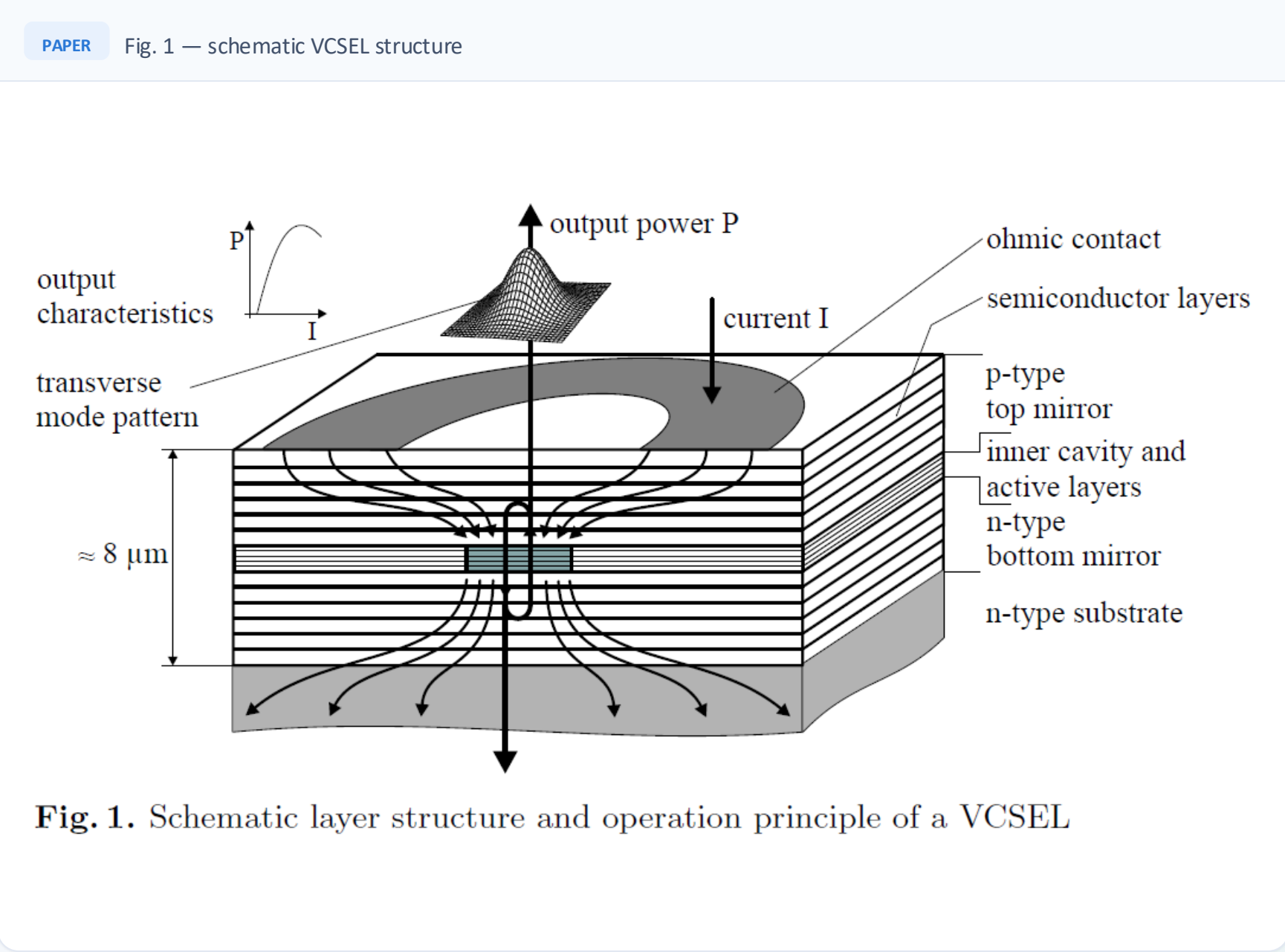


Phazic reproduces the Michalzik–Ebeling VCSEL

Layer-for-layer against “Operating Principles of VCSELs” (Michalzik & Ebeling, Springer) — the 980 nm DBR and full device device

Paper schematic vs the Phazic layer stack

The paper's Fig. 1 schematic, and the Fig. 4 mirror rebuilt in Phazic: incident $\text{Al}_{0.3}\text{Ga}_{0.7}\text{As}$ · 18 quarter-wave GaAs/AlAs pairs (36 layers) · transmitted to air.



