# SHORT PROGRAM

## 21st International Conference on Molecular Beam Epitaxy

September 6-9, 2021
Virtual Conference

This series of successful conferences began in 1978 in Paris, and in recent years, has taken place in Nara, Japan (2012); Flagstaff, USA (2014); Montpellier, France (2016), and Shanghai, China (2018). The 21st International Conference on Molecular Beam Epitaxy will take place *virtually* in Puerto Vallarta, Mexico.

The International Conference on Molecular Beam Epitaxy provides a prominent international forum for reporting new developments in the areas of fundamental and applied molecular beam epitaxy research, including advances in the technique, synthesis of new materials, discovery of new physical properties, formation of novel heterostructures, and the development of innovative devices.



# 21st International Conference on Molecular Beam Epitaxy

**SEPTEMBER 6 - 9, 2021**

| SCHEDULE | Monday, Sept 6 | Tuesday, Sept 7 | Wednesday, Sept 8 | Thursday, Sept 9 | |
|---|---|---|---|---|---|
| 09:30 - 10:00 | Opening Session | 09:50 - 10:00<br>Prologue | 09:50 - 10:00<br>Prologue | 09:50 - 10:00<br>Prologue | |
| 10:00 - 10:50 | Plenary<br>**Anna Fontcuberta** | Plenary<br>**James Speck** | Al Cho MBE Award<br>**Charles Tu** | Young Inv. MBE Award<br>**Stephanie Law** | 10:00 - 10:50 |
| 10:50 - 11:25 | Invited<br>**Alexandre Arnoult** | Invited<br>**Eva Benckiser** | Invited<br>**Federico Panciera** | Invited<br>**Gunther Springholz** | 10:50 - 11:25 |
| 11:25 - 12:00 | Invited<br>**Joanna Millunchick** | Invited<br>**Sergei V. Novikov** | Invited<br>**Abderraouf Boucherif** | Invited<br>**Peter Schüffelgen** | 11:25 - 12:00 |
| 12:00 - 12:15 | **Break** | **Break** | 12:00 - 12:30<br>**Awards Ceremony** | **Break** | 12:00 - 12:15 |
| 12:15 - 12:50 | Invited<br>**David Ritchie** | Invited<br>**Matt Hardy** | | Invited<br>**Nitin Samarth** | 12:15 - 12:50 |
| 12:50 - 13:25 | Invited<br>**Cheng Shang** | Invited<br>**Alan Doolittle** | | Invited<br>**Matthew Barone** | 12:50 - 13:25 |
| | | | | **Closing Session** | 13:25 - 13:45 |
| 18:30 - 19:05 | | | Invited<br>**Hideki Yamamoto** | | 18:30 - 19:05 |
| 19:05 - 19:40 | | | Invited<br>**Shiro Tsukamoto** | | 19:05 - 19:40 |
| 19:40 - 20:15 | | | Invited<br>**Yuefeng Nie** | | 19:40 - 20:15 |

American Central Daylight Savings Time (CDT, UTC -5) is used as a reference.
Wednesday night's session has been considered for the convenience of Asian countries.

The plenary and invited sessions consist of:
1) a prerecorded talk, available at the beginning of each session (max. 40min / 25 min), according to the schedule,
2) ten minutes of a live streaming session (embedded in Whova) after the prerecorded talk to answer written questions via the Whova platform's Q&A feature.

After the plenary and invited presentations, the prerecorded talks will be available to the attendees to benefit those in different time zones.

Pre-recorded oral and poster sessions will be available on demand during the conference.
The virtual Conference platform offers tools to easily interact with presenters through messaging and video conferencing.

**World clock and time converter**

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# PLENARY SPEAKERS

**Anna Fontcuberta i Morral,** *EPFL, Switzerland*
**Growth mechanisms of III-V and II-Vs : insights of the nanoscale**

**Jim Speck,** *University of California - Santa Barbara, USA*
**β-$Ga_2O_3$: Growth, Doping, and Device Design**

# INVITED SPEAKERS

**Alexandre Arnoult**, *LAAS-CNRS, Toulouse, France*
**In-situ magnification inferred curvature measurement applied to dilute bismide growth**

**Matthew Barone,** *Cornell University, USA*
**An MBE Approach to Record-Breaking Millimeter-Wave Tunable Dielectrics**

**Eva Benckiser,** *Max Planck Inst., Stuttgart, Germany*
**Complex oxide interfaces: Mind the facet.**

**Abderraouf Boucherif,** *Université de Sherbrooke, Canada*
**Nanoscale substrate engineering for cost-effective III-V solar cells**

