APECS

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Demonstrator 3: Photonic Integration (PI)

Integration of optical and III/V components with RF flexlines and photonics wire bonds for transmitters

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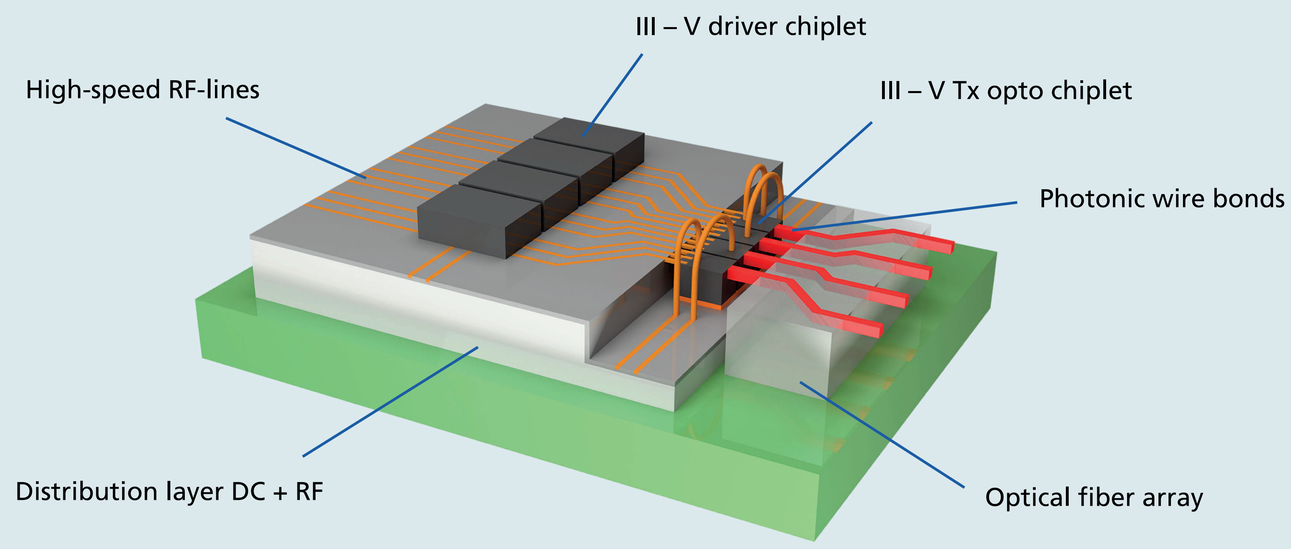
Demonstrator 3 focuses on the development and validation of a hybrid-integrated photonic–electronic high speed transmitter module. We address two levels of development. On the one hand the components, like the InP EML and the InP-HBT driver, on the other hand the interconnection technologies, like HF-Flexlines, photonic wire bonds and 3D interposer assembly.

Demonstrator Description

A hybrid integrated high shoreline density o-band 4 channel transmitter (4x200Gbps PAM4) for I/O in HPC systems will be realized. The transmitter will consist of the EML-4-array chip 4 EML drivers, electrical RF feeding lines and an optical connection to a 4-fiber array. All components will be mounted on a common interposer. For the electrical connection between EML driver and EML polymer-based RF flexlines will be used. The optical connection between the EML output facets and the fiber arrays will be realized with Photonic Wire Bonds.
The functions of the interposer are three-fold: as carrier for EML drivers, EML array and fiber array, as electrical connection between connector and EML driver and for efficient vertical heat dissipation.

Schematics of the Hybrid-integrated Photonic–Electronic high speed Transmitter Module



EML-4-Array
Benchmark InP based EML-4-arrays with 375µm pitch allowing for 4 x 290 Gbps PAM4 modulation have been successfully developed, fabricated and tested. Respective results will be published at the optical Fiber Conference 2026 in Los Angeles. The final target is to achieve a pitch of 250 µm only without impeding the high-speed performance and avoiding any crosstalk between the adjacent EMLs on the array. Respective work is ongoing.

Example of an EML 4-array (top)
RF flex lines with Au stud bumps (bottom)
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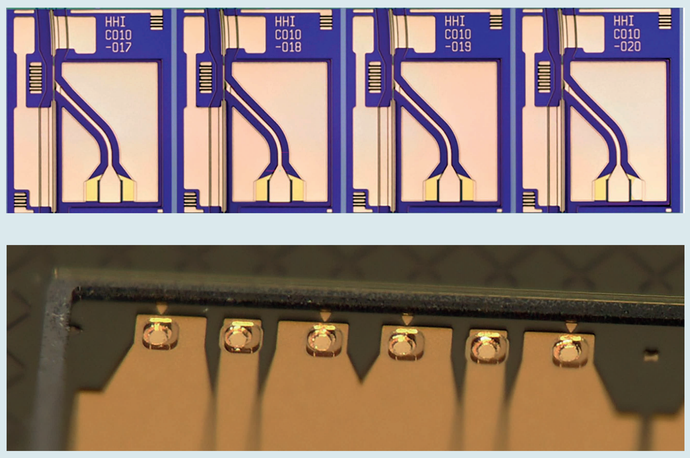

RF Flexlines
Polymer based RF flexlines have been developed with an electrical bandwidth exceeding 200GHz and thus suitable for the high speed connection between EML and EML driver. Work now focusses on the realization of Au stud bumps allowing for the flip chip mounting of these RF-flexlines on the EML array high speed contacts.

Photonic Wire Bonds
For the optical interface between the EML array and the fiber array Photonic Wire Bonds will be used. A first successful demonstration of a multi channel optical coupling to a fiber array using this technique was realized. Ongoing work now focusses on the optimization of the EML output facet / Photonic Wire Bond interface regarding low optical losses and ultralow reflection.

3D printed Photonic Wire Bond
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EML driver
The distributed topology is the most promising choice to design ultra-wideband (beyond 100% relative bandwidth) driver amplifiers with highly linear and low phase dispersion characteristics. Five unit-cells, each a tricode, are placed equidistantly and connected at transistor input and output, forming an upper and lower transmission line. The individual subcells with their inherent capacitance compensate the inductance of the pieces of transmission line for their respective section. The layout of the distributed amplifier is provided in the figure. A tricode based distributed amplifier provides very high bandwidth from DC to 175 GHz with >14 dBm RF output power. The gain bandwidth product of the amplifier reaches 697 GHz, an output power of ~ 10 dBm and a power added efficiency of > 5% are obtained. Further scaling of the transistors will provide even better performance with a predicted DC - 200 GHz bandwidth and 15 dB gain soon.

InP HBT-based driver MMIC
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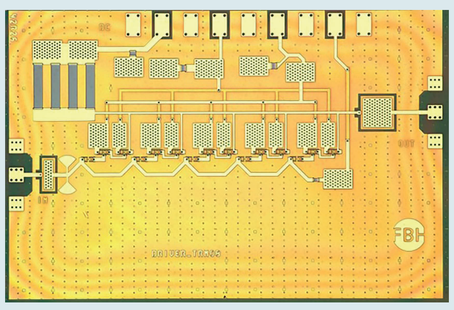

Interposer
A Si interposer will be used for the hybrid integration of the transmitter. This interposer will carry the RF feeding lines for the EML driver. The interposer will be optimized regarding efficient heat dissipation and as short as possible electrical RF connections to avoid electrical losses. Furthermore, the interposer will also carry the fiber array connection.

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Additional information

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