Michalzik & Ebeling · “Operating Principles of VCSELs” · Springer · GaAs/AlAs quarter-wave DBR at 980 nm

$\text{Al}_{0.3}\text{Ga}_{0.7}\text{As}$ — incident

n_0

GaAs high index

AlAs low index

$\times 18$

$\lambda/4$

Air — transmitted

$n = 1.0$

DESIGN λ

980 nm

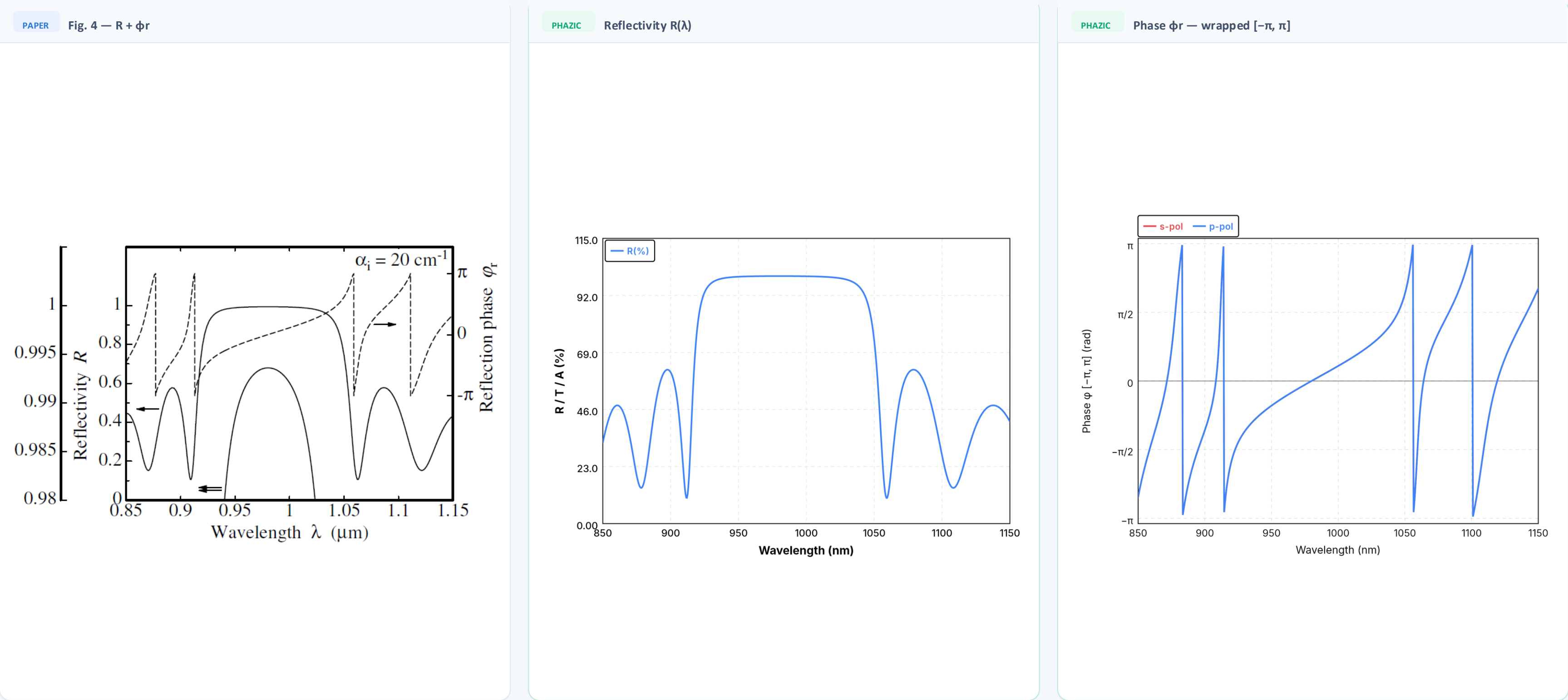
LAYERS

36

PAIRS

18

FIGURE 4 Reflectivity R and reflection phase ϕ_r



✓ Four side-lobes reproduced to within a few nm, and the wrapped phase crosses zero smoothly across the stop-band with $\pm\pi$ jumps sitting on the R-minima.

