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FIG. 1A

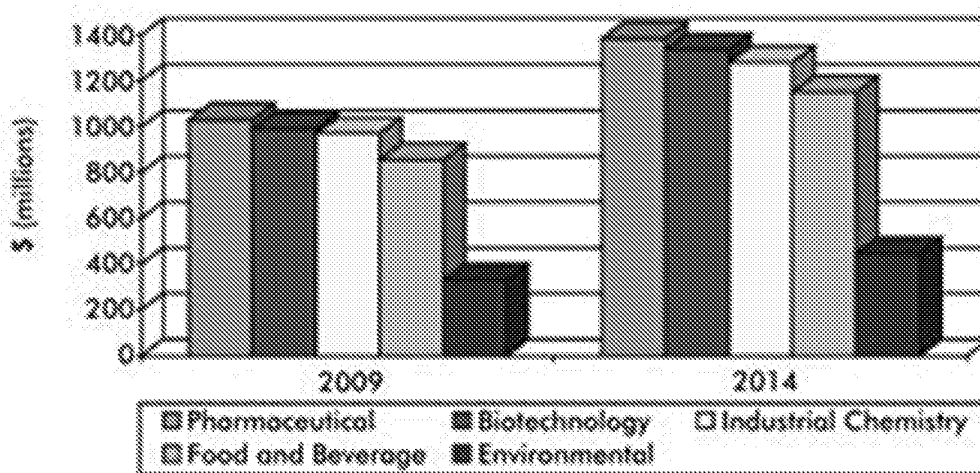
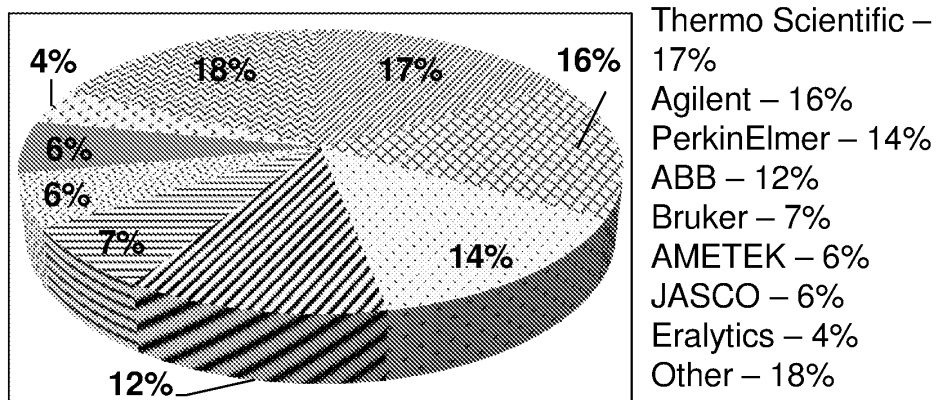
100a

FIG. 1B

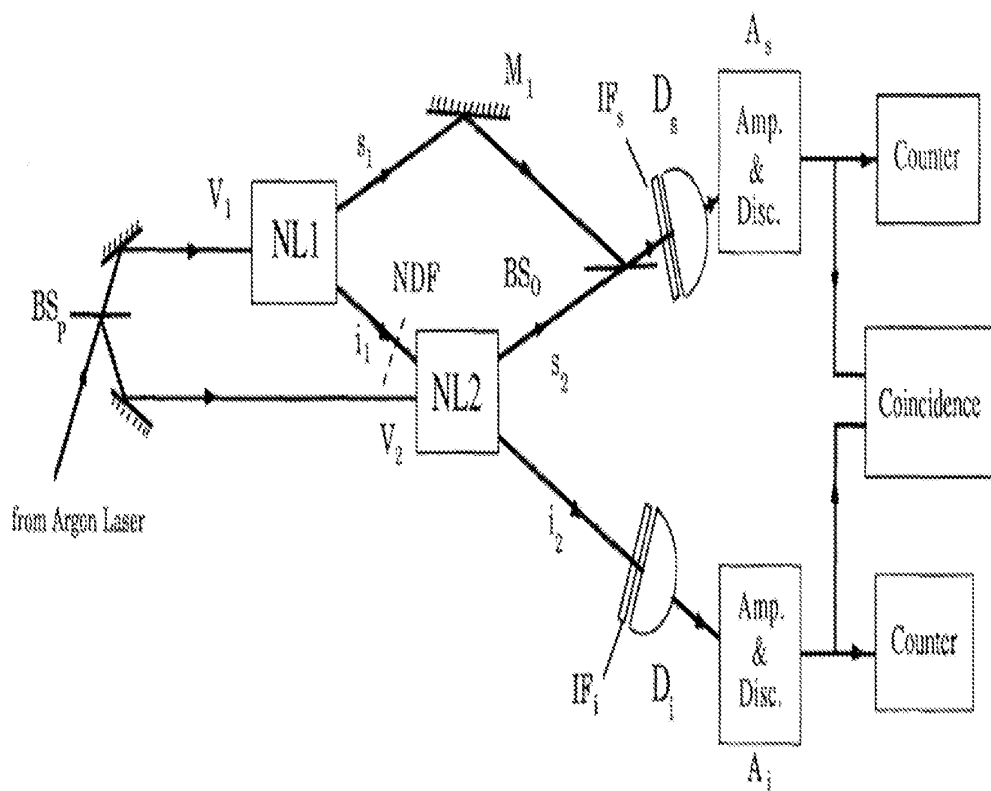
100b

Example: Petrochemical FT-IR and FT-NIR vendor share in 2011.



