

Power Efficient G_{65} -based Optoelectronics for Space and Remote Sensing Applications

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Outline:

- Introduction
- Technology
- Device results
- Summary and Outlook



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Business:

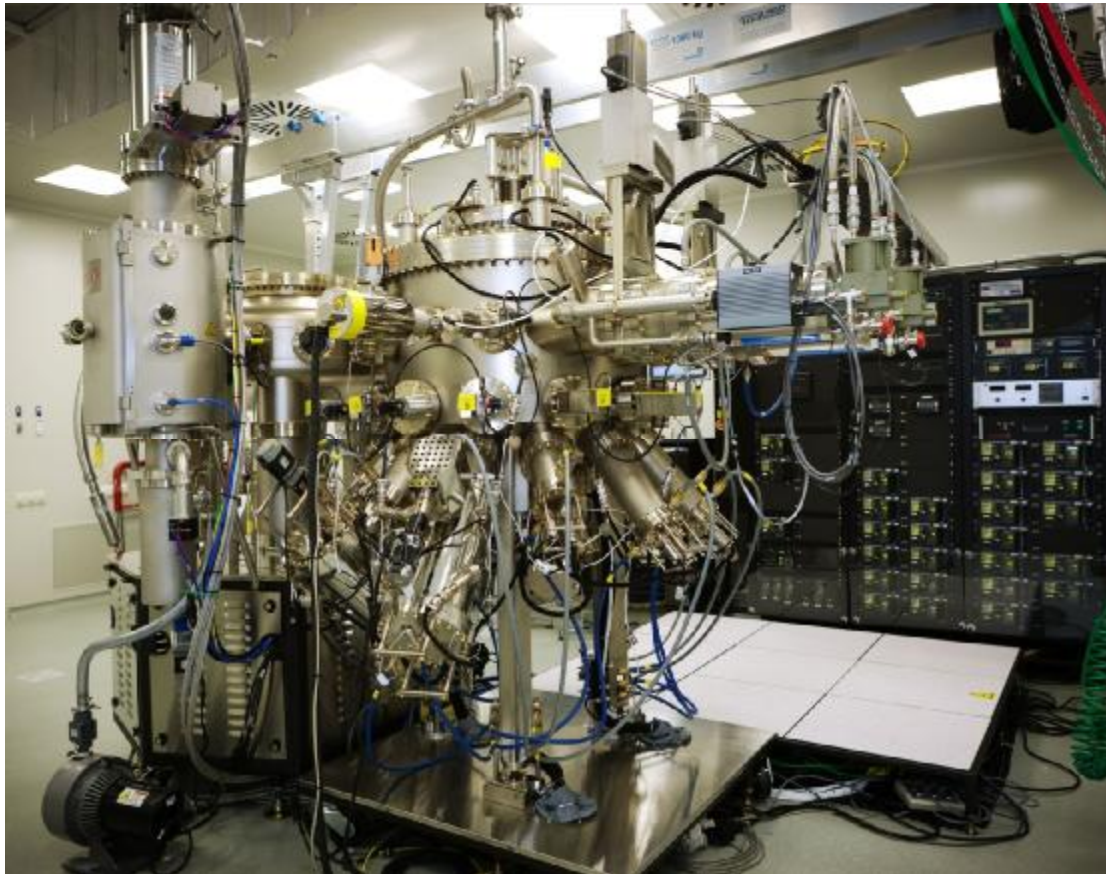
- **MBE foundry service for AlGaInAsSb platform**
- **Mid-IR GaSb laser diodes (1.8 – 4 μm)**