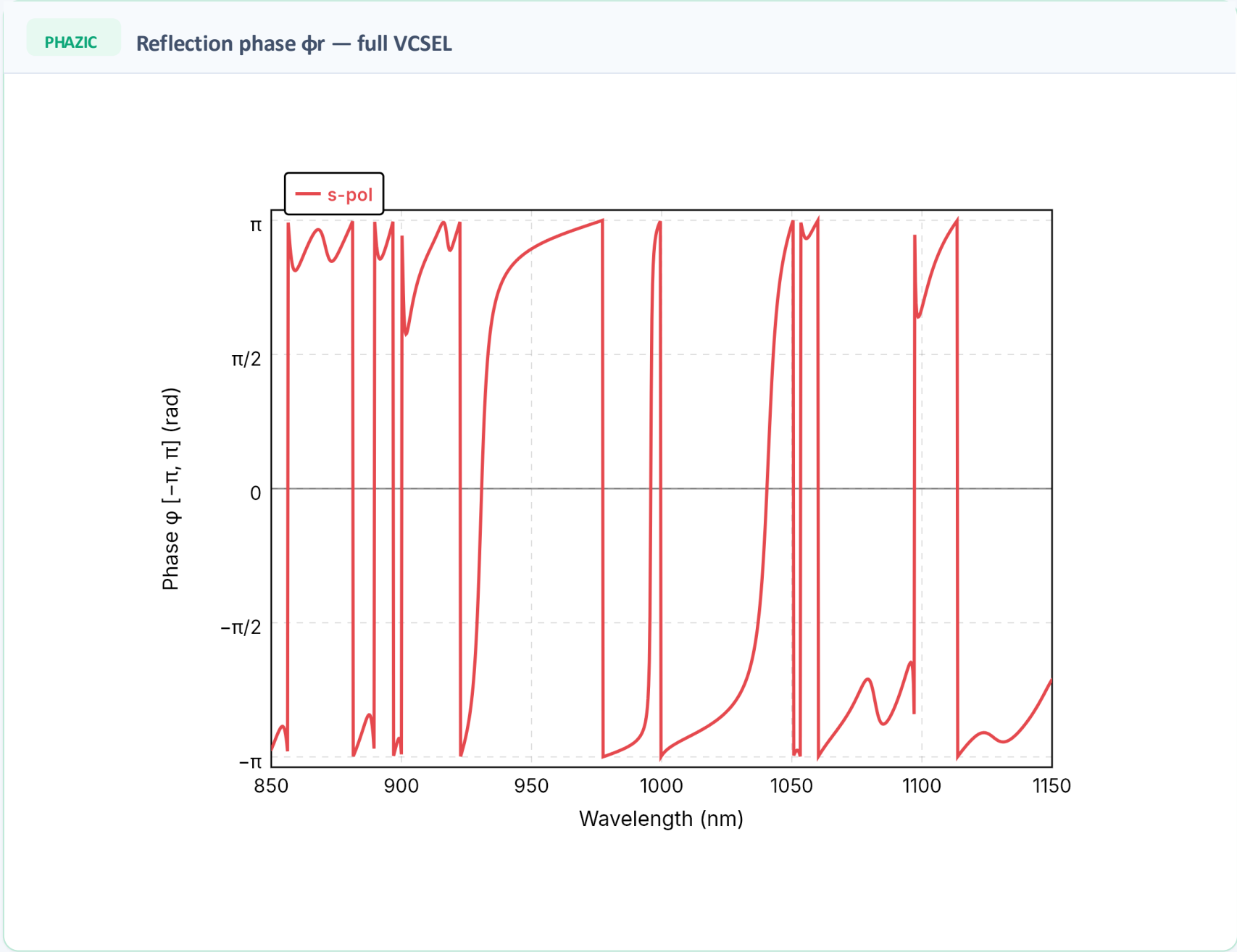
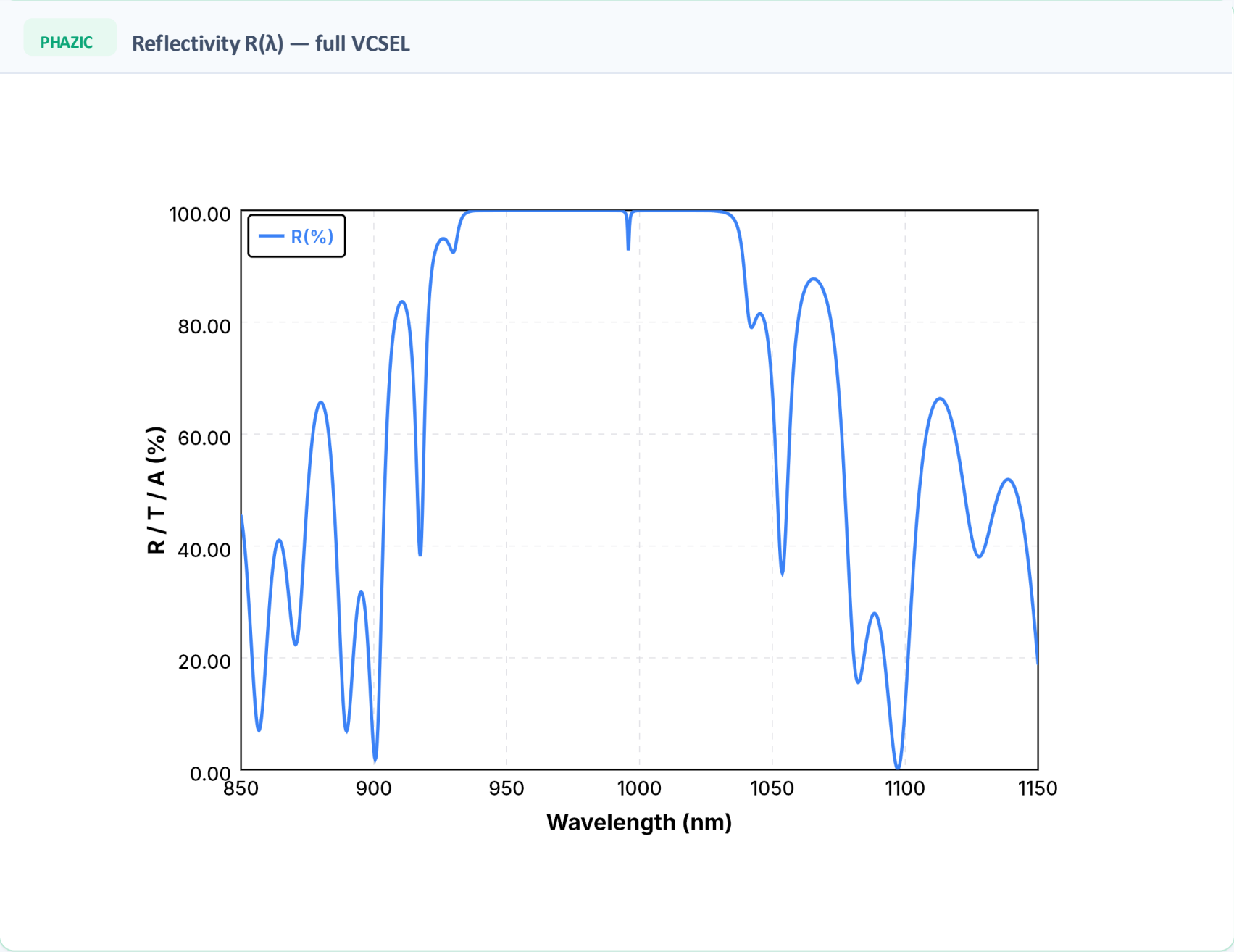
Feature for feature, R and phase line up

