8ste FirW Doctoraatssymposium

Papers 2006

Mechanics

001 *Design of composite material for cost effective large scale production of components for floating offshore structures*
Chris Blommaert

002 *Characterization of refrigerant two-phase flow for air-conditioning applications*
Hugo Canière

003 *Humidity control by solar heated desiccant wheel in Cuba*
Tania Carbonell Morales

004 *Optical fibres and electrical resistance measurement for in-situ monitoring of composite fatigue*
Ives De Baere, Wim Van Paepegem and Joris Degrieck

005 *Damage behaviour of composite systems under biaxial fatigue loading*
Ebrahim Lamkanfi and Wim Van Paepegem

006 *Forces, Moments and Motions Induced by the Vicinity of Banks on a Sailing Vessel*
Evert Lataire

007 *Mechanical properties, microstructure and IASCC susceptibility of Stainless Steels with different SFE*
Xiaoqiang Li, A. Al Mazouzi and P. Verleysen

008 *Experimental characterisation of the impact behaviour of fibre reinforced thermoplastics for aerospace applications*
Alexander Moentjens, Joris Degrieck and Wim Van Paepegem

009 *Vibration reduction using dynamic absorbers*
Frits Petit, Mia Loccufier and Dirk Aeyels

010 *A comparative economical analysis of different methods to size cogeneration plant*
Julio Vaillant Rebollar

011 *Coupling CFD with a pyrolysis model as tool for fire engineering*
Karim Van Maele

012 *Development of high-performance artificial turf for soccer applications*
Rudy Verhelst

Applied Physics

013 *Plasma technology for surface engineering and biomedical applications*
Alec De Kuyper

014 *Comparison of quantification and image degrading factors for different iodine isotopes (I-123, I-124 and I-131)*
Erwann Rault, Stefaan Vandenberghe, Roel Van Holen, Jan De Beenhouwer and Ignace Lemahieu

015 *Performance of tungsten materials under ITER relevant thermal loads*
Inge Uytdenhouwen, Guido Van Oost, Marc Decréton and Jochen Linke

016 *Mn-doped zinc silicate thin films made with sol-gel technology for electroluminescent displays.*
Karel Vanbesien, Philippe Smet, Dirk Poelman and Patrick De Visschere

Photonics

017 *All-optical flip-flop employing a DFB-SOA optical*
Wouter D'Oosterlinck

Biomedical Engineering

035 *Co-recording of EEG and fMRI data: EEG artifact removal*
Assecondi Sara

036 *Numerical Assessment of the Influence of a Flow Wire on its Measured Maximum Velocity*
Wim Hillewaert, Piet Claus, Guy Mareels, Pascal Verdonck, Paul Devos and Patrick Segers

037 *Challenges in realizing vascular fluid-structure-interaction using Fluent and Abaqus software*
Lieve Lanoye, Jan Vierendeels, Patrick Segers and Pascal Verdonck

038 *Assessment of strategies to improve oxygen availability in the AMC bioartificial liver using CFD*
Guy Mareels, Paul P. C. Poyck, Sunny Eloot, Robert A. F. M. Chamuleau and Pascal Verdonck

Chemical Engineering

039 *Ab initio modeling of the oxidation of hydrocarbons over metal oxide catalysts*
Konstantinos Alexopoulos

040 *Single Event Microkinetic Modeling for Hydroprocessing of n-alkanes: Role of catalyst descriptor in optimizing shape selective catalyst design*
I. Roy Choudhury, Joris W. Thybaut and Guy B. Marin

041 *Catalytic Reaction Network Elucidation from Noisy Transient Kinetic Data*
Raf Roelant

042 *Kinetic Modeling of steam cracking*
Maarten K. Sabbe

043 *Single event microkinetics of hydrocarbon cracking on acid catalysts*
Rhona Van Borm

044 *Fundamental kinetic model for the suspension polymerization of vinyl chloride*
Joris Wieme

Material Sciences

045 *On the formation of Cr-rich precipitates in FeCr*
Giovanni Bonny, Dmitri Terentyev and Lorenzo Malerba