Background

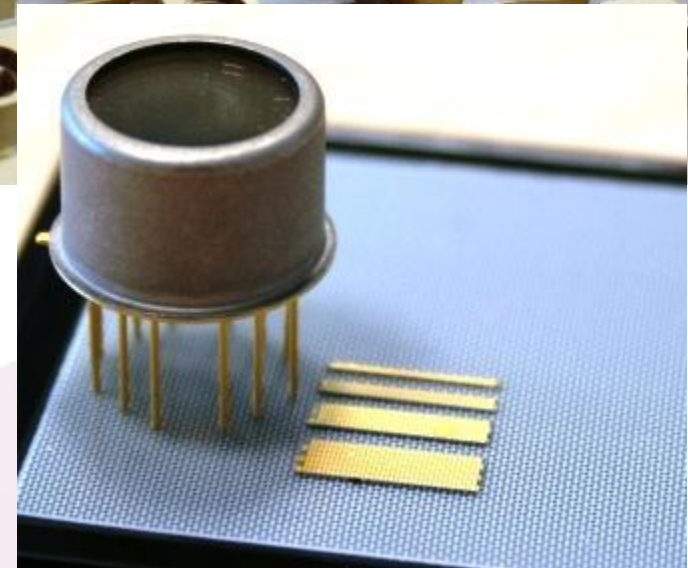
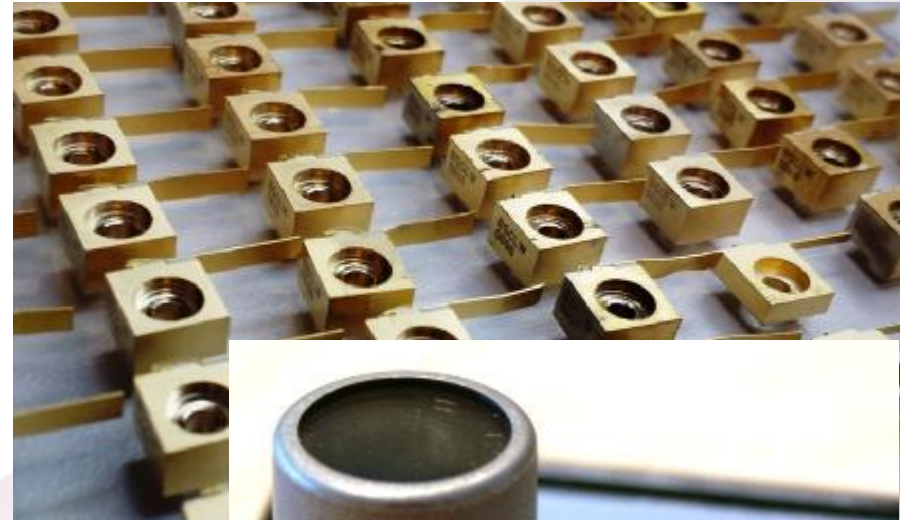
- Company established in **August, 2011;**
- Industrial R&D facility opened **December, 2012;**
(total investment **5 M EUR**)
- Number of employees: **9 (2013)**



