



DEMAND: Deterministic Electrically-driven Monolithic Architecture for quantum Network Distribution

QuantERA Call 2025 (AQS)



University of Sheffield

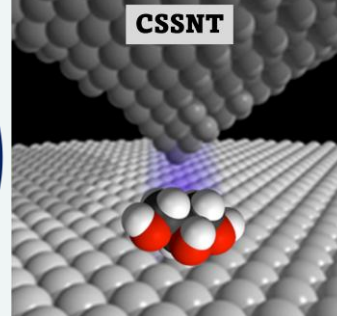
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Motivation and objectives

The bottleneck

- **Deployability gap**
Current high performance deterministic single photon sources (SPS) rely on bulky, off-chip lasers and complex optical alignment.
- **Telecom compatibility**
Existing monolithic sources lack on-demand, deterministic excitation and operate outside telecoms bands.

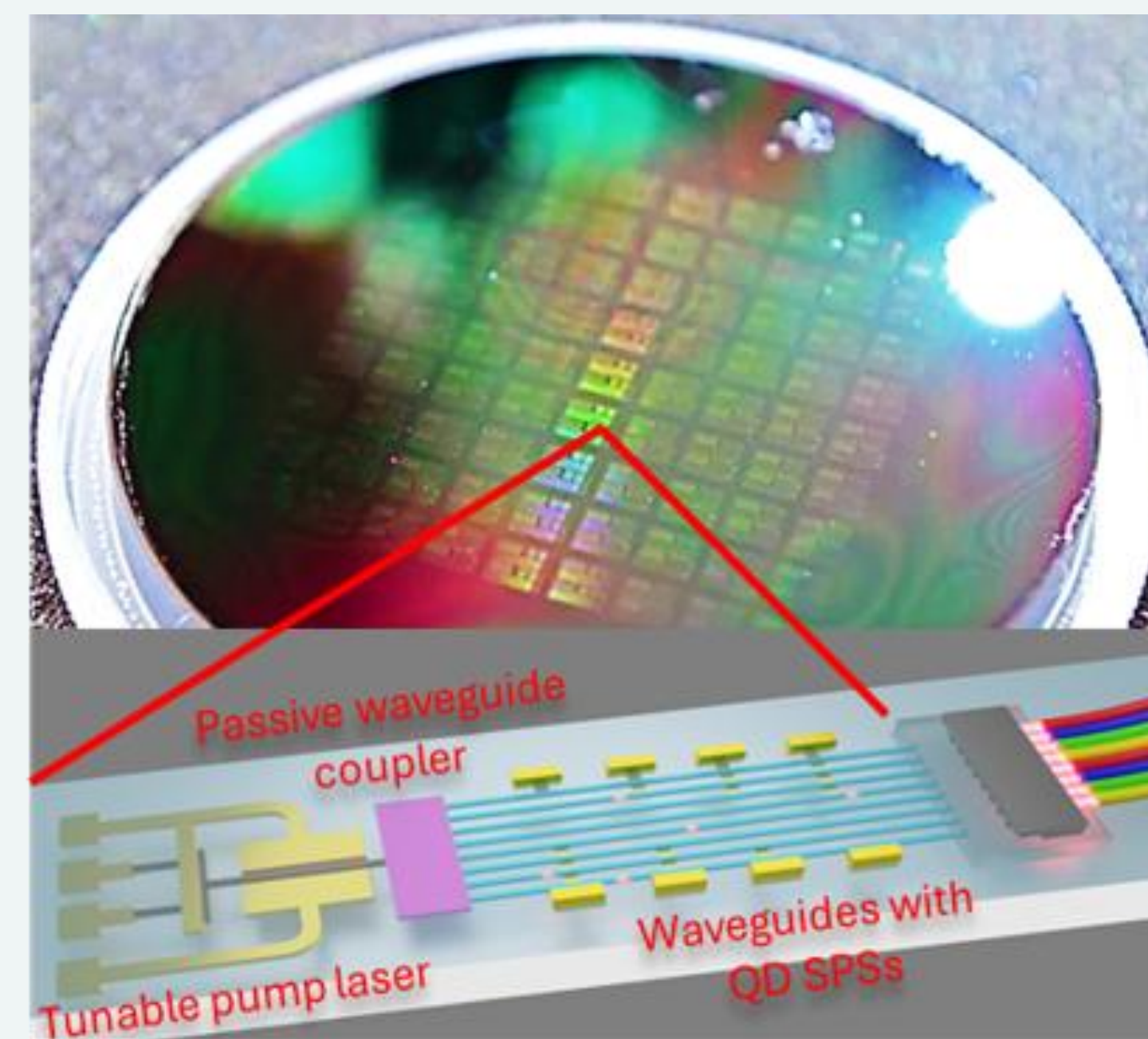
The solution

First monolithic telecom C-band SPS integrating pump lasers, passive circuitry, and quantum dot (QD) SPS, all on a single Indium Phosphide (InP) chip. Uses MOVPE butt-joint regrowth with InP-Membrane-on-Silicon (IMOS) fabrication.

Primary Technical Objectives

1. **MOVPE butt-joint regrowth (BJR):** Co-integrate high-density QD gain media ($> 10^{10} \text{ cm}^{-2}$) with low-density QD SPS sections ($1 \times 10^9 \text{ cm}^{-2}$) on InP.
2. **Electrically driven PIC:** Realise near-resonant QD excitation via directly modulated lasers (DML) and mode-locked lasers (MLL).
3. **High-Speed Deterministic Emission:** Achieve single-photon generation at $> 1 \text{ GHz}$ rep rates in the telecom C-band.
4. **Network Field Validation:** Demonstrate high-rate time-to-spatial demultiplexing and entanglement swapping over the Geneva Quantum Network (GKN).

Architecture



e.g. [1] Semicond. Sci. Technol. **36**, 013001 (2021) [2] Appl. Phys. Lett. **127**, 194001 (2025)

