Thunder Optics

TECHNICAL NOTE TN-002

Repeatability of a 532 nm Raman Excitation Chain

Power-step response verified through silicon Raman measurements

Laser tested: RM-T-X 532 | High-stability, TEC-cooled model

KEY MEASURED RESULT

≤1.2% repeat difference

in fitted Si Raman peak area at repeated 20 and 50 mW settings

A complete-chain measurement including the laser, delivery optics, sample interaction, Raman collection and spectral fitting. It is not an isolated laser-head specification.

Measured performance. Transparent characterization.

Revision C | 03 September 2026

01 / MEASUREMENT DESIGN

What was tested — and what was not

The experiment tested whether an adjustable 532 nm Raman excitation chain returns to the same optical response after cycling between two power settings. The laser source was the RM-T-X 532 high-stability, TEC-cooled model; it was not the standard TEC-cooled RM-T-532. A silicon wafer was used as a stable Raman reference and the fitted peak area served as an in-situ response indicator.

Acquisition conditions

- Laser: RM-T-X 532 high-stability, TEC-cooled version
- Silicon wafer; same analysis point P1
- 20× microscope objective
- ORT2 Raman spectrometer, thermally stabilized
- 500 ms integration; continuous acquisition
- Laser sequence: $20_1 \rightarrow 50_1 \rightarrow 20_2 \rightarrow 50_2 \rightarrow 20_3 \rightarrow 0$ mW
- First two spectra removed from each complete plateau
- Gaussian peak fit with local linear baseline
- One post-acquisition Si offset correction per experiment

Four complete plateaus

Plateau	Power	n
20_1	20 mW	19
50_1	50 mW	17
20_2	20 mW	19
50_2	50 mW	17

The third 20 mW plateau contained one usable spectrum only. It is reported qualitatively but excluded from same-level repeatability calculations.

Three different questions

Repeatability

Does the response return to the same value at the same setting?

Linearity

Does response scale proportionally with the power setting?

Wavelength stability

Does the laser wavelength remain constant? This was not measured directly.

Figure 1. Independent power-meter record of a stepped 532 nm sequence.

Post-acquisition Raman-axis correction

For each experiment, one constant offset was applied: $\nu_{corr} = \nu_{fit} + (520.70 - \nu_{Si,ref})$. The first stabilized plateau defined $\nu_{Si,ref}$: 10 mW for the wide sweep and 20 mW for the repeat sequence. Applied offsets: +3.432 cm^{-1} and +2.786 cm^{-1}, respectively. No spectrum-by-spectrum recentering was used; all relative shifts and branch differences are preserved. This is a local offset correction near the Si line, not a full multi-point calibration.

02 / PRIMARY RESULT

Return-to-setting repeatability

Two complete 20 → 50 mW transitions produced nearly identical fitted Raman responses. The peak-area difference between returns to the same setting was 1.16% at 20 mW and 0.50% at 50 mW.

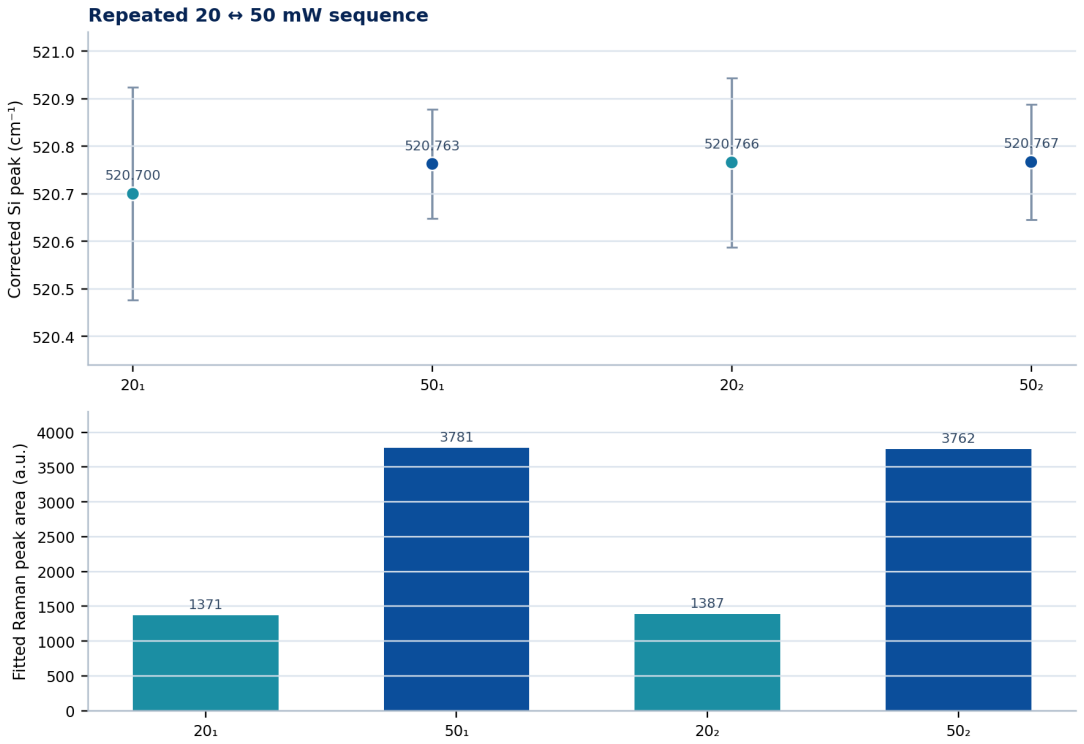

Figure 2. Post-corrected mean Si peak position (± plateau SD) and fitted peak area for four complete plateaus.

