Book of Abstracts

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Plenary Speakers

Uwe Bandelow	Weierstrass Institute for Applied Analysis and Stochastics (WIAS), Germany
Christa Willnauer	Infineon Technologies Dresden AG & Co. KG, Germany

Invited Speakers

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Igor Kuskovsky	The City University of New York, USA
Elena Orlenko	Peter the Great Saint-Petersburg Polytechnic University, Russian Federation
Mauro Menichelli	INFN Perugia, Italy

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Murat Pak	IMEC-Litho R D Team Leader, Belgium

PLENARY SPEAKER
Id-008

Modeling And Simulation of the Dynamics in Semiconductor Lasers

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Abstract: This contribution is dedicated to the modeling, simulation, and analysis of nonlinear dynamical effects in semiconductor lasers. It aims on their realistic, self-consistent simulation, as well as on qualitative understanding. Different levels of modeling complexity are introduced and important approximation techniques will be explained. Suitable model reductions allow at least qualitative understanding of measured effects. For lasers with well-defined cavity and limited gain spectrum a modal representation of the optical field enables low-dimensional approximations to the critical dynamics. Thereby it allows for qualitative insight into many technologically relevant effects. Multi-section lasers with transverse single mode design will be shown to exhibit rich dynamical behavior, such as self-Q-switching, mode beating, and mode locking. Interestingly, it turns out that some of these dynamics can be related to exceptional points in the spectrum of the optical evolution operator, where eigenvalues become non-semisimple [1]. Applications can use locking of self-pulsating lasers to external modulation [2], and enhanced modulation response [3]. High-power broad area semiconductor lasers (BALs) can support hundreds of modes and exhibit almost irregular dynamics above the lasing threshold. BALs are important sources for high-performance laser systems, where single devices emit tens of watts output. Thereby large amounts of heat are generated, which has significant impact on the laser operation. We incorporate such heating effects by coupling a dynamical electro-optical model to a heat-transport model [4].

Keywords: Modeling; Simulation; Semiconductor; Lasers.

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PLENARY SPEAKER

Id-011

The Incoming Clean of Raw Silicon Wafers and Its Challenges: Applying the T6sigma Methods to the Root Cause Evaluation

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Abstract: We have investigated the cleaning efficiency of our current incoming cleaning, depending on the raw wafer properties of different vendors. It will be discussed whether the observed vendor-dependences are caused by our incoming cleaning methods and tools or by the wafers themself. The issue investigation and the problem analysis/solving was done by using T6sigma methods [1]. How the project has developed and how we found proper solutions to overcome the issue will be reported. In the measurement phase of the project, we found significant variations of the wafer surface already before the incoming clean by using particle [2] and contact angle measurements [3], QCEPT [4], REM [5] and EDX [6]. Therefore, we have analyzed the packaging, the transport and the unpackaging of our raw wafers very carefully and found the possible root cause for the vendor-dependent cleaning performance in volatile organic carbon (VOC) [7] on wafer surface. Furthermore, in analyze phase of the project different solutions were found and will be presented. The implementation of these solutions was done and proved. As a preventive action a change in raw wafer specification will be recommended. I want to thank all co-workers and partners for the intense investigations on this topic and successful problem solving. Many thanks go to our vendors for their trustful cooperation and the willing implementation of all the containment and corrective actions. Special thanks go to the Infineon management for the great support during the project period.

Keywords: Incoming clean; Bare wafers; VOC; Contact angle; Cleaning efficiency.

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INVITED SPEAKER

Id-001

Formal Gate-Level Transformation Theorems for IP-Aware Functional Equivalence in Digital Logic Design

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Abstract: The globalization of semiconductor manufacturing and hardware design outsourcing has created pressing challenges around circuit originality, IP-safe reuse and legal differentiation of digital designs. Although Boolean equivalence checking is mature, methods to systematically generate functionally identical yet structurally non-isomorphic circuits are under-explored. In response, we develop a formal theory of IP-Aware Functional Equivalence (IP-AFE) that rigorously separates behavioral identity from topological isomorphism and embeds synthesis lineage as a first-class criterion. Within this framework, we introduce a new class of structural transformation rules that include absorption expansion, dual-selective amplification and orthogonal gate injection to preserve Boolean behavior while enforcing provable non-isomorphism. We prove a family of Functionally Equivalent Gate Construction Theorems, such as a three-minterm OGI decomposition for OR using only NAND gates and derive additional families for XOR, MUX and majority logic. To validate our approach, we provide Boolean proofs, truth tables, graph-theoretic invariants and non-isomorphism arguments (via gate-type histograms, depth profiles and dominance orders). Our results demonstrate that designers can reliably produce legally and structurally distinct implementations of the same logic function, enabling IP-compliant circuit diversification and innovation without sacrificing correctness.