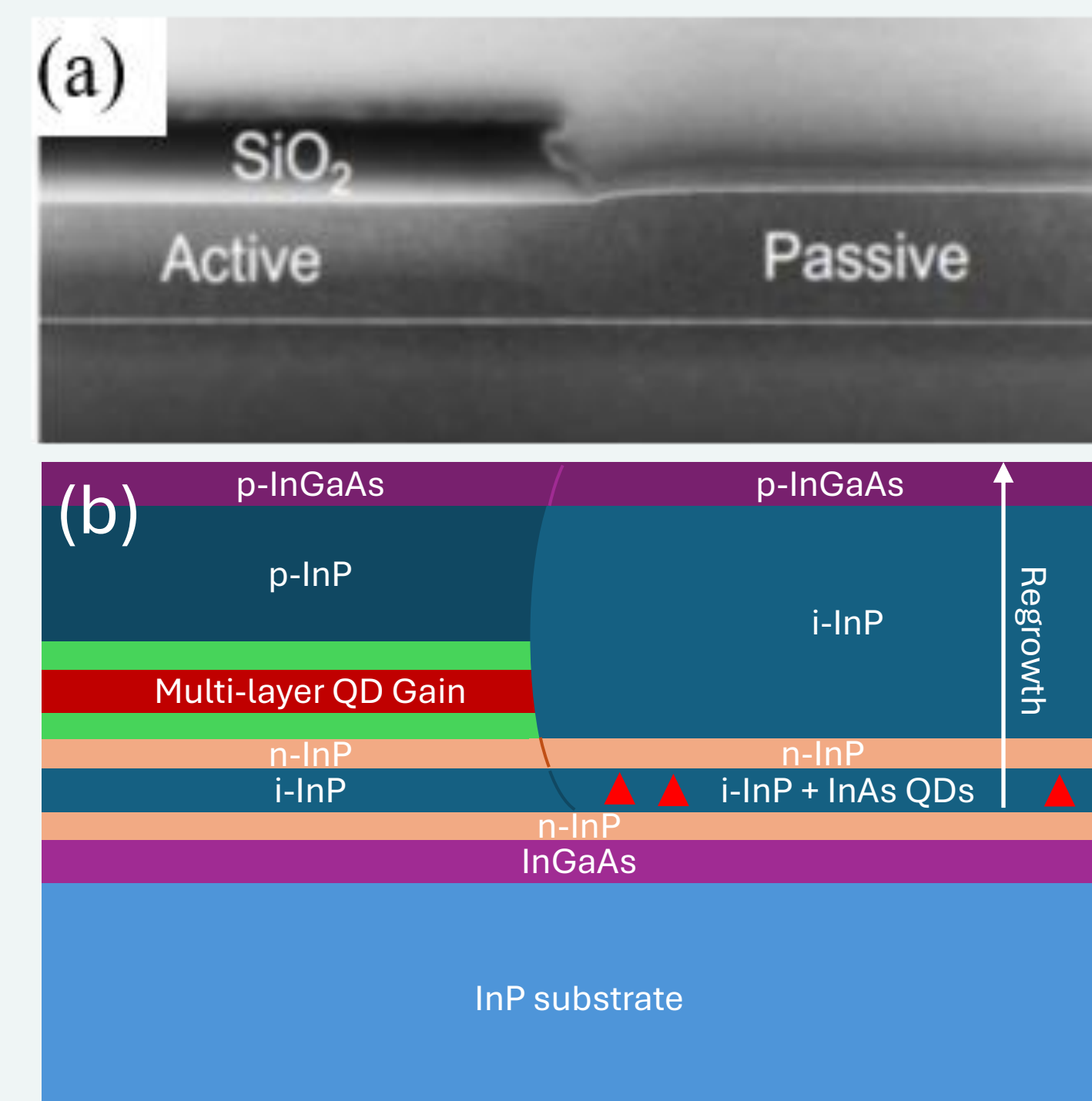


Fig 2. (a) Cross-section SEM image of BJR sample, showing SiO₂ mask, active and passive sections. (b) Schematic of proposed layer sequence incorporating gain section (LHS) and QD SPS (RHS).