Plateau	n	Peak position	FWHM	Peak area
20_1	19	520.700 ± 0.224 cm^{-1}	13.317 cm^{-1}	1371 a.u.
50_1	17	520.763 ± 0.115 cm^{-1}	13.325 cm^{-1}	3781 a.u.
20_2	19	520.766 ± 0.178 cm^{-1}	13.250 cm^{-1}	1387 a.u.
50_2	17	520.767 ± 0.121 cm^{-1}	13.253 cm^{-1}	3762 a.u.

20 MW REPEAT

1.16%

1371 vs 1387 a.u.

50 MW REPEAT

0.50%

3781 vs 3762 a.u.

50/20 RATIO

1.66%

2.76 vs 2.71

03 / INTERPRETATION

Stable intensity, no wavelength claim

A separate 10 → 80 → 10 mW sweep showed an almost perfectly linear Raman peak-area response ($R^2 \approx 0.9997$ ascending; $R^2 \approx 0.99998$ descending). Peak position, however, was non-monotonic and differed between branches.

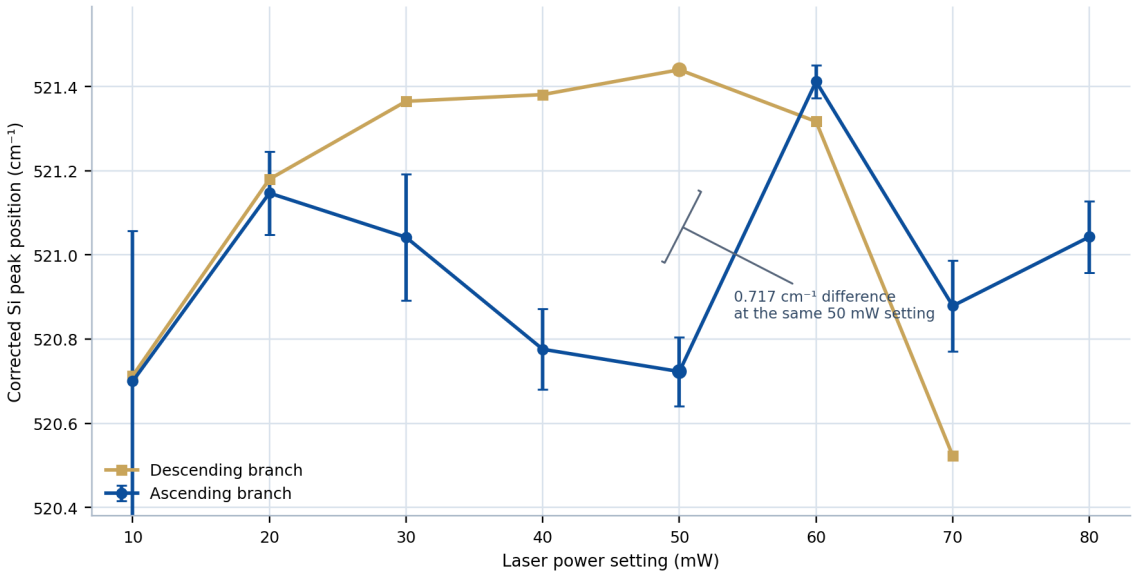

Figure 3. Post-corrected silicon peak position during both power branches. Error bars: within-plateau SD where available.

What is demonstrated

- Very linear Raman intensity response over the broad sweep
- Same-level peak-area differences of 0.5–1.2% in the dedicated repeat test
- Reproducible 50/20 response ratios: 2.76 and 2.71
- Return to the initial 10 mW peak position within 0.013 cm^{-1} after the wide cycle

What is not demonstrated

- No direct measurement of laser wavelength versus time or power
- No isolated laser-head power stability value
- No reproducible thermal redshift of the silicon peak
- The 0.717 cm^{-1} branch difference at 50 mW cannot be assigned to one cause

Scientific interpretation

The second, dedicated 20 ↔ 50 mW sequence did not reproduce the apparent redshift seen in part of the wide sweep. A small excitation-wavelength drift and/or spectral-axis drift remains plausible, but the present data do not identify the cause. The result should therefore be presented as response repeatability, not wavelength stability.

NEXT VALIDATION — DIRECT LASER CHARACTERIZATION

- Record optical power continuously at each fixed setting after warm-up
- Measure 532 nm wavelength simultaneously with ≤0.01–0.02 nm resolution

Power stability | Setting repeatability | Wavelength drift