Project III. 5: CIRCUITS and DEVICES for OPTOELECTRONIC INTERCONNECTIONS

Project leader: G. Halkias

Other key researchers: S. G. Katsafouros PhD candidates: K. Minoglou M. Sc. student: V. Grivas External collaborators: E. Kyriakis-Bitzaros

Projects Running:

- E.U. IST PICMOS
- ESA, "Multigigabit Optical Backplane Interconnections"
- GSRT, MILI-A

Goals- Basic results:

The general goal of the project is the development of the necessary technologies for the future high-density and high-speed optoelectronic interconnections. A recent parallel goal of the project is the successful implementation of optoelectronic technologies in spacecraft environment.

a) Development of a model for the simulation of Vertical Cavity Surface Emitting Lasers (VCSELs) and circuit topologies for the efficient driving of the device

A compact non-linear circuit model for the input of packaged high-speed VCSELs is presented. The model includes the thermal effects as well as the parasitics, due to the various levels of the packaging hierarchy, to ensure a realistic representation of the input of the VCSELs. The values of the model parameters are extracted from dc current-light-voltage characteristics and S_{11} vector measurements using a two-step parameter extraction procedure. Extraction of the model parameters and comparison between measured and simulated results have been performed for two different commercially available VCSELs operating at 2.5Gb/s. The achieved agreement between the measured and simulated results for the S_{11} curves in the frequency range from 3MHz to 3GHz.



Fig. III.4.1: Measured and simulated VCSEL S₁₁ parameter

b) Multigigabit optical backplane for space applications

In this activity an optical backplane, able to function at multigigabit speeds, is studied and will be fabricated using space worthy Wavelength Division Multiplexing technologies. The project is executed in collaboration with IMEC (Belgium) and Intune Technologies Ltd (Ireland). The objectives of the program are demonstrated by a system depicted schematically in *fig. III.4.2*. It consists of 4 nodes connected by an optical backplane. Two nodes have transmitting and receiving capability, while the other two can only receive so as to limit the number of lasers needed for the demonstrator. The system basically consists of three parts: the wavelength router, the transponders and the nodes generating or receiving data and implementing the control plane. Additionally, deciding which connections to set up, switching and monitoring of the backplane are controlled by a PC. Our main involvement in this project is the design and implementation, in a high-speed FPGA, of the backplane control unit as well as the real-time pseudo-random data generation and Bit-Error-Rate (BER) measurement capability for system evaluation and testing.



Fig. III.4.2: Block diagram of the multigigabit optical backplane

c)

Heterogeneous integration of optical interconnections onto CMOS ICs

In this activity various methods for the heterogeneous integration of active optoelectronic devices (microlasers, photodiodes in III-V semiconductors) along with passive (waveguides) components onto deep submicron CMOS ICs are examined. Specifically, our goal is the development of a metallic bonding methodology using the appropriate alloy for the simultaneous mechanical attachment and electrical interconnection of the III-V photonic dies on the silicon circuits. The use of rare earth elements in the bonding alloy is investigated for the enhancement of the bonding strength and encouraging results have been obtained. The project is executed in collaboration with IMEC (Belgium), ST, CEA, CNRS-FMNT (France) and TUE (Holland) in the framework of the European project PICMOS.

PUBLICATIONS in INTERNATIONAL JOURNALS

- "Low temperature wafer bonding for thin silicon film transfer", D. Goustouridis, K. Minoglou, S. Kolliopoulou, S. Chatzandroulis, P. Morfouli, P.Normand and D. Tsoukalas, *Sensors and Actuators A: Physical* Volume 110, Issues 1-3, 401-406, (February 2004)
- "A compact non-linear equivalent circuit model and parameter extraction method for packaged high-speed VCSELs", K. Minoglou, E. D. Kyriakis-Bitzaros, D. Syvridis, G. Halkias, *IEEE Journal of Lightwave Technology*, Vol.22, No.12, pp.2823-2827, (December 2004)