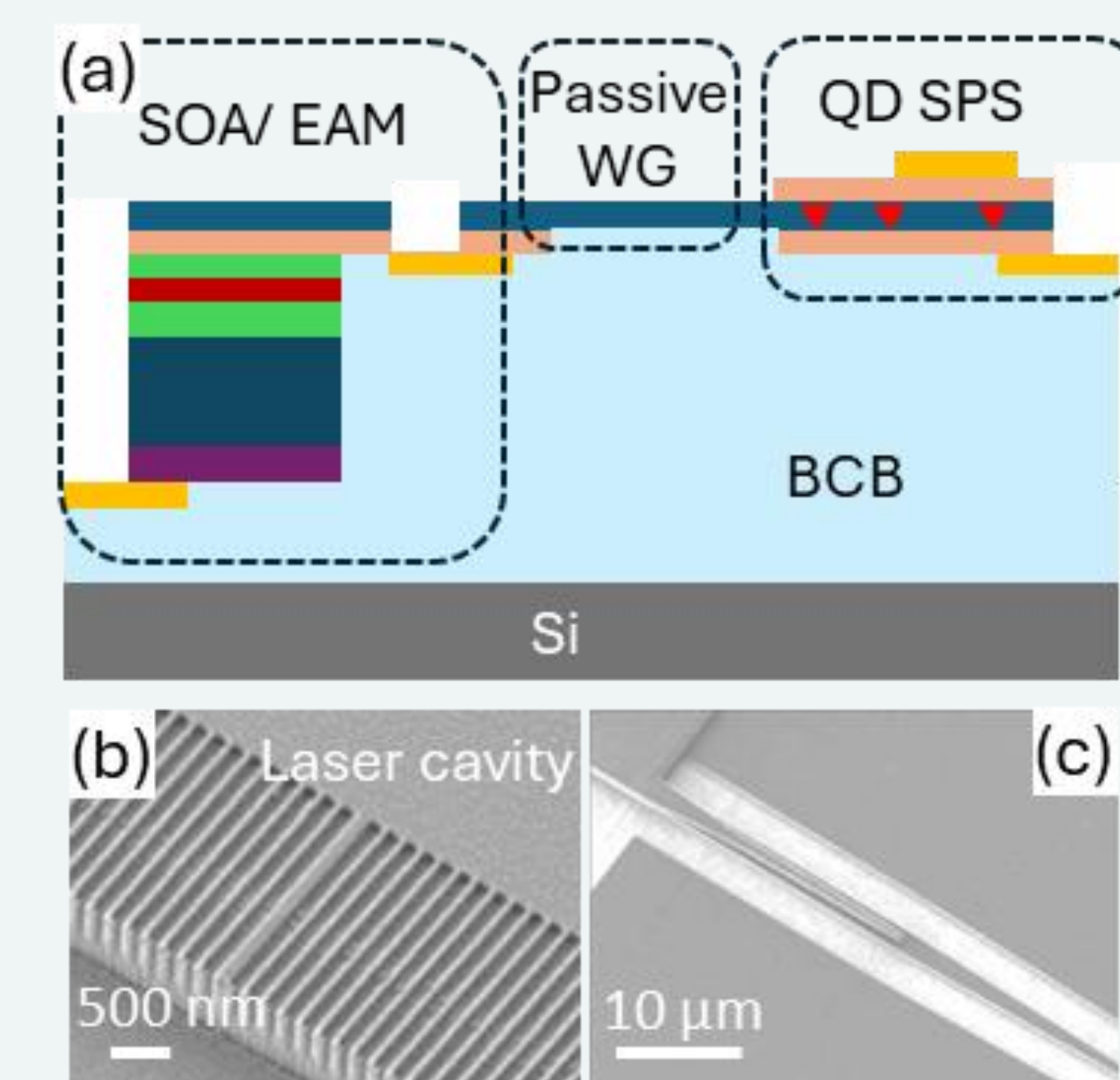