Veeco Gen200Edge multiva for M E system



Laser diode technology: 3-inch GaSb platform

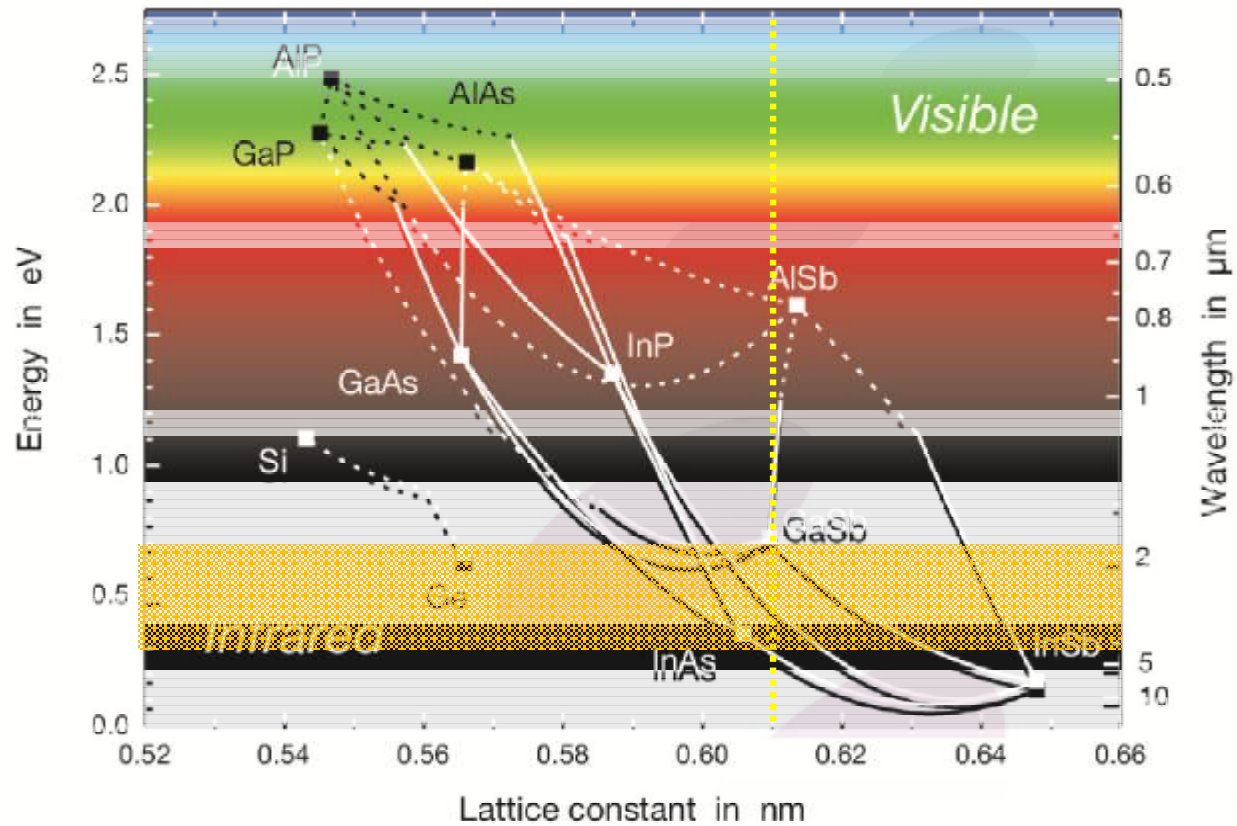


- Lower cost per chip
- Large area devices (arrays, bars)
- Scalable for mass-production

Outline:

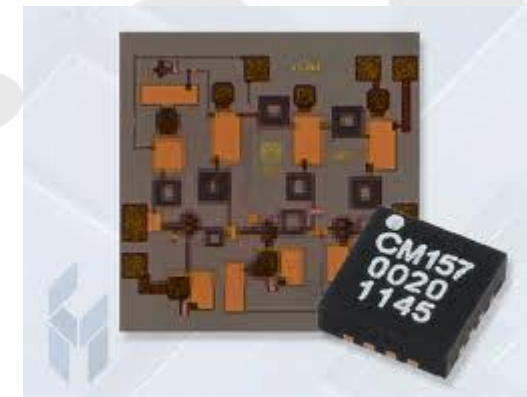
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GaSb material platform for 1.8-4 μm spectral range



Ultrafast electronics for space applications :

- Space applications require :
 - Low-power consumption (payload)
 - Radiation hardness
 - Compactness
 - Reliability



Example: High-frequency MMIC LNA power consumption figure:

Material platform	Disipated power
GaAs	18 mW
InP	6 mW
InAs/GaSb	1.8 mW

B. R. Bennet et al., Solid-state electronics, 49 (2005), 1875-1895.

New generation optoelectronics for space:

- Power efficiency
- Radiation hardness
- Reliability
- Compactness
- Specific wavelength

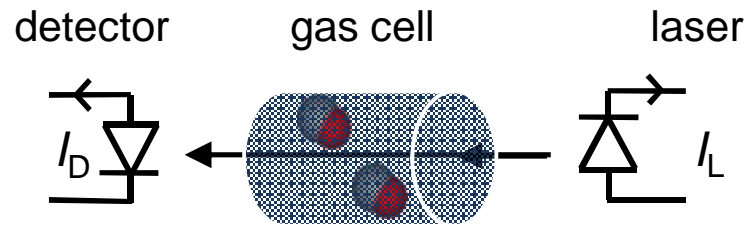


Example: Different laser diode platforms (~3000 nm)

Technology	Dissipated el. power
InP QCL	15 000 mW
GaSb ICL	100 mW
GaSb type-I	< 30 mW

GaSb laser applications: 1.8 - 4 μm

- **Sensing**



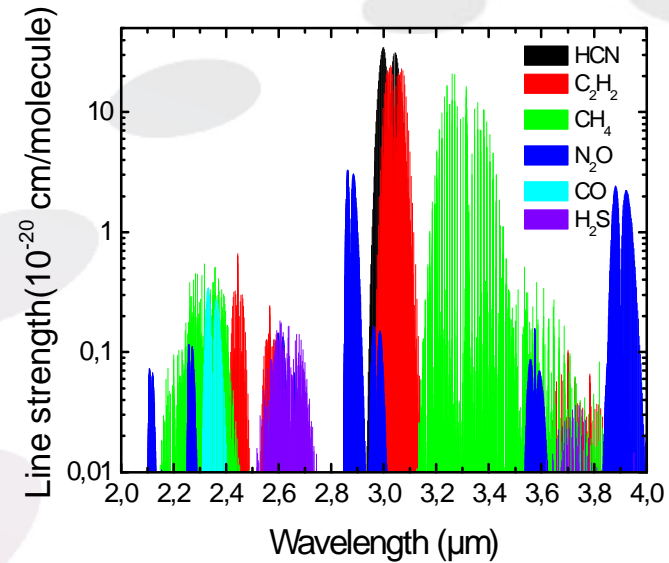
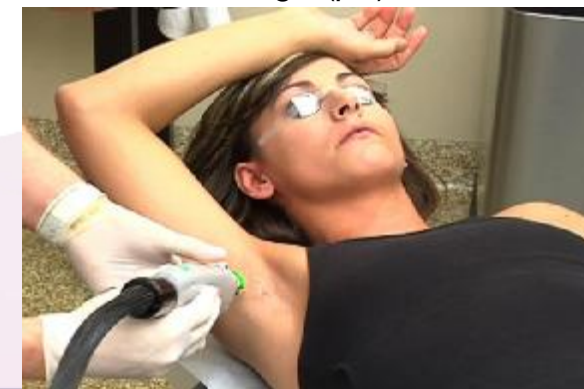
- **SAR & Defense**

