Workshop on Semiconductor Processing for Photonic Devices

Institute of Electron Technology, Warsaw, Al. Lotników 32/46, Blg. VI, R. 120

September 30 – October 2, 2004, Warsaw, Poland

FINAL PROGRAM & ABSTRACTS

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Institute of Electron Technology, Warsaw

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Institute of Electron Technology, Warsaw

Patrycja Mihalovits
Institute of Electron Technology, Warsaw

Thursday, September 30, 2004

8:00 AM **Registration**

9:00 AM **Welcoming & Organizational Remarks**
A. Piotrowska
Institute of Electron Technology, Warsaw, Poland

9:30 AM **Invited**
Electron beam lithography in laboratory practice
J. Wróbel
Institute of Physics, Polish Academy of Sciences, Warsaw, Poland

10:30 AM **Coffee Break**

11:00 AM **Invited**
Micro and nano fabrication of optical, electronic and mechanical devices by X-ray lithography
E. Di Fabrizio
ELECTRA Synchrotron Light Lab., INFM, Trieste, Italy

12:00 AM **Invited**
Micro- and Nano-optics: Visions, Technologies and Applications
E.-B. Kley
Institute of Applied Physics, Friedrich-Schiller University, Jena, Germany

1:00 PM **Lunch**

2:00 PM **Training of young scientists at CEPHONA Labs.**
Part 1: Patterning functional thin films by means of photo- and e-beam lithography
- Photolitography using Suss MJB 3 250/300/400 system
- E-beam Lithography using *Raith ELPHY Plus/JEOL* system.

Friday, October 1, 2004

9:00 AM **Invited**
SuMBE: Growth of Nanostructured Organic, Cluster Assembled and Hybrid Materials by Supersonic Molecular Beams
S. Iannotta
Institute of Photonics and Nanotechnology, IFN-CNR, Trento, Italy

10:00 AM **Invited**
Transparent Conducting Oxides in Photovoltaics
A. Klein
Institute of Materials Science, Darmstadt Technical University, Germany

11:00 AM **Coffee Break**

11:30 AM **Invited**
X-rays techniques as a powerful tool for characterisation of thin film nanostructures
E. Dynowska
Institute of Physics, Polish Academy of Sciences, Warsaw, Poland

1:00 PM **Lunch**

2:00 PM **Training of young scientists at CEPHONA Labs.**
Part 2: Nanostructure analysis of functional thin films
- **XRD, SIMS, SEM, TEM**

Saturday, October 2, 2004

9:00 AM **Training of young scientists at CEPHONA Labs. Part 3.**
Manufacturing optoelectronic device structures: GaN-based Amber/Green RCLEDs and GaSb-based IR photodetectors.

1:00 PM Summarising Address

ABSTRACTS

Th-I-1

ELECTRON BEAM LITHOGRAPHY IN LABORATORY PRACTICE

J. Wróbel, P. Jakubas
Institute of Physics, Polish Academy of Sciences, Warsaw, Poland

In this talk we will describe the main issues of electron beam lithography with primary emphasis put on laboratory systems based on converted Scanning Electron Microscopes (SEMs). Special attention will be devoted to the so called proximity corrections. As a "case study" we will describe the fabrication of submicron metal diaphragms for microluminescence studies.

Th-I-2

MICRO AND NANO FABRICATION OF OPTICAL, ELECTRONIC AND MECHANICAL DEVICES BY X-RAY LITHOGRAPHY

E. Di Fabrizio,
ELECTRA Synchrotron Light Lab., INFM, Trieste, Italy

One of the most relevant fact of the next years will be the incorporation of a wide range of new functionalities in the single chip. This will allow not only to process the electric signal but also to detect, act, communicate with the “external world”. This change of quality will be supported by the introduction and the development of new interdisciplinary technologies. Furthermore it is possible to use the biocompatibility and biodegradability of many new material such as polymers and bio-polymers down to macro-porous silicon, and also possible to design in advance the dissolution rate, as a function of the geometrical structures created by means of micro- and nano-fabrication. These properties could also allow the release of a medical drug with spatial and temporal control. Extensive use of nanofabrication techniques can be registered in the field of microchemistry (local chemistry) and biophysics, where among other there is a strong activity in spectroscopy and chemistry of small micro-sized domanis. Experiments combining trapping with fluorescence, absorption spectroscopy, photochemistry and electrochemistry are routinely performed. Polimerization, ablation and other microfabrication technique were demonstrated with micrometer samples. Beam-scanning techniques were developed for trapping of micron-sized metal particles, low index particles and moving of particle in complex patterns.
The presentation will show applications to interdisciplinary activity made by LILIT group.

Th-I-3

MICRO- AND NANO-OPTICS: VISIONS, TECHNOLOGIES AND APPLICATIONS

E.-B. Kley
Institute of Applied Physics, Friedrich-Schiller University, Jena, Germany

Miniaturisation and microstructures are keywords in the modern technical world. Optical components and systems are affected by this trend, too. This means, miniaturised optical lenses, prisms, gratings and even artificial materials based on sub-wavelength structures have to be fabricated for a lot of applications. As a consequence micro- and nano-machining

is challenged to realise complex micro-optical elements as well as artificial materials, both on the base of 2D and 3D microstructures. In order to fabricate such optical elements and materials, special demands on lithography or micro- and nano-machining arise from the wave nature of light. This refers to the accuracy, as well as to special 2D and 3D fabrication techniques. The talk is discussing the basics as well as the vision of Micro- and nano-optics and gives an overview of the technologies (with an accent on lithography). Selected applications illustrate the potential of the field.