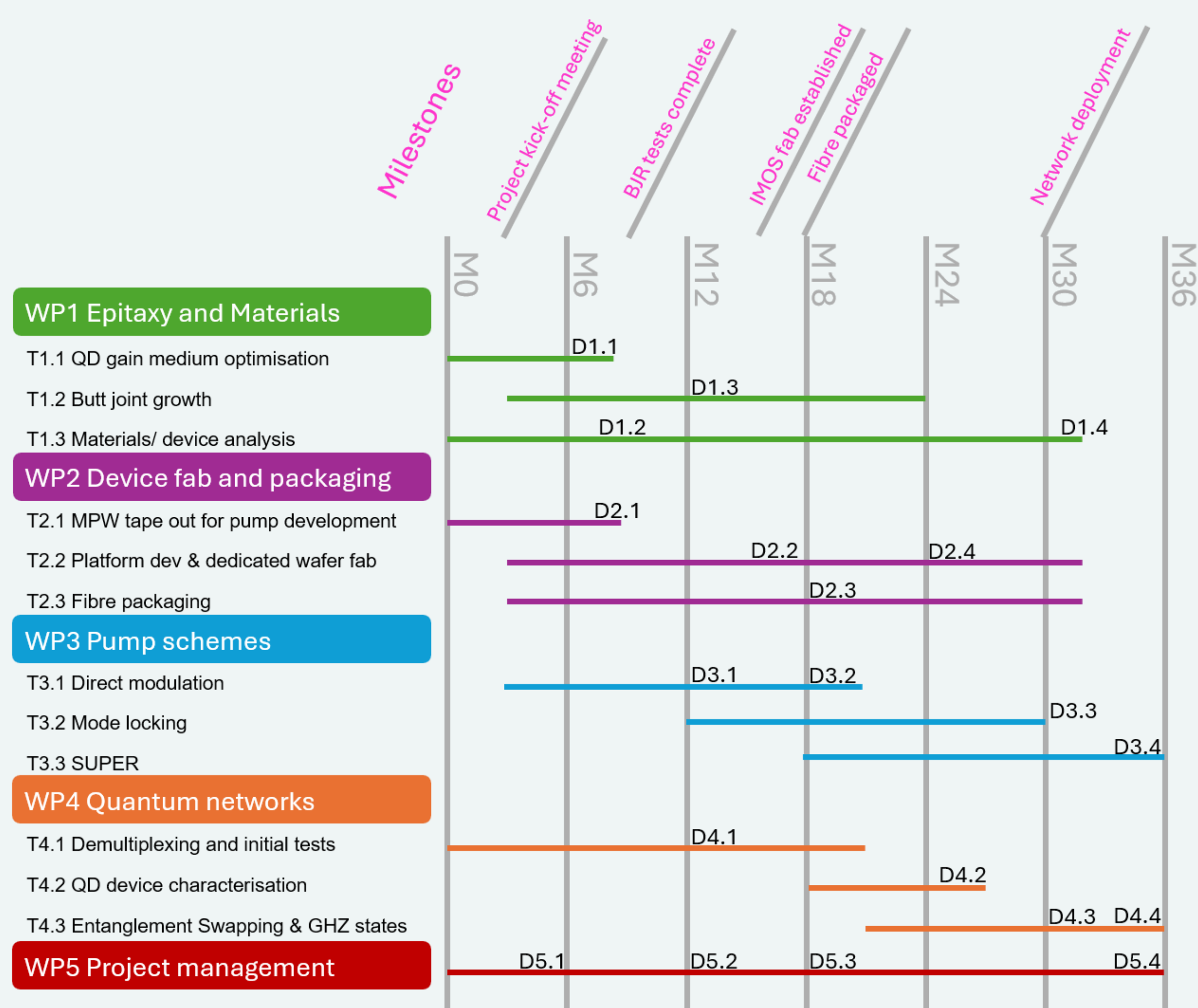