Keywords: Circuit non-isomorphism; IP-Aware functional equivalence; Orthogonal gate injection; Structural transformation rules; Boolean algebra transformations; Gate construction theorems.

INVITED SPEAKER

Id-003

Type-II Submonolayer CdTe/ZnCdSe Quantum Dots as an Active Layer for Intermediate Band Solar Cells

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Abstract: The intermediate band solar cell (IBSC) concept [1, 2] has been proposed as a way to overcome the efficiency limits of single-junction devices. In IBSCs, mid-gap states in the host material create an additional intermediate absorption pathway for below-bandgap photons, increasing both the short-circuit current and the opencircuit voltage. The theoretical efficiencies for IBSCs are 42% (1 sun) and 63% (full solar concentration) [1, 2]. To reach maximum efficiency, the optimal values of the host bandgap and the intermediate band (IB) energies are ~2.0 eV and ~0.7 eV, respectively [1, 2]. Quantum dots (QDs) are ideal candidates for forming the IB; moreover, they can be grown in arrays and stacks to increase the probability of photon absorption and to provide either “true” bands or a collection of localized levels. For efficient absorption via the IB, the density of band-forming QDs must be sufficiently high so that the contribution of carriers promoted to the continuum through the IB states is comparable to that from fundamental absorption. Many approaches to create an IB using QDs have been proposed, with the majority relying on III–V QDs. However, successful demonstrations of IBSCs are very limited [3-5], since III–V semiconductors do not possess the required optimal material parameters. We have shown that doped sub-monolayer CdTe QDs embedded in ZnCdSe, forming a type-II band alignment, can be employed to form the IB [6]. These QDs are grown by migrationenhanced epitaxy (MEE), while the rest of the device is grown by conventional MBE. Importantly, these dots are grown without a wetting layer, which is often a challenge in many other systems. Moreover, we can grow hundreds of QD-containing layers, in contrast to the limited number achievable with the Stranski–Krastanov (SK) method used for the majority of III–V systems. The ability to grow hundreds of QD-containing layers is particularly important for addressing the inherently low absorption in IBSCs, especially those using type-II QDs (e.g., Ref. 2 and references therein). This approach also enables selective, direct doping into alternating QD layers [7], which should promote partial filling of the IB with charge carriers. Here, we report results from recently grown CdTe/ZnCdSe type-II QDs, which exhibit deeper PL emission, indicating the formation of larger QDs required for the optimized IB energy position. We also present symmetric and asymmetric X-ray diffraction data, from which we obtained QD parameters, as well as temperature- and intensity-dependent photoluminescence, FTIR, and optical absorption measurements. Finally, we show that these QDs are also successfully formed within full solar cell device structures containing both n- and p-type layers, using etching and intensity studies as shown in Figure 1. This work was supported by NSF Grant No. HRD-2112550 (Phase II NSF CREST Center IDEALS) as well as Cycles 54 and 55 PSC-CUNY Grants.

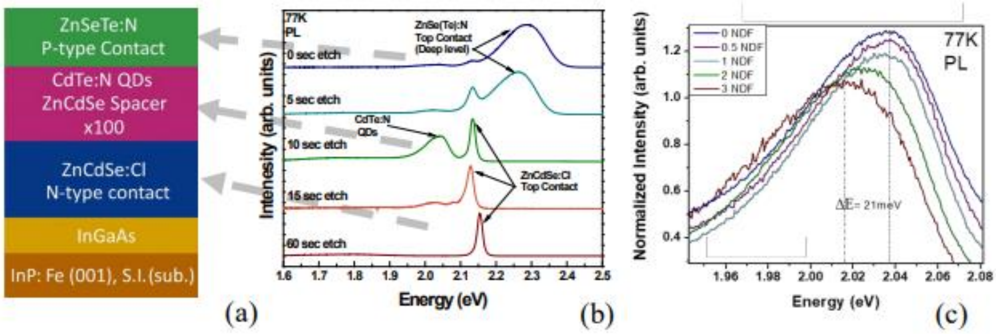

Figure 1: (a) Schematic of IBSC based on CdTe/ZnCdSe type-II QDs; **(b)** 77 K PL after etching to reach various layers; **(c)** Strong blue shift with increase in excitation intensity in CdTe/ZnCdSe layer, confirming type-II nature of the QDs.