- Missile CMs
- LIDAR
- Illumination



- **Medicine**

- Dermatology, hair removal
- Odontology
- Breath analysis



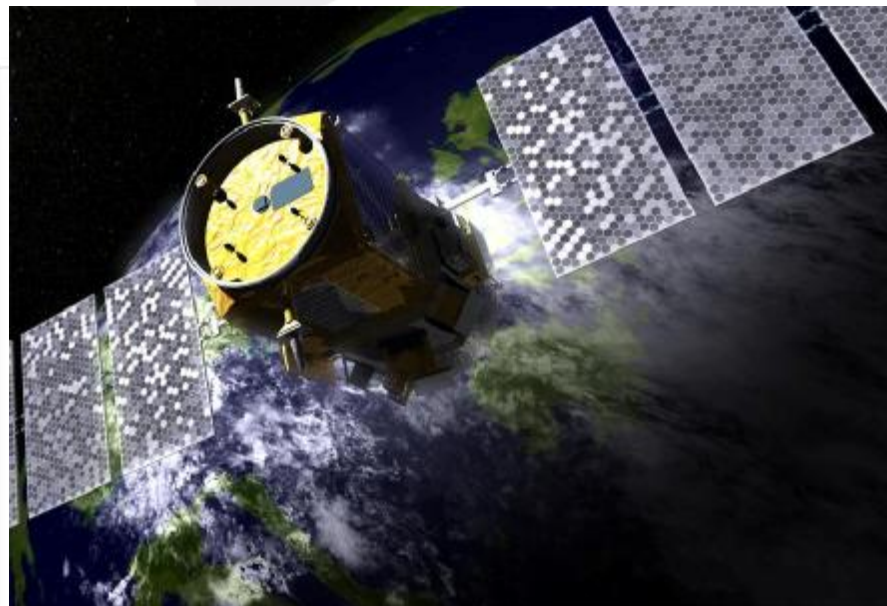
Typical applications at $\sim 2 \mu\text{m}$

- **Medical**

- Strong H_2O absorption - Low penetration depth surgery
- Replace Ho and Tm laser where performance is comparable
- Resonantly pump Ho and Tm laser for better performance

- **Space & Defense**

- LIDAR
- CO_2 sensing
- Illumination
- Missile countermeasures (IRCM)



penetration depth in tissue

Requirements for the laser source

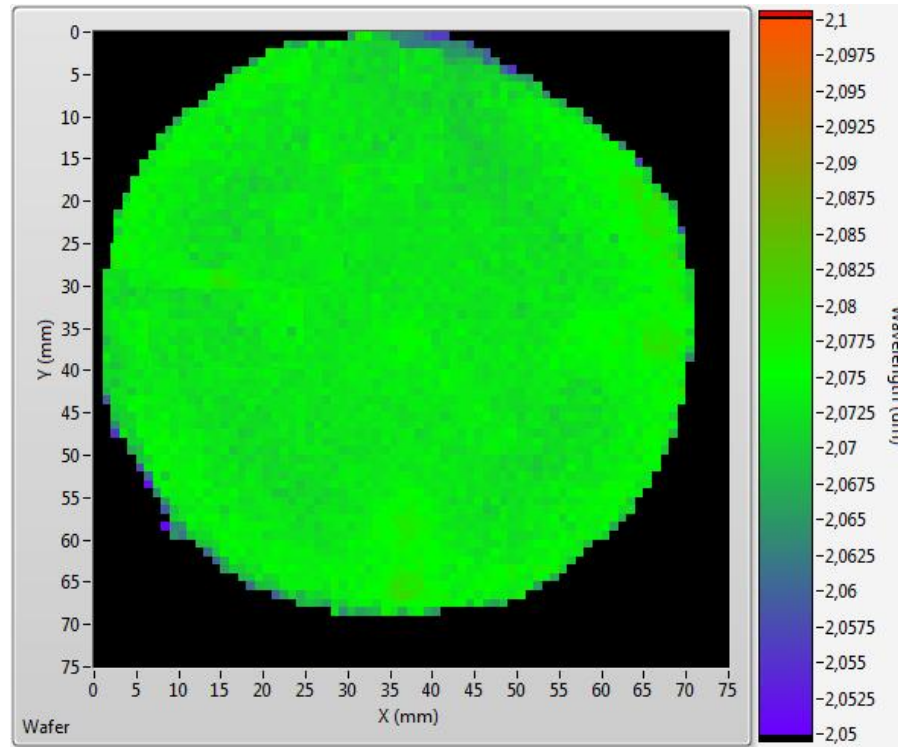
- **Medical**
 - Output power typically in the 1-30 W.
 - Wavelength compatibility
 - Beam quality
- **Space & Defense**
 - Output power: 1-10 W, 100 W, 1 kW
 - Power efficiency
 - Robustness, lifetime & reliability.
 - High-T operation
- **Sensing**
 - Single mode output
 - Power efficiency – frequency stability, field applications
 - Lifetime & reliability
 - Low-cost