046 *Behaviour and modelling of multiphase TRIP steels*
J. Bouquerel and J. Van Slycken

047 *Simulation of the weft insertion on airjet and rapier looms*
Simon De Meulemeester

048 *Design of textile antennas for smart clothing*
Carla Hertleer, Hendrik Rogier and Lieva Van Langenhove

049 *Advanced experimental techniques for the comprehension of hardening and embrittlement mechanisms in RPV-steels*
Marlies Lambrecht, A. Al Mazouzi and Yvan Houbaert

050 *Microstructure and mechanical properties of n-irradiated Fe-Cr model alloys and steels*
Milena Matijasevic, A. Al Mazouzi and Patricia Verleysen

051 *ADS-candidate materials compatibility with Pb-Bi in n-irradiation environment*
Joris Van den Bosch, A. Al Mazouzi and Joris Degrieck

Electronics

052 *Fabrication of Elastic Electronic Circuits*
Dominique Brosteaux

053 *FPGA Architectures for Fast Circuit Compilation*
Karel Bruneel

054 *Improvement of copper adhesion by chemical modification of epoxy surfaces*
Bert De Roo, Alfons Vervaet, Etienne Schacht, An Gielen, Johan De Baets and André Van Calster

055 *Synthesis of reversible circuits*
Yvan Van Rentergem and Alexis De Vos

056 *Dynamic thermal simulation and modelling of micro- and nano-electronics*
Bjorn Vermeersch

Software

057 *Advanced Techniques for Automated Linux Kernel Memory Footprint Reduction*
Dominique Chanet

058 *Analysis of Runtime Implementation Switching in OSGi Based Applications*
Raf Hens

059 *Performance estimation of applications using microarchitecture-independent characteristics*
Kenneth Hoste, Lieven Eeckhout and Koen De Bosschere

060 *Information Systems on Mathematical Foundations - Turning Software Development into Software Engineering*
David Matthys

Communication Technology

061 *Dimensioning of IP Networks for Transport of Unicast/Multicast TV Channels*
Zlatka Avramova, Sabine Wittevrongel, Herwig Bruneel and Danny De Vleeschauwer

062 *Hybrid Optical Switching as an Enabling Technology for Next Generation Service Grids*
Jurgen Baert, Marc De Leenheer, Chris Develder, Bart Dhoedt, Filip De Turck and Piet Demeester

063 *Cross-layer Architecture and Optimizations in Hybrid Wireless Mesh Networks*
Stefan Bouckaert, Ingrid Moerman and Piet Demeester

064 *Burst-mode Receivers for Long-reach Amplified Optical Networks at 10 Gbit/s*
Tine De Ridder, Peter Ossieur, Xing-Zhi Qiu and Jan Vandewege

065 *Predicting the Performance of Reconfigurable Interconnects in Shared-Memory Systems*
Wim Heirman, Joni Dambre and Jan Van Campenhout

066 *Micromobility Support and Resource Reservations in IP-based Access Networks*
Liesbeth Peters

067 *Resilience in all-optical label switching networks: a node dimensioning point of view*
Ruth Van Caenegem, Didier Colle, Mario Pickavet and Piet Demeester

068 *Data-aided channel estimation in a multipath fading environment*
Dieter Van Welden

Information Technology

069 *Optical Interconnects embedded in flexible substrates*
Erwin Bosman, Wim Christiaens, Peter Geerinck, Geert Van Steenberge,

Jan Vanfleteren and Peter Van Daele

070 *A Framework for Parallel Event Driven Simulation of Large Spiking Neural Networks*

Michiel D'Haene

071 *Broadband over Powerline*

Els De Backer, Johan Bauwelinck, Xing-Zhi Qiu and Jan Vandewege

072 *Video Shot Detection on H.264/AVC Compressed Bitstreams Using Temporal Prediction Types*

