Monitoring Using Thermal Conductivity Sensing";  
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12. J. Kuntner, F. Kohl, B. Jakoby:  
"Characterizing the Thermal Transport Properties of Liquids Using a Miniaturized Pulsed Hot-Film Sensor";  
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"Micromachined thermal conductivity sensor for the liquid phase";  
13th International Conference on Solid-State Sensors, Actuators and Microsystems (Transducers 05), Seoul, Korea; 05.06.2005 - 09.06.2005; in: "Digest of Technical Papers - Volume 2", (2005), ISBN: 0-7803-8952-2; p. 571 - 574.
14. M. Vellekoop:  
"Micro-Devices for Particle Detection and Analysis";  
Annual Workshop on Semiconductor Advances for Future Electronics and Sensors, Veldhoven, Netherlands (invited); 17.11.2005 - 18.11.2005; in: "Proceedings SAFE 2005", M. Vellekoop (Hrg.); Technology Foundation SAFE & ProRISC, (2005), ISBN: 90-73461-50-2; 1 page
15. M. Vellekoop, S. Kostner, J. Nieuwenhuis:  
"On-chip particle analysis";  
7. Dresdner Sensor-Symposium - Neue Herausforderungen und Anwendungen in der Sensortechnik, Dresden, D; 12.12.2005 - 14.12.2005; in: "Tagungsband 7. Dresdner Sensor-Symposium", (2005), ISBN: 3-938863-29-3; p. 57 - 60.
16. R. Beigelbeck, J. Kuntner, F. Kohl, B. Jakoby:  
"Sensing Thermal Material"; EUROSENSORS XX, Göteborg, Schweden;  
17.09.2006 - 20.09.2006; in: "Proceedings EUROSENSORS 2006", Vol. II (2006), ISBN: 91-631-9280-2; p. 242 - 243.

17. Hairer, M. Vellekoop:  
“*Experiments on Hydrodynamic Focusing of Non-coaxial Sheath Flows*”; IEEE Sensors, Daegu, Korea; 22.10.2006 - 25.10.2006; in: “*Abstract Book IEEE Sensors 2006*”, (2006), p. 123.
18. F. Keplinger, J. Kuntner, A. Jachimowicz, F. Kohl, B. Jakoby:  
“*Highly Sensitive Sensor for Flow Velocity and Flow Direction Measure*”; IEEE Sensors, Daegu, Korea; 22.10.2006 - 25.10.2006; in: “*Abstract Book - IEEE Sensors 2006*”, (2006), p. 398.
19. F. Kohl, R. Beigelbeck, P. Loschmidt, J. Kuntner, A. Jachimowicz:  
“*FEM-Based Analysis of Micromachined Calorimetric Flow Sensors*”; IEEE Sensors, Daegu, Korea; 22.10.2006 - 25.10.2006; in: “*Abstract Book - IEEE Sensors 2006*”, (2006), p. 337.
20. F. Kohl, F. Keplinger, R. Beigelbeck, J. Kuntner, J. Schalko, A. Jachimowicz:  
“*Refined Thermal Flow Sensors by Transduction Engineering*”; EUROSENSORS XX, Göteborg, Schweden; 17.09.2006 - 20.09.2006; in: “*Proceedings EUROSENSORS 2006*”, Vol. II (2006), ISBN: 91-631-9280-2; p. 186 - 187.
21. S. Kostner, M. Vellekoop:  
“*Optical Detection of Different Single Biological Cells in an Integrated Projection Cytometer*”; IEEE Sensors, Daegu, Korea; 22.10.2006 - 25.10.2006; in: “*Abstract Book IEEE Sensors 2006*”, (2006), p. 36.
22. J. Kuntner, A. Jachimowicz, F. Kohl, B. Jakoby:  
“*Determining the thin-film thermal conductivity of low temperature PECVD silicon nitride*”; EUROSENSORS XX, Göteborg, Schweden; 17.09.2006 - 20.09.2006; in: “*Proceedings EUROSENSORS 2006*”, Vol. II (2006), ISBN: 91-631-9280-2; p. 388 - 389.
23. J. Kuntner, A. Jachimowicz, F. Kohl, B. Jakoby:  
“*Determining thermal properties of liquids: membrane-based versus bridge-based micromachined sensors*”; IEEE Sensors, Daegu, Korea; 22.10.2006 - 25.10.2006; in: “*Abstract Book - IEEE Sensors 2006*”, (2006), p. 391.
24. E. Reichel, Ch. Riesch, A. Jachimowicz, B. Weiß, B. Jakoby:  
“*A Novel Micromachined Liquid Property Sensor Utilizing a Doubly Clamped Vibrating Beam*”; EUROSENSORS XX, Göteborg, Schweden; 17.09.2006 - 20.09.2006; in: “*Proceedings EUROSENSORS 2006*”, Vol. I (2006), ISBN: 91-631-9281-0; p. 114 - 115.
25. Ch. Riesch, E. Reichel, F. Keplinger, B. Jakoby:  
“*Characterizing Resonating Cantilevers for Liquid Property Sensing*”; IEEE Sensors, Daegu, Korea; 22.10.2006 - 25.10.2006; in: “*Abstract Book - IEEE Sensors 2006*”, (2006), p. 293.
26. C.P.L. Van Vroonhoven, D. Rocha Wiese Meneses, M. Vellekoop, C. Nöhammer:  
“*A Readout Circuit for Capacitive Biosensors with Integrated SAR A/D Conversion*”; IEEE International Symposium on Circuits and Systems, Island of Kos, Greece; 21.05.2006 - 24.05.2006; in: “*Proceedings*”, (2006), ISBN: 0-7803-9390-2; p. 1418 - 1421.
27. M. Vellekoop, S. Kostner:  
“*On-Chip Cell Handling and Analysis*”; EUROSENSORS XX, Göteborg, Sweden (invited); 17.09.2006 - 20.09.2006; in: “*Proceedings Euroensors 2006*”, Vol. I (2006), ISBN: 91-631-9280-2; p. 28 - 29.