Semiconductor lasers are ideal candidates

Outline:

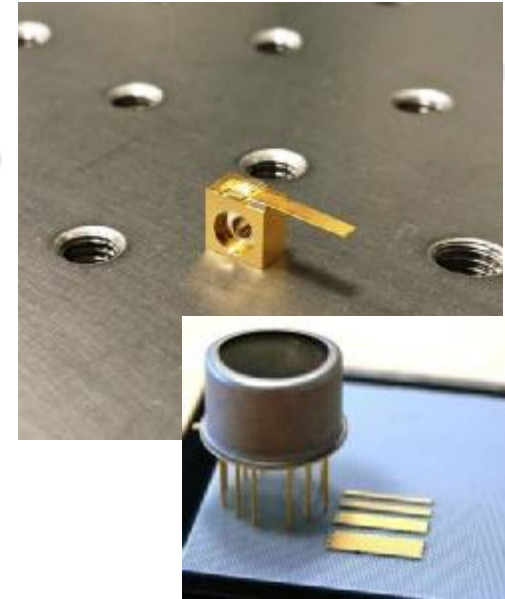
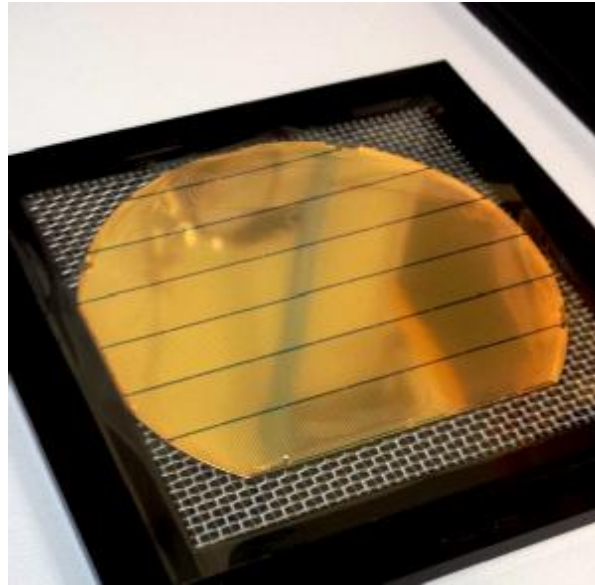
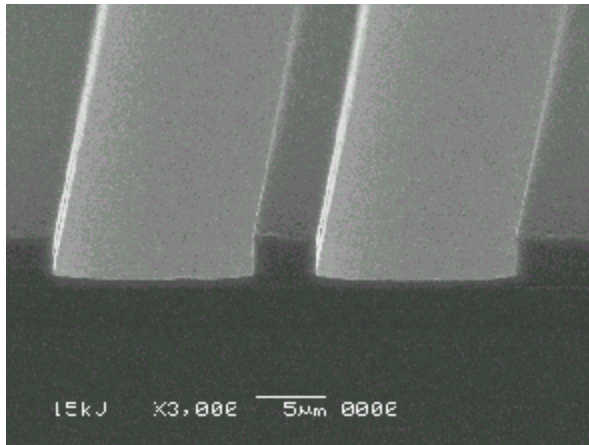
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2.1 μm devices: optical uniformity