Sarah De Bruyne

073 *Requantization techniques for H.264/AVC rate reduction transcoding*

Jan De Cock and Stijn Notebaert

074 *Increasing the efficiency of beam tracing for noise mapping*

Bram de Greve

075 *Performance Analysis of Retransmission Protocols in a Wireless Environment*

Koen De Turck

076 *Towards an end-to-end QoS enabled overlay multicast platform*

Bart De Vleeschauwer

077 *Applying unequal error protection in H.264 by means of flexible macroblock ordering*

Yves Dhondt

078 *Parallel Multilevel Fast Multipole Algorithm for GRID computing allowing Full-Wave Electromagnetic Simulations*

Jan Fostier and Femke Olyslager

079 *Workload reduction for multiprogrammed workloads running on multithreaded processors*

Filip Hellebaut

080 *Halftoning with Grid Diffusion*

Stefaan Lippens and Wilfried Philips

081 *Digital Reconstruction Of Degraded Low Resolution Images*

Hi Luong and Wilfried Philips

082 *Data partitioning in H.264/AVC: a performance evaluation*

Stefaan Mys and Rik Van de Walle

083 *Quality assessment of MPEG-2 to H.264/AVC intra transcoding architectures*

Stijn Notebaert and Jan De Cock

084 *Motion Compensation and Reconstruction of H.264/AVC-coded Pictures using the GPU*

Bart Pieters, Dieter Van Rijsselbergen and Wesley De Neve

085 *Robust moving object detection in video surveillance applications*

Chris Poppe

086 *Intersubband Error Concealment for Subband Coded Images*

Joost Rombaut and Wilfried Philips

087 *Function Level Parallelsim Lead by Data Dependencies*

Sean Rul and Hans Vandierendonck

088 *Anycast Routing Algorithms for Effective Job Scheduling in Optical Grids*

Tim Stevens and Marc De Leenheer

089 *Phonological Features for Automatic Speech Recognition*

Frederik Stouten

090 *Characterizing the industrial wireless channel at practical frequencies*

Emmeric Tanghe, Wout Joseph and Luc Martens

091 *An exact 2.5D BiCGS-FFT forward solver to model electromagnetic scattering in an active millimeter wave imaging system*

Sara Van den Bulcke and Ann Franchois

Optical interconnections embedded in flexible substrates

Erwin Bosman

Supervisor(s): Prof. Dr. Ir. Peter Van Daele (1), Prof. Dr. Ir. Jan Vanfleteren (2)
(1) Ghent University – Department INTEC, (2) Ghent University – Department ELIS
TFCG-Microsystems, Technologiepark Building 914A, 9052 Zwijnaarde

Abstract— **Optical data transmission has become the obvious choice for communication over long distances, but new trends force the designers to use optical interconnections also to bridge short distances. This results in the integration of these interconnections on the printed circuit boards. Flexible substrates have the extra advantage of being lighter, more reliable and assembly-friendly and are therefore becoming increasingly important.**

This paper combines both trends by embedding optical waveguides, interconnections and opto-electronic chips in flexible substrates. These optical structures are stacked between two Polyimide layers, which increases the mechanical stability and the reliability. Different optical materials have been studied (Truemode™ Backplane Polymer, Ormocer® and Epoxies) as well as different techniques for applying the Polyimide layers (spin-coating and lamination).

Ongoing research focuses on the embedding of opto-electronic components, the electronic assembly on top of the Polyimide layers and the mechanical- and optical characterization of the flexible structure.

***Keywords*— flexible, interconnection, Optical, Polyimide, waveguide**

I. Introduction

The ever increasing telecommunication sector results in a continuously growing demand for higher communication speeds and data-rates, forcing the step towards optical data transmission. This step is already established for long distance communication, but the increasing density and integration of electronic components on boards forces the market to integrate optical interconnections on the boards.

Together with this trend, the demand for flexible substrates for electronic applications has doubled in the last 5 years [1]. Because of their flexible behavior, the use of these substrates can significantly lower the over-all substrate thickness and weight. Moreover they can ease the assembly, increase the module compactness and can be applied to a curved surface, and even to a dynamic one.