**W. Alan Doolittle,** *Georgia Inst. of Technology, USA*
**Chemical and Kinetic Mechanisms to Overcome Perceived Limitations in III-Nitride Epitaxy**

**Matthew Hardy,** *Naval Research Laboratory, USA*
**Growth of ScAlN: A Multi-functional Nitride**

**Stephanie Law,** *University of Delaware, USA* Young Investigator MBE Award
**Molecular Beam Epitaxy Growth of van der Waals films and nanostructures**

**Joanna Millunchick,** *University of Michigan, USA*
**Kinetics, Morphology, and Microstructure of III-V-Bi alloys**

**Yuefeng Nie,** *Nanjing University, China*
**Extreme tunability and novel functionality in ferroelectric oxide membranes**

**Sergei V. Novikov,** *University of Nottingham, UK*
**High-Temperature MBE of Hexagonal Boron Nitride for Deep-Ultraviolet, Lateral Heterostructures and Single-Photon Emitters**

**Federico Panciera,** *C2N, Paris-Saclay, France*
**Real-time TEM observations of III-V nanowire growth**

**David Ritchie,** *University of Cambridge, UK*
**Semiconductor quantum light sources using InAs quantum dots**

**Nitin Samarth,** *Penn State University, USA*
**Molecular Beam Epitaxy of Hybrid Topological Semimetal Heterostructures**

**Peter Schüffelgen,** *FZ-Jülich, Germany*
**From Materials to Devices: Topological Insulators for Quantum Computation**

**Chen Shang,** *Univ. California - Santa Barbara, USA*
**Robust high temperature operation of quantum dot lasers grown on (001) Si**

**Gunter Springholz,** *Johannes Kepler Univ. Linz, Austria*
**Natural Heterostructure Formation and Magnetic Doping of Bi- and Sb-Chalcogenide based Topological Insulators**

**Shiro Tsukamoto,** *Univ. Electro-Communications, Japan*
**Droplet epitaxy from beginning to present, pursuing initial cluster size**

**Charles W. Tu,** *Univ. of California, San Diego, USA* Al Cho MBE Award
**Bandgap Engineering and Device Applications of Dilute Nitrides**

**Hideki Yamamoto,** *NTT Basic Research Lab., Japan*
**Electron-Beam-Evaporation-Based Multi-Source Oxide MBE as a Synthesis Method for High-Quality and Novel Magnetic Materials - Beyond 3d Transition Metal Compounds**

| | | | |
|---|---|---|---|
| ORAL<br>**ConfCode - 45** | III-V Semiconductors | **Real-time Reflectance Anisotropy Spectroscopy of GaAs Epitaxial Growth: Temperature-Induced As vacancies**<br>Presenter: **Jorge Ortega-Gallegos**<br>*Universidad Autónoma de San Luis Potosí, México* | |
| ORAL - OSMAw<br>**ConfCode - 46** | III-V Semiconductors | **Doping Assessment of Ga-assisted MBE Grown Be-Doped GaAs and Te-Doped GaAsSb Nanowires.**<br>Presenter: **Priyanka Ramaswamy**<br>*North Carolina A&T State University, USA* | |
| ORAL<br>**ConfCode - 47** | III-V Semiconductors | **Chemical beam epitaxy of $GaP_{1-x}N_x$ alloys and $GaP_{1-x}N_x/GaP_{1-y}As_y$ short-period superlattices on nominally (001)-oriented GaP-on-Si substrates**<br>Presenter: **Karim Ben Saddik**<br>*Universidad Autónoma de Madrid, Spain* | |
| ORAL<br>**ConfCode - 48** | III-V Semiconductors | **Optimization of AlGaAsSb growth on lattice matched InGaAs on InP Substrates by MBE**<br>Presenter: **Pallavi Patil**<br>*EPSRC National Epitaxy Facility, University of Sheffield, UK* | |
| ORAL - OSMAw<br>**ConfCode - 49** | III-V Semiconductors | **A study of Epitaxial GaAsSbN (Te) ensemble nanowires for near-infrared region photodetection.**<br>Presenter: **Rabin Pokharel**<br>*North Carolina A&T State University, USA* | |
| ORAL - OSMAw<br>**ConfCode - 50** | III-V Semiconductors | **Examination of the Optical Properties of $GaSb_{1-x}Bi_x$ by Spectroscopic Ellipsometry**<br>Presenter: **John H. McElearney**<br>*Tufts University, USA* | |
| ORAL - LATE NEWS - OSMAw<br>**ConfCode - 51** | III-V Semiconductors | **Strain Balancing for InAs Based ICL growth**<br>Presenter: **Maximilian Beiser**<br>*TU Wien, Austria* | |
| POSTER - OSMAw<br>**ConfCode - 52** | III-V Semiconductors | **Alternative for ultraviolet disinfection. Cubic and hexagonal AlGaN-based UVC-LED challenges**<br>Presenter: **Horacio Solís-Cisneros**<br>*Tecnológico Nacional de México/Instituto Tecnológico de Tuxtla Gutiérrez, México* | |
| POSTER - OSMAw<br>**ConfCode - 53** | III-V Semiconductors | **GaN growth on (0 0 1) and (1 1 0) MgO under different Ga/N ratios by MBE**<br>Presenter: **Kevin Meyer**<br>*Clausthal University of Technology, Germany* | |
| POSTER<br>**ConfCode - 54** | III-V Semiconductors | **Growth of 6.2 Å semiconductor topological materials on lattice engineered virtual substrates**<br>Presenter: **Heather Haugan**<br>*Air Force Research Laboratories, USA* | |
| POSTER<br>**ConfCode - 55** | III-V Semiconductors | **Impact of $As_2$ pressure on the molecular beam epitaxial growth of AlGaAs superlattice at temperature over 700?**<br>Presenter: **Reiji Suzuki**<br>*Ehime University, Japan* | |
| POSTER<br>**ConfCode - 56** | III-V Semiconductors | **Indium Accumulation in Self-assembled Nanoholes in GaAs(001) Surfaces**<br>Presenter: **Shiro Tsukamoto**<br>*The University of Electro-Communications, Japan* | |
| POSTER - OSMAw<br>**ConfCode - 57** | III-V Semiconductors | **Relating as-grown surface morphologies to electron transport properties in high mobility InSb quantum wells**<br>Presenter: **Erik Cheah**<br>*ETH Zürich, Switzerland* | |