Keywords: Submonolayer type-II quantum dots; Intermediate band solar cells; MEE-MBE; CdTe; ZnCdSe.

INVITED SPEAKER

Id-005

Coherent Phonon States in Heat Transfer in Nanomaterials with Different Size Dimension

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Abstract: A general formalism of thermal conductivity is proposed. It takes into account both free thermal phonons and coherent Schrödinger states of the oscillatory system in the heat flow. We describe the energy transfer by coherent thermal excitations in nanoscale systems by using the technique of secondary quantization and a conception of coherent states as eigentstates of annihilation operator. A general form of the solution of the time-dependent problem with arbitrary initial conditions for coherent states, is obtained. The exact solution is obtained analytically for the heat flux transferred by coherent phonons for the case, when an electron wave packet formed by a laser pulse acting on the nanomaterial. This exact solution in form of quadratures creates a basis for an accurate quantitative description of coherent phonons with different initial conditions, as well as taking into account thermal distributions, which allows predicting the thermal properties of nanocrystals. It is shown that at certain ratios of the constants characterizing the interaction of phonons with the electron subsystem, a heat flux that does not decay with time can be established in the crystal. The effect of superthermal conductivity in nanomaterial is predicted. [1]. These coherent states with a Poisson distribution over the number of phonons in a given mode play an important role and lead to the heat superconductivity [2,3]. We consider nanomaterials with low dimension: quasy-2-dimension- thin films, quasi-1-dimension—quantum wires and common 3D system. The authors are grateful to the wonderful pianist Anna Maruchek for inspiration and the harmony unity of music and mathematics.

Keywords: Coherent phonons; Schrödinger states; Superthermal conductivity; Heat superconductivity; Low dimensional nanomaterial.

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INVITED SPEAKER

Id-009

Status and Perspectives of the Haspide Project Aiming at the Fabrication and Testing of Hydrogenated Amorphous Silicon Radiation Detectors for High Energy Physics, Medical and Space Applications

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Abstract: The HASPIDE (Hydrogenated Amorphous Silicon PIxel DEtectors) project aims at the development of Hydrogenated Amorphous Silicon (a-Si:H) detectors on flexible substrate for high energy physics, medical and space applications. The program started in 2022 and the first phase ended in 2025. The main results of the first phase will be highlighted in this talk in terms of: i) radiation hardness tests, ii) linearity and sensitivity tests with x-rays electrons and protons, iii) specific tests for medical applications and iv) the design and construction of a prototype for solar energetic particle (SEPs) events monitor. Furthermore the program has been approved and funded for the forthcoming 3 years (2026-2028) by INFN (Istituto Nazionale di Fisica Nucleare) and will continue in two directions: a) the development of indirect detectors (a-Si:H photosensor + scintillator) for medical physics and astroparticle physics, and b) the development of a beam monitor active particle flux detector to be placed on the vacuum-to-air separation membrane for precise beam monitoring in high energy physics and medical accelerators. Indirect detectors will be based on the previous development of a-Si:H direct devices, optimized for light detection (n-i-p or charge selective or hybrid devices with reduced thickness of the intrinsic layer and transparent electrodes) and the scintillator will be flexible and have a good radiation hardness suitable for each application. We are considering for this purpose polysiloxane scintillators. Additionally a devoted scintillator R & D will be performed for adding perovskite nanocrystals or perovskite thin layers to enhance scintillator photon emittance still based on a polysiloxane scintillator scaffolding. The same strategy will be also adopted with the SEP detector for space application in order to improve his sensitivity to lower particle fluxes. Concerning the beam monitoring detector a prototype of a complete system will be developed and tested in order to enhance the Technological readiness level for this technology from level 4 to level 7-8.

Keywords: Flexible amorphous silicon sensors; Dosimetry; Scintillation detector, Space applications; Medical applications.

ALL SUBMISSIONS & TOPICS

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