Fig 3. (a) Schematic cross-section of flip-bonded structure, showing gain/modulation section connected to QD SPS section. (b) and (c) show SEM images of exemplar laser gratings and taper connections between active/passive sections.

Project workflow



- **WP1 - Epitaxy & Materials (Lead: SHF | Partners: CSSNT)**
Key Tasks: Butt-joint regrowth (BJR) process optimisation and multi-scale metrology.
- **WP2 - Device Fabrication & Packaging (Lead: TUE | Partners: SHF, CSSNT, ICON)**
Key Tasks: PDK building blocks, IMOS MPW test runs, cryo packaging.
- **WP3 - QD SPS Pump Schemes (Lead: SHF | Partners: TUE, GEN, ICON)**
Key Tasks: DML and MLL for two-colour SUPER excitation, and ML-assisted parameter optimisation.
- **WP4 - Quantum Networks & Field Validation (Lead: GEN | Partners: SHF, AGQ)**
Key Tasks: Spatial demultiplexing, multi-photon GHZ state distribution over GQN.
- **WP5 - Management, Dissemination & Exploitation (Lead: SHF | All Partners)**
Key Tasks: Reporting, IP management, foundry-ready PDK exploitation, and commercialisation roadmap.

The team

Partner	Country	Type	Key Roles
Univ. of Sheffield	UK	Academic (Coordinator)	Lead Coordinator; MOVPE epitaxy & regrowth; QD pump schemes
TU Eindhoven	NL	Academic	IMOS platform design nanofabrication & pump laser development
POLITEHNICA Bucharest	RO	Academic	Advanced materials metrology structural & electrical interface analysis
Univ. of Geneva	CH	Academic	Quantum network protocols; PNR-SNSPD detection; demultiplexing GQN deployment
ICON Photonics	FR	High-Tech SME	Cryogenic 3D polymer micro-optics; spot-size converters; multi-channel packaging
Aegiq Ltd	UK	High-Tech SME	Network emulator testbed; PQC hardware targets; commercialisation roadmap