# Strain Balancing for InAs Based ICL growth

M. Beiser, M. Giparakis, H. Knötig, H. Detz, M. Giparakis, B. Schwarz, A.M. Andrews, G. Strasser
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**ABSTRACT. Interband cascade lasers (ICLs) emerged to a promising monolithic platform to enable on-chip dual-comb spectroscopy. In order to compensate the increased absorption at longer wavelengths, the number of active regions can be increased. This can exceed the critical thickness of the InGaSb layers and limit the MBE growth. Strain balancing the structure is therefore a crucial tool to be able to grow an increased number of active regions. We present an alternative approach to interface engineering with an additional layer that works as a barrier for the electron injector region and balances the strain of the type-II heterostructure.**

**Keywords: Interband Cascade Lasers, Strain Balancing, type-II heterostructures, Mid-infrared laser**

ICLs are ideal candidates for miniaturized spectrometers, due to their low power consumption and the possibility to integrate sensitive on-chip detectors using the same epilayer material [1, 2]. In addition, ICLs work as frequency combs [1], offering the possibility to build integrated frequency combs. The spectrum of frequency combs consists of a set of evenly spaced modes, working as rulers in the frequency domain. Frequency combs are ideal candidates to realize miniaturized spectrometers without moving parts, ideally with a high spectral bandwidth and a manifold of comb teeth. Recent efforts showed how to engineer the spectral bandwidth of quantum cascade laser frequency combs to achieve broadband rulers for dual-comb spectroscopy [3]. Intrinsically, the operating emission wavelength of the individual ICLs is limited, which requires different active region designs. ICLs were demonstrated to work on InAs and GaSb substrates, where InAs-based ICLs are more often used for longer wavelength emission, due to the better extinction coefficients of InAs [6,7].

However, the InGaSb layers required for the type-II broken bandgap alignment in the active regions W quantum well induces significant strain into the laser structure. State of the art devices are typically grown with 5 to 6 active quantum wells and do not exceed the critical thickness of InGaSb. The increased cumulative thickness of the InGaSb layers for longer emission wavelengths also increases the strain in the laser structure, which can limit the crystal growth when the critical thickness is exceeded. Throughout the community the engineering of the AlSb/InAs interface of the claddings towards the AlAs side of the interface is a well-established method of strain balancing in the cladding layers [4, 5]. As this is a mixed group V interface it is difficult to control the As-for-Sb exchange with the flux ratio and is challenging for reproducibility. The incorporation of Arsenic changes both the nominal layer composition and the quantum well energy levels.

We present a straight-forward idea to implement an additional strain balanced InAlAs layer in the active region, that can serve as strain compensation layer and barrier for the electron injector region of the laser structure. We present high-resolution XRD (HR-XRD) and AFM data to verify the high quality growth. Additionally, we can show good agreement of the modelled strain with the grown structure. This proof-of-concept allows the strain-balanced growth of a high number of cascades independent of the claddings.