Both increasing trends and needs will result in applications which combine the advantages of optical interconnections and flexible substrate technologies.

This paper focuses on the fabrication of flexible substrates with embedded active opto-electronic components and passive optical interconnections based on multimode waveguides, 45˚-turning mirrors and aligning structures. Different commercially available optical materials were studied, and both a Polyimide foil and a spin-coated Polyimide film is used as flexible substrate. The definition of the optical waveguides, micro-mirrors and aligning structures is done by photolithography and laser ablation. Later on, the fabrication of a proof-of-principal demonstrator is intended, in means of a functional alone-standing opto-electrical flexible module.

II. Materials

The material for the optical transmission medium needs to show low light propagation losses for the common wavelengths for data communication (850 nm) and telecommunication (1.3 or 1.55 µm) and must have the right properties in means of UV-crosslinking ability, spin-coating, temperature- and chemical resistance and mechanical brittleness. Special care must be taken to ensure the compatibility of the material with standard flexible PCB production processes.

Truemode Backplane™ Polymer [2], Ormocer® [3] and Epocore are materials which meet these requirements and have shown good results when applied on rigid substrates in the past [5].

The material for the flexible substrate itself is Polyimide (PI) which is the dominant material in the flexible circuits industry because of its good electrical, chemical, temperature and mechanical behavior [4]. Precautionary steps had to be taken to assure the adhesion of the PI with the optical materials because of the chemical inertness of Polyimide (PI).

III. Stacking of optical- and Polyimide-layers

The creation of waveguides consists of the stacking of an undercladding,-, core- and uppercladding layer by spin-coating. The optical materials are however not flexible and strong enough to be bended without cracking or damaging. Therefore these layers are sandwiched between two spin-coated Polyimide layers, one at the top and one at the bottom, which absorb all stress and pressure during bending, protecting the inner optical layers from breaking.

Stacking of materials with such a different chemical and mechanical behavior demands special measures like CTE (Coefficient of Thermal Expansion) matching to avoid curling and bad adhesion, and low cure-temperatures for the PI to protect the layers underneath from reaching their glass transition temperature.

As an alternative way to fabricate the stack, lamination of the optical layers between prefabricated commercially available PI-foil was proposed and studied. This method has the advantage that the PI-foil and the optical layers can be handled and cured separately since the lamination step is one of the last steps in the process flow. A semi cured adhesive, fixed on a ceramic substrate by dubbelsided tape is used as a carrier for the spincoating of the optical layers and acts as a release layer later in the process by peeling of this adhesive.

When creating the stack special care must be taken to ensure no outgassing of remaining solvents in underlying layers appears during cure steps.

IV. Fabrication of Passive Optical Interconnections

A. *Fabrication of optical waveguides*

Creating a core transmission channel, isolated inside a bulk cladding material with a lower refractive index results in an optical waveguide which captures the light due to total internal reflection.

This isolation can be done by patterning the core-layer with a standard photolithographic process with selective exposure of the waveguides to UV-light and in an alternative way by laser ablation, removing the core-material at both sides of the waveguide.

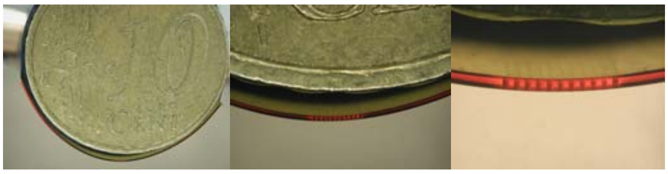

Figure 1 Complete stack with laser ablated waveguides in Truemode Backplane™ Polymer, using a 248 nm wavelength Kr-F Excimer laser, bended with radius 1cm.