## Patents

1. F. Keplinger, R. Beigelbeck:  
“*Elektrodeneinrichtung zur Messung eines elektrischen Potentials*”;  
Patent: Österreich, Nr. A 858/2005; submitted: 19.05.2005.
2. F. Keplinger, H. Hauser, S. Kvasnica:  
“*Verfahren zur Messung starker Magnetfelder und Sensor zur Ausführung des Verfahrens*”;  
Patent: Austria, Nr. AT 413 448 B; submitted: 04.10.2002, granted: 15.02.2006.

## Doctor's Theses

1. J. Nieuwenhuis:  
“*Microsystems for particle analysis*”;  
Reviewer: M. Vellekoop, P. Telleman; Institut für Sensor- und Aktuatorssysteme, 2005.

## Diploma Theses

1. T. Lindenbauer:  
“*Seminumerische Analyse von piezoelektrischen TSM Quarzresonatoren in viskosen Flüssigkeiten*”;  
Supervisor: B. Jakoby; Institut für Sensor- und Aktuatorssysteme, 2005.
2. Ch. Riesch:  
“*Auswertelektronik für einen Schwingquarz-Viskositätssensor mit Kompensation der parasitären Komponenten*”;  
Supervisor: B. Jakoby; Institut für Sensor- und Aktuatorssysteme, 2005.

## Cooperations

1. AC2T, Wiener Neustadt, F. Franek
2. AMS Unterpremstätten, M. Brandl, F. Schrank
3. ARC Seibersdorf, H. Kroath, C. Nöhammer
4. IMS, E. Fantner, H. Löschner
5. EVG, Schärding, Lind, J. Weixlberger
6. Jenbacher, Jenbach, S. Chvatal
7. OMV, Wien, F. Novotny-Farkas
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9. R. Bosch, Stuttgart, Germany, H. Eisenschmidt
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11. Applikon, the Netherlands, A. Oudshoorn
12. National Center for Scientific Research, Demokritos, Athens, Greece, D. Ithakissios
13. National Hellenic Research Foundation, Athens, Greece, I. Siotis
14. TU Wien, B. Lendl, E. Benes
15. Universität für Bodenkultur Wien, U. Sleytr, D. Pum, B. Schuster



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18. Universität Krems, D. Falkenhagen
19. ÖAW Forschungstelle Integrated Sensor Systems, T. Sauter, F. Kohl
20. TU Delft, The Netherlands, A. Bossche, C. Dekker, P.J. French, I.T. Young
21. ETH Zürich (CH), Ch. Hierold, A. Hierlemann
22. University of Freiburg, IMTEK, Germany, G. Urban, J. Korvink, O. Paul.
23. University of Technology Berlin, Germany, E. Obermeier
24. University Leuven, Belgium, C. Kirschhock