EIW-10: Thermal Microsensors

The idea of organizing a Europhysics Industrial Workshop devoted to thermal microsensors was born at the Institute for Physical High Technology (IPHT), the former Physical-Technical Institute of the east German Academy of Sciences, were thermal sensors group was both active for many years. It was taken up by other groups working in the field, notably those at the Swiss Federal Institute of Technology (ETH) in Zurich and at Heimann Optoelectronics GmbH in Wiesbaden, both of which agreed to join the workshop's Organizing Committee, chaired by J. Müller and U. Dillner providing considerable support.

The workshop aimed to bring together scientists from industry and from research institutions for an informal discussion of the state-of-the-art and developments in order to promote a wider industrial application of thermal microsensors. The current trend towards developing new, cost-effective micro-mechanical technologies (e.g., CMOS-compatible) for manufacturing thermal microsensors was seen as an essential topic. The workshop was therefore of special interest to companies which envisage or foresee the manufacture and application of the various types of thermal microsensors.

There were invited review talks on physical principles (A.W. van Herwaarden, Xensor Integration BV, Delft), the thermoelectric efficiency of bulk and thin-film materials (F. Völklein, Fachhochschule Wiesbaden), CMOS and micromachining for thermal sensors (H. Baltes, ETH, Zurich), and the applications of thermal microsensors (J. Schifferdecker, Heimann Optoelectronics GmbH, Wiesbaden, Germany). A round-table discussion and short contributions presented by 27 of the 52 participants, who came from Belgium, France, Germany, The Netherlands, Russia, Switzerland, the Ukraine, the UK, and the USA, completed the scientific programme. The ample opportunity for discussions and the secluded but attractive venue (a holiday hotel in Oberhof, a health resort in the Thuringian Forest) clearly helped promote a stronger collaboration between fundamental research and industry in the field of thermal microsensors.

1. Much effort will be spent in evaluating important material properties (thermal conductivity, heat capacity, emissivity, etc.) of the functional layers of thermal microsensors and their dependence on thickness and on quantities which are clearly influenced by the manufacturing technology (e.g., doping concentrations and grain size and other structural parameters). This will lead to more realistic thermal simulations for sensor optimization since the results of such calculations (see cover illustration) depend strongly on the quality of input parameters.

2. The potential of thin-film technologies (e.g., as nanostructured films, quantum wells, superlattices) to improve the thermoelectric efficiency of sensor materials will be studied.

3. The development of thermal microsensor arrays and of multisensing chip configurations will be intensified (an example of the latter is the ETH Zurich group's building control chip shown in Fig. 1d).

4. Micromachined free-standing micro-thermopiles consisting of thin wires and showing very fast response times (less than 20 µs) will be improved. The aim is to fabricate the sensors as planar arrays.

5. Technological solutions such as SIMOX wafers, CMOS-compatible infra-red absorbers and porous-silicon technology will be introduced into thermal microsensors.

6. Thermal sensing principles will be employed in designing new chemosensors and biosensors. The arrangement of small drops on thin-film membranes is promising for both microanalytical applications and microcalorimetry as well as for monitoring chemical reactions in small volumes. For instance, recent experiments at the IPHT, Jena, have shown that salt concentrations in solutions can be measured by monitoring chemical reactions in droplets supported on a thermopile of the type shown in Fig. 1c.

7. Research dealing with the reliability of thermal microsensors will be intensified since the reliability issue is crucial for the industrial acceptance of new sensor devices.

J. Müller, U. Dillner, IPHT, Jena
The IPHT's Beutenberg complex photographed earlier this year. The soon to be completed clean-room facility is the last building on the left.

Jena, one of the two rival Zeiss companies, employed 27,000 in Jena alone. The State of Thuringia oversaw restructuring and transformation of the combined into Jenoptik and Jena-Optronik. It also provided significant investment, with the two companies and their continuous offshoots becoming important nuclei, along with Jena's Friedrich-Schiller University and several distinguished institutes such as the PTI itself, recreated as the Institute for Physical High Technology (IPHT), the Hans-Kroll Institute for Research on Biomaterials, the Institute for Molecular Biology, and the Fraunhofer Institute for Applied Optics and Fine Mechanics. Several of the institutes consolidated all or part of their activities to the Beutenberg science park on the outskirts of Jena that has become a principle focus for revived industry and research activities.

The PTI, which was well known for its work in plasma physics, magnetic materials, glass-fibre optics, and infrared sensors, had some 300 staff members at reunification. The plan is to stabilise the number at around 150, including 90 permanent positions with a significant number of temporary posts to provide flexibility and training opportunities (things that tended to be lacking in the past). Managing the transition remains difficult for most of today's approximately 180 staff members hold temporary positions, with funds for 50 of the 140 posts covered by Thuringia due to end within the next two years. Some two-thirds of the IPHT's annual operating budget (28 MDM in 1993 including about 10 MDM for capital investment) presently comes from Thuringia, while the federal government supports through its research ministry — the BMFT — some 7 MDM of regular project funding. A further 1.5 MDM come from industrial contracts, mostly carried out in consortia. Expansion of the project work, including European Union projects, is vital, and the ground is being prepared for this. Major new investments include refurbishment of the institute and a new, almost completed, 15 MDM clean room equipped for circuit design, pattern generation and microfabrication, testing, and materials characterisation.

The first Round Encouraging

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It appeared in the early 1980's that collisions of relativistic heavy ions in existing accelerators would most likely give the energy densities required for the formation of the elusive quark-gluon plasma. Moreover, data-taking involving the hundreds of secondary events produced in a single collision event was shrouded by a pre-equilibrium partonic phase and subsequent hadronic rescattering. A decade of intense theoretical work has sought signals that might pin down the transient plasma and its phase transition. Two approaches have emerged, based on looking either at features established during the initial phase or at hadrons produced in the later stages.

First Round Starts

CERN proposed in 1988 a second round of fixed-target experiments got underway using medium-sized ions (S, Si) accelerated to centre-of-mass energies per nucleon of 20 GeV at CERN and of 5 GeV at the Brookhaven National Laboratory (BNL), USA. The energy densities sought were attained and there have been encouraging signals that some thermalization seems to be taking place; nucleus-nucleus collisions cannot simply be considered as more superpositions of nucleon-nucleon collisions. There is no doubt that a new state of matter is created, with a density 10-times that of hadronic matter. But one does not yet know if there is a phase transition between two very different forms of dense matter, as expected by QCD.