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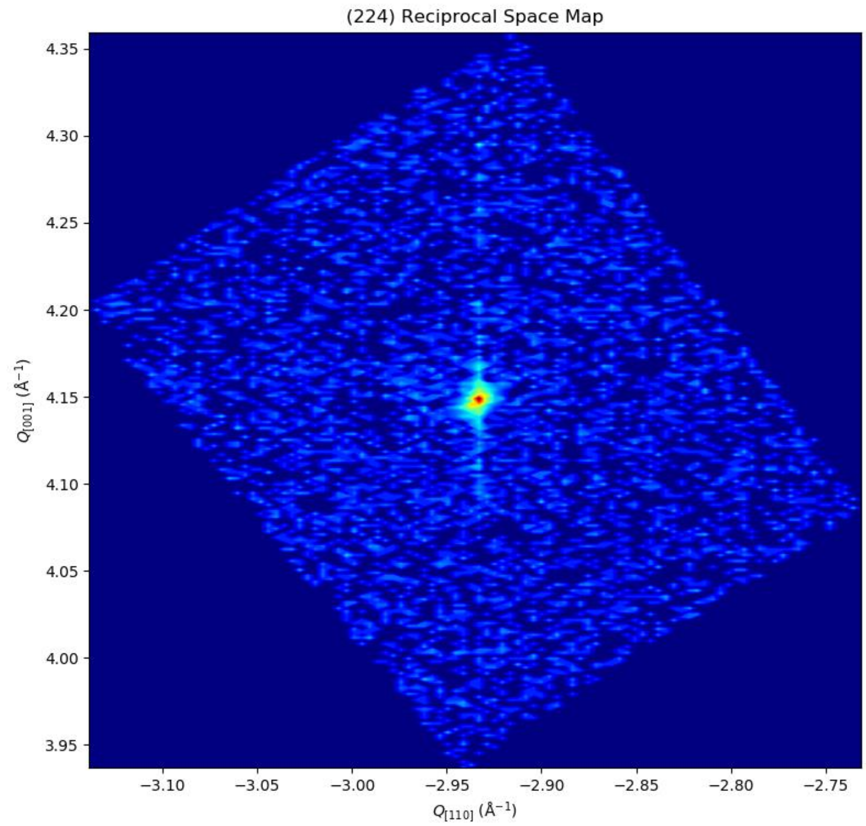


Fig. 1: (224) Reciprocal Space Map of a strain balanced type-II heterostructure. The reciprocal space map shows a strain-balanced superlattice.

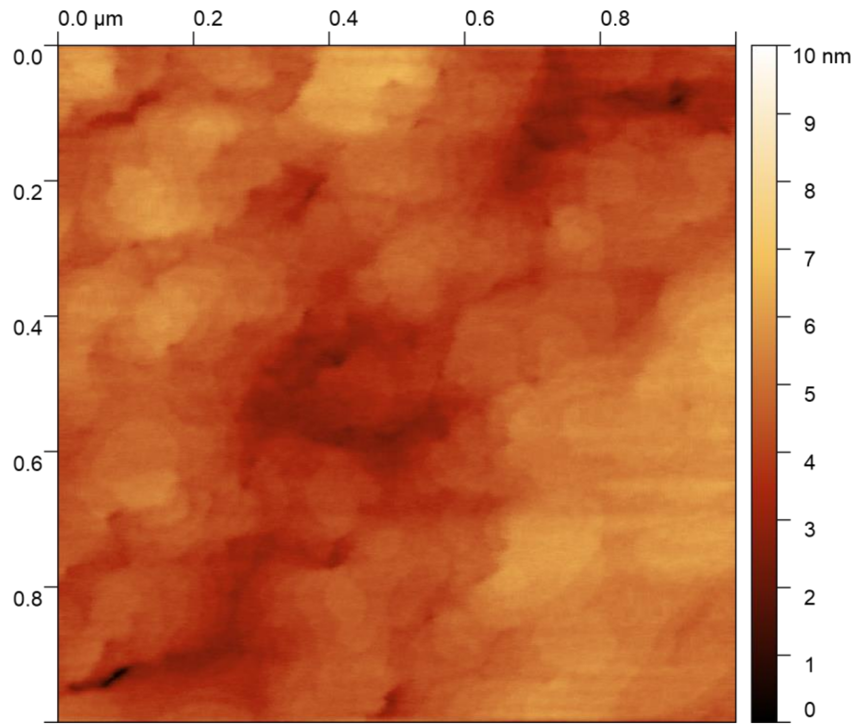


Fig.2: 1x1µm image performed with Atomic Force Microscopy of a strain balanced type-II heterostructure. The rms roughness is 0.82nm.