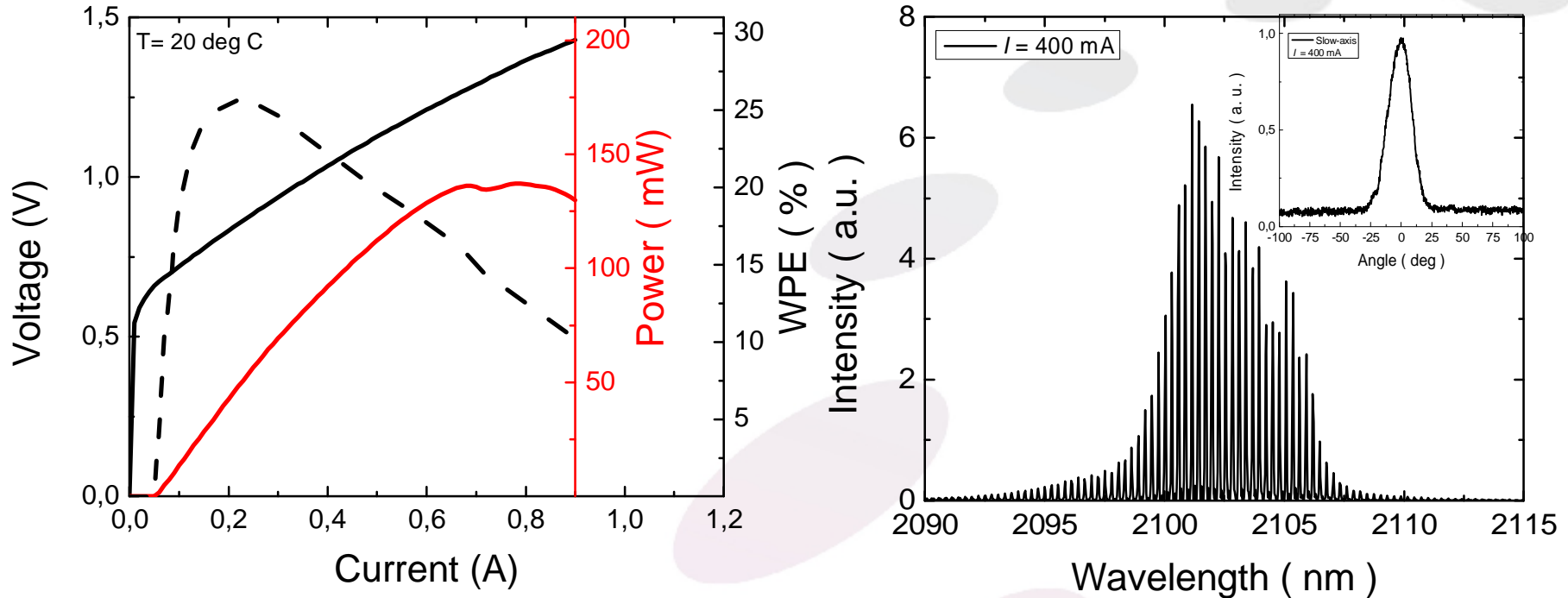
- MBE grown 3-inch GaSb substrate platform
- Multi-layer growth
- Deviation of peak R wavelength uniformity across the platform is less than 0.3 %
- **Excellent uniformity and volume scalability prospects for GaSb platform**

2.1 μm devices



- MBE grown 3-inch GaSb substrate platform
- Low-Al (10 %) containing waveguide – low fast axis divergence
- Two 1.5% compressively strained GaInAsSb QWs
- Double-trench ridge waveguide devices

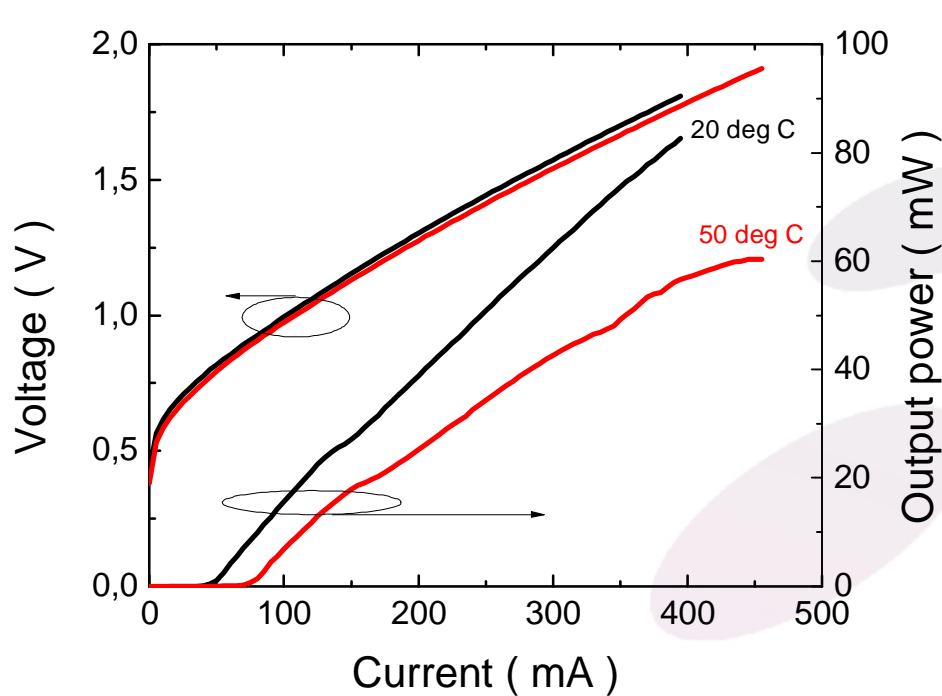
Products: Laser diodes: 2100 nm single-TE00 mode