Fri-I-1

SUMBE: GROWTH OF NANOSTRUCTURED ORGANIC, CLUSTER ASSEMBLED AND HYBRID MATERIALS BY SUPERSONIC MOLECULAR BEAMS

S. Iannotta
Institute of Photonics and Nanotechnology, IFN-CNR, Trento, Italy

The approach to the growth of films of π-conjugated organic materials, Cluster Assembled and Hybrid materials combining a supersonic free jets (which allows a fine control on kinetic energy, state of aggregation, momentum and flux) with a UHV deposition apparatus including surface characterization methods (UPS, XPS, LEED, Auger) will be discussed. We study “in situ” the growth process and the interfaces. Our major aim is to understand the role of the initial state of the precursors in the beam on the film formation and to exploit the unique control achievable with supersonic beams on initial kinetic energy, momentum and state of aggregation in the preparation of materials with controlled properties at the different length scales. Results on organic semiconductors show the important role of kinetic energy on structure and morphology of films: it appears to be a critical factor for growing high quality organic crystalline films. Prototype FET devices have been developed to study and correlate the growth process, functional properties, structure and morphology. Results obtained on oligothiophenes, pentacene and phthalocyanines will be reported. We have also studied reactivity processes, activated by the kinetic energy of the precursors, to synthesize materials with different structures and morphologies. This is the case of the synthesis of SiC at moderate temperatures produced with different degrees of crystallinity depending on the initial state of the fullerene precursors in the supersonic beam. The growth from supersonic beams can also be extended to metal clusters. We have developed and used this approach to prepare thin films of metal oxides that show different nano-crystalline character (anatase-rutile-brookite) depending on the state and size of precursors. This is achieved without any thermal treatments so that the size and morphology of the nanostructures can be better controlled compared to more standard methods. Gas sensing devices, based on these methods, are being developed and show very promising performances. We are now addressing the very interesting perspective of applying our approach to the sensitization of nanostructured oxides combining organic and cluster supersonic beams. Preliminary results on gas-sensing devices based on these nano-hybrid materials will be discussed.

Fri-I-2

TRANSPARENT CONDUCTING OXIDES IN PHOTOVOLTAICS

A. Klein
Institute of Materials Science, Darmstadt Technical University, Germany

Transparent conducting oxides (TCOs) as In_2O_3, ZnO and SnO_2 are used as electrodes in thin film solar cells and other opto-electronic devices. Despite being all highly degenerate n-type semiconductors they are sometimes also used for contacts to p-type material. The most prominent example is the use of ITO (In_2O_3:Sn) as hole injecting electrodes in organic light emitting devices. The differences in the contact properties are related to electronic surface and interface properties of the TCOs, which we have studied extensively using photoelectron spectroscopy (XPS, UPS) with TCO films deposited in-situ by magnetron sputtering. After introducing the TCO materials, their preparation and applications, as well as a short description of the experimental procedure, an overview of the surface and interface properties of the TCOs and dependencies on preparation conditions will be given.

Fri-I-3

X-RAYS TECHNIQUES AS A POWERFUL TOOL FOR CHARACTERISATION OF THIN FILM NANOSTRUCTURES

E. Dynowska
Institute of Physics, Polish Academy of Sciences, Warsaw, Poland

Nanostructured devices are becoming very important for applications in electronics, optoelectronics and X-ray optics. They are realized as single or multilayer films grown epitaxially on crystalline substrates. The functionality of these devices requires high crystal quality of the sublayers and smooth interfaces. Such layers are grown using specially designed growth methods, such as molecular-beam epitaxy (MBE) or metal-organic vapour deposition epitaxy (MOVPE), for example. Layer-by-layer deposition allows for the construction of tailored stacks of sublayers with monolayer and submonolayer accuracy. Nevertheless, under real conditions of growth, several real-structure effects appear that reduce efficiency of the electronic and optoelectronic devices. On the other hand, the formation of the ohmic contacts in the devices by the metallization process requires an advanced studies of metal/semiconductor interface.

The technological process of layer preparation, as well as ohmic contacts formation requires non-destructive methods of sample characterization. Whereas scanning-probe techniques, such as scanning electron microscopy (SEM) and atomic force microscopy (AFM), are used to characterize surface of the film, X-ray techniques still remain the most important tool for probing the internal structure of mono- and multilayer structures (interfaces including) close below the surface.

In this lecture the selected X-ray methods, most often used in thin layers characterization, will be presented. The most sensitive for thin layer examination X-ray techniques use the refraction of X-ray beam at the air-film interface. Because the refraction index of matter for X-rays is smaller then unity, the X-ray penetration depth can be drastically reduced to several nanometers if the beam strikes the sample surface at a very small grazing angle. Such measurement geometry allows to probe the vertical density profile inside the film, layer thickness determination, as well as surface and interfaces roughness examination. The other conventionally used techniques, based on the X-ray diffraction phenomenon, allow to determine the strain fields, chemical composition, defect structure of the layers, and so on. By mapping out the reciprocal space in the vicinity of a Bragg peak of the substrate it is possible, among other things, to separate the dislocation structure from the lattice parameter fluctuations inside the layer. The advantages of using synchrotron radiation instead the conventional sources for described above X-ray techniques will be point out.