FEATURE	PAPER FIG. 4	PHAZIC
R side-lobes (each side)	$2 + 2 = 4$	$2 + 2 = 4$
R-minima (nm)	$875 \cdot 915 \cdot 1060 \cdot 1115$	$878 \cdot 912 \cdot 1060 \cdot 1108$
Stop-band centre	$\sim 980 \text{ nm}$	$\sim 980 \text{ nm}$
Phase φ_r at centre	crosses 0 (smooth)	crosses 0 (smooth)
Phase sawtooth jumps	$4 (\pm \pi)$ at R-minima	$4 (\pm \pi)$ at R-minima
Phase axis	$-\pi \dots \pi$	$-\pi \dots \pi$ (wrap)

✓ Every R-minimum lands within $\sim 3 \text{ nm}$, and the reflection phase reproduces the textbook's dashed φ_r exactly — smooth through the stop-band, sawtooth on the minima.

The complete 92-layer device — cavity resonance

18-pair GaAs/Al_{0.7}Ga_{0.3}As top DBR · λ -cavity with 3 InGaAs QWs · 24.5-pair GaAs/AlAs bottom DBR on GaAs. A cavity-resonance dip appears near **~995 nm** inside the stop-band — the VCSEL's band — the VCSEL's longitudinal mode.



✓ The ~2.4× thicker 92-layer stack adds finer Fabry–Pérot side-lobes and a rapid resonant phase swing at the cavity mode — the reflectance signature of the Fig. 1/6 device.

THE VERDICT

Independent solver, same VCSEL physics.

4 / 4

side-lobes & phase jumps reproduced.

~3 nm

R-minima positions, to within a few nm.

~995 nm

cavity mode captured in the full 92-layer device.

Ref: Michalzik & Ebeling · Operating Principles of VCSELs · Springer