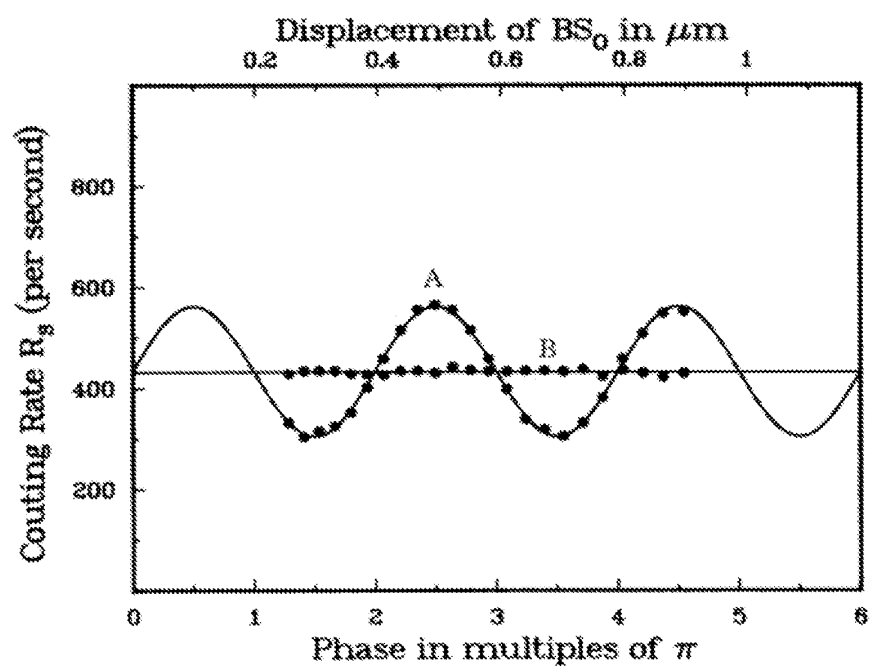
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FIG. 1C

100c

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FIG. 1D

100d

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FIG. 1E

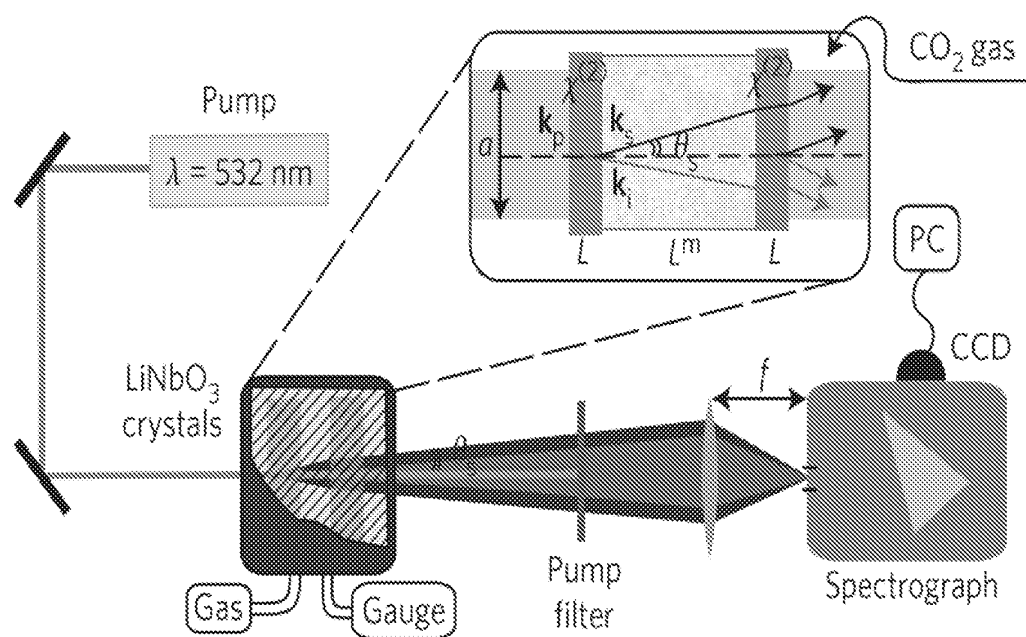