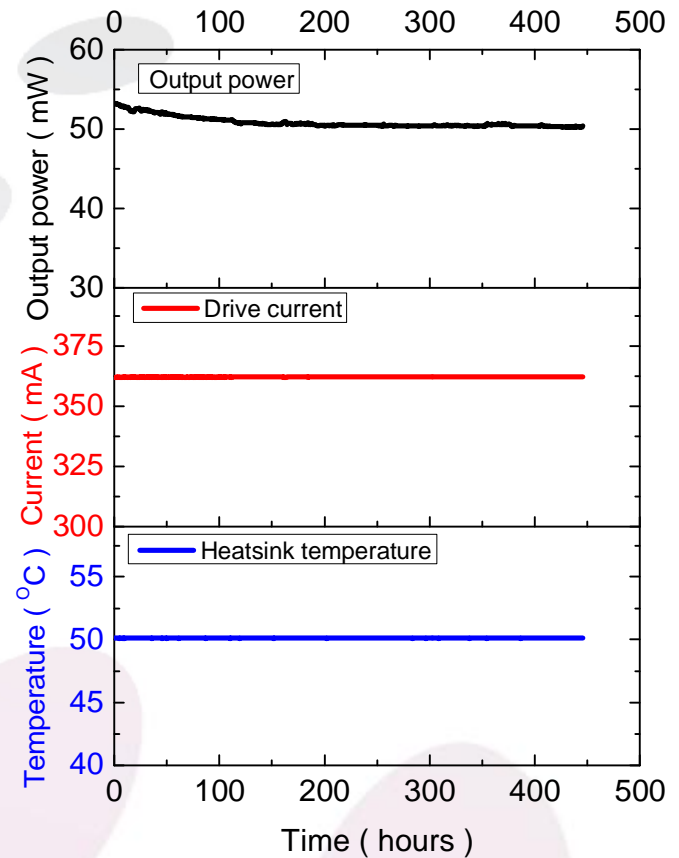
- $P_{\text{INth}} = 30 \text{ mW}$
- $\text{WPE} = 25.6 \%$
- Defense, medical, LIDAR.

Beyond state-of-the-art

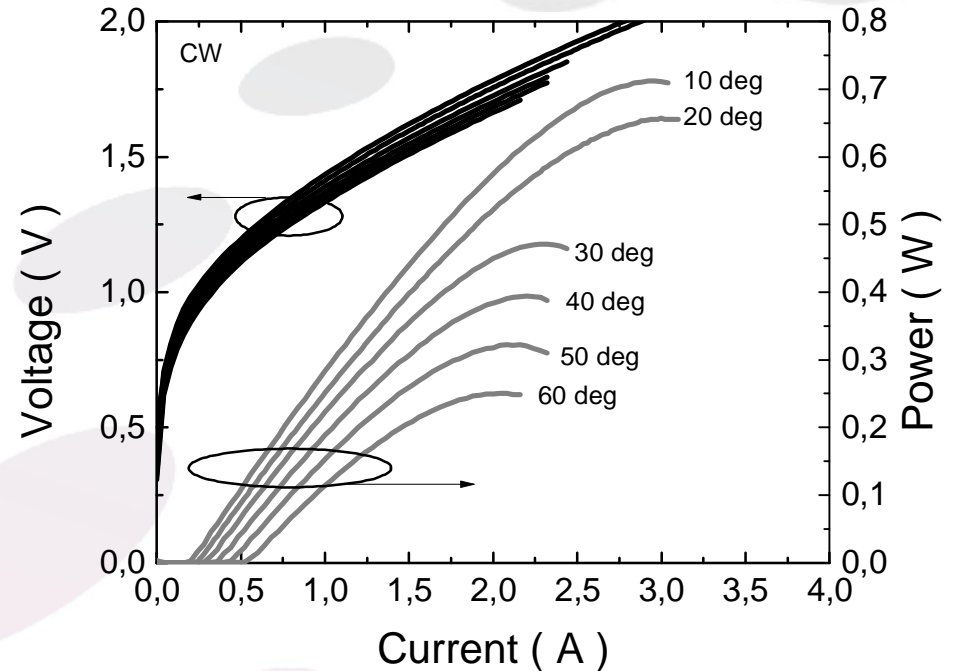
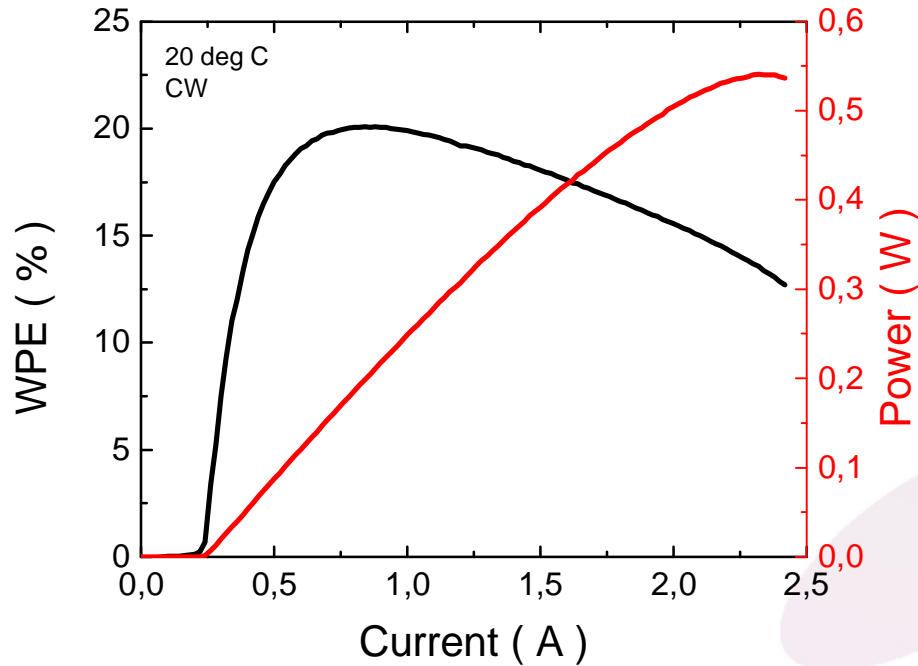
Products: Laser diodes: 2100 nm single-TE00 mode