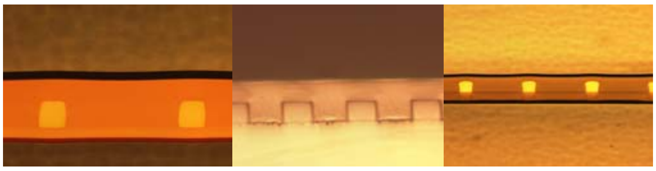

Figure 2 Complete stack with photolithographic waveguides in *left:* Ormocer®, *middle:* Epocore (on FR4-material) and *right:* Truemode™

B. *Fabrication of 45 degrees out of plane turning mirror*

The data-carrying light can be vertically coupled in- and out of the waveguides with 45 degrees out of plane deflecting micro-mirrors, terminating the waveguides and connecting them with laser diodes, receivers, optical fibers, open air or optical elements. These mirrors are realized by laserablation with a Kr-F Excimerlaser (248 nm wavelength) [5].

C. *Fabrication of alignment structures for a proof-of-principle demonstrator*

This research not only focuses on the optical assembly of flexible circuits but the combination of optical and electronic assembly on the same module. This means that the positioning of the VCSEL's and receivers on one hand and optical fiber-arrays, optical elements and deflecting micro-mirrors on the other hand is crucial. Alignment structures like alignation holes, mechanical stand-offs and fiducials are therefore needed and fabricated using the laser ablation technique .

A proof-of-principle demonstrator will be fabricated in the future, including all the elements which have been discussed in this paper to create a standalone flexible module with embedded optical interconnections and electrical assembly on top of the Polyimide.

V. Embedding of Active Optoelectronic Devices

Experiments have been done with success to embed ultra thin dummy chips into the optical layers by implementing a cavity with photolithography. Later in the research functional opto-electronic chips, thinned down to 30 µm thickness [6], will be embedded. Micro-via's will be ablated using a frequency tripled Nd:YAG laser (355 nm wavelenght) and metallized by sputtering and plating to fan out the contacts on the top PI layer where all other electrical assembly can be done with standard flex assembly processes. The optical layers have proven to stand the temperature cycles during these processes.

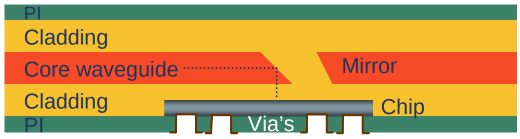

Figure 3 Schematic representation of the embedding, alignment and electrical connection of active components and waveguides in the optical layers.

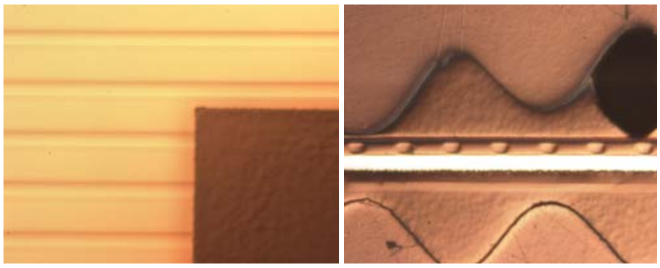

Figure 4 Embedded 5x5 cm^2 dummy chip and waveguides in Ormocer® material. *Left:* Top view ; *Right:* Cross section.

VI. Conclusion

The increasing need for flexible modules and the integration of photonics on boards results in a challenging and competitive research which combines both needs by embedding passive optical interconnections and active optoelectronic devices on flexible Polyimide substrates.

A complete autonomous opto-electrical and flexible module will be demonstrated.

References

[1] www.bpaconsulting.com

[2] www.exxelis.com Truemode Backplane™ Polymer data sheets

[3] http://www.microresist.de Ormocer® material datasheets

[4] Joseph Fjelstad, "An engineer's guide to flexible circuit technology", Elektromechanical Publications LTD, 1997

[5] G. Van Steenberge, N. Hendrickx, E. Bosman, J. Van Erps, H. Thienpont, P. Van Daele "Laser Ablation of Parallel Interconnect Waveguides", IEEE Photonics Technology Letters, Vol. 18, No. 9, May 2006.

[6] W. Christiaens, M. Feil, T. Loeher, J. Vanfleteren, "Embedded ultra-thin Chips in Flex", Proceedings of Forum for Flexible Electronic Systems, Munich, November 2005.