PUBLICATIONS in CONFERENCE PROCEEDINGS

- 1. "Effects of Packaging Parasitics on High Speed operation of VCSELs", K. Minoglou, E. D. Kyriakis-Bitzaros, A. Arapoyanni and G. Halkias, *NEWCAS 2004*, pp.53-56 20-23 June 2004, Montreal, Canada
- "Development of a new parameter extraction methodology for the modeling of the input of the VCSELs", K.Minoglou, E. D. Kyriakis-Bitzaros, D. Syvridis, G. Halkias, *HETECH 2004, 13th European Workshop on Heterostructure Technology*, October 3-6, 2004, Heraklion, Crete, Greece

PARTICIPATION in CONFERENCES

 "Metallic bonding of optoelectronic dies to silicon wafers", K. Minoglou, E. D. Kyriakis-Bitzaros, E. Grivas, S. Katsafouros, A. Kostopoulos, G. Konstadinidis and G. Halkias, "MMN 2004", November 14-17, 2004, Athens, Greece

EDUCATIONAL OUTPUT in 2004

a) PhD THESES

3 PhD theses completed in 2004. The following PhD theses carried out at IMEL the year 2004, were defended in Greek Universities:

1. Vassilios Bellas

Title: "Development of novel siloxane and polymeric materials for high resolution lithography. Structure-properties relationships" Department of Chemistry, University of Athens Supervisor: Dr. P. Argitis Defended at: February 2004

Margarita Chatzichristidi
 Title: "Chemically amplified photoresist materials for the fabrication of Microsystems" Department of Chemistry, University of Athens
 Supervisor: Dr. P. Argitis
 Defended at: December 2004

 Dimitris-Nikolaos Pagonis
 Title: "Local silicon thermal isolation technology-application on a silicon flow sensor"
 Department of Informatics, University of Athens
 Supervisor: Dr. A. G. Nassiopoulou
 Defended at: February 2004

b) DIPLOMA THESES

- Diploma thesis: M.Sc., University of Athens. Name: Loukas Michalas Title: Investigation of hot carrier effects in polycrystalline silicon TFTs Defended at: Physics Department, University of Athens, 27-1-2005 Supervisor: D. Kouvatsos
- Diploma thesis: M.Sc., University of Athens Name: Tasos Nikas Title: Fabrication of MOS devices utilizing W or W/Cu metallization and characterization of MOS capacitors and TFTs Defended at: IMEL, 10-11-2004 Supervisor: D. Kouvatsos
- 3. Master of Science Thesis Name: Evangelos Th. Grivas Title: High Data Rate Optical Interconnections for Satellite Processing Systems. Defended at: Athens University, November 2004 Supervisors: S.G. Katsafouros, G. Halkias
- 4. Diploma thesis (AEI): Bachelor's degree Name: Dimitris Kontziabassis Title: Fabrication of micromechanical structures with epoxy resists Defended at: University of Ioannina, Sept. 2004 Supervisor: E. Gogolides
- 5. Diploma thesis (AEI): Bachelor's degree Name: Vassilis Sarris
 Title: Simulation of the dissolution of thin polymer films for microlithography with stochastic models
 Defended at: National Technical University of Athens, November 2004
 Supervisor: E. Gogolides

6. Diploma thesis (AEI) Name: I. Xidi
Title: Electronic properties of Si nanostructures Defended at: Physics Department, University of Athens, date : September 2004 Supervisor: N. Papanikolaou 7. Diploma thesis (AEI): Bachelor's degree Name: Maria Kitsara
Title: Layer-by-layer UV micromachining methodology of epoxy based resist embedded microchannels
Defended at: University of Ioannina, September 2004
Supervisor I. Raptis

c) LABORATORY TRAINING

- Katsaros I., TEI of Athens
- Georga Th., TEI of Athens
- Makris K TEI of Athens
- Michailidis E., TEI of Athens
- Pappas D., TEI of Athens