MTTF > 10 000 hours even at 50 deg C



Products: Laser diodes: 2100 nm MM HP



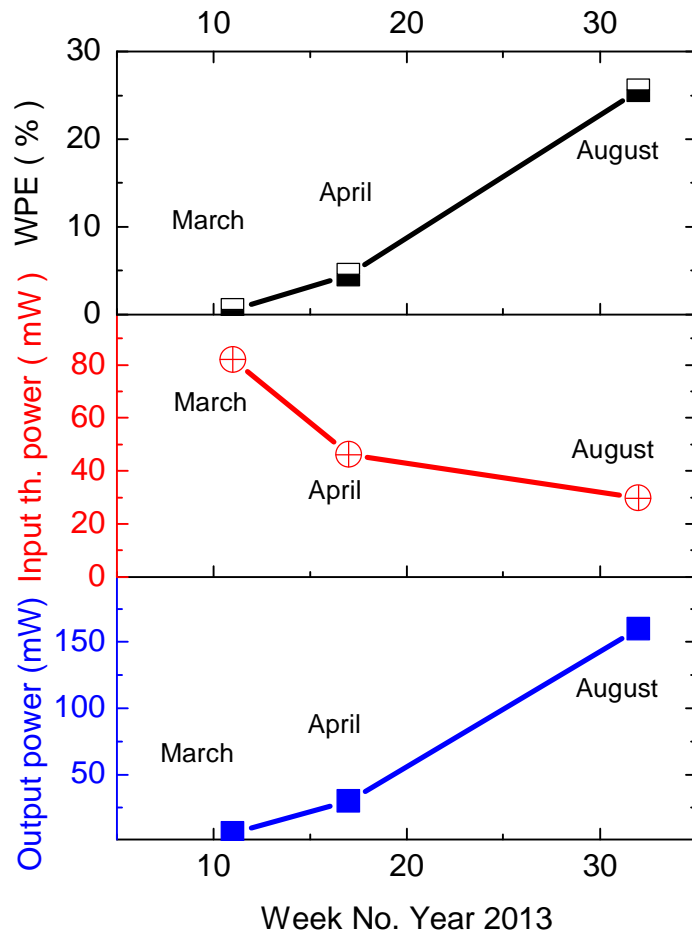
- $P_{INth} = 180 \text{ mW}$
- **WPE = 21%**
- Defense, medical, LIDAR.

State-of-the-art

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Summary: Progress



Output power:

- **6 mW** (L0055) to **160 mW** (L0079)

Threshold input power:

- **82 mW** (L0055) to **29.7mW** (L0079)

Wall-plug efficiency:

- **0.5 %** (L0055) to **25.6 %** (L0079)

Tremendous progress within less than a year

Outlook:

- 1 W single emitter and > 10 W CW from a bar by the end of 2013
- Multi-10's of Watts from stacks in 2014
- High-power products in the entire 1800- 2600 nm range
- Single-mode DFB laser diodes at 2330 nm



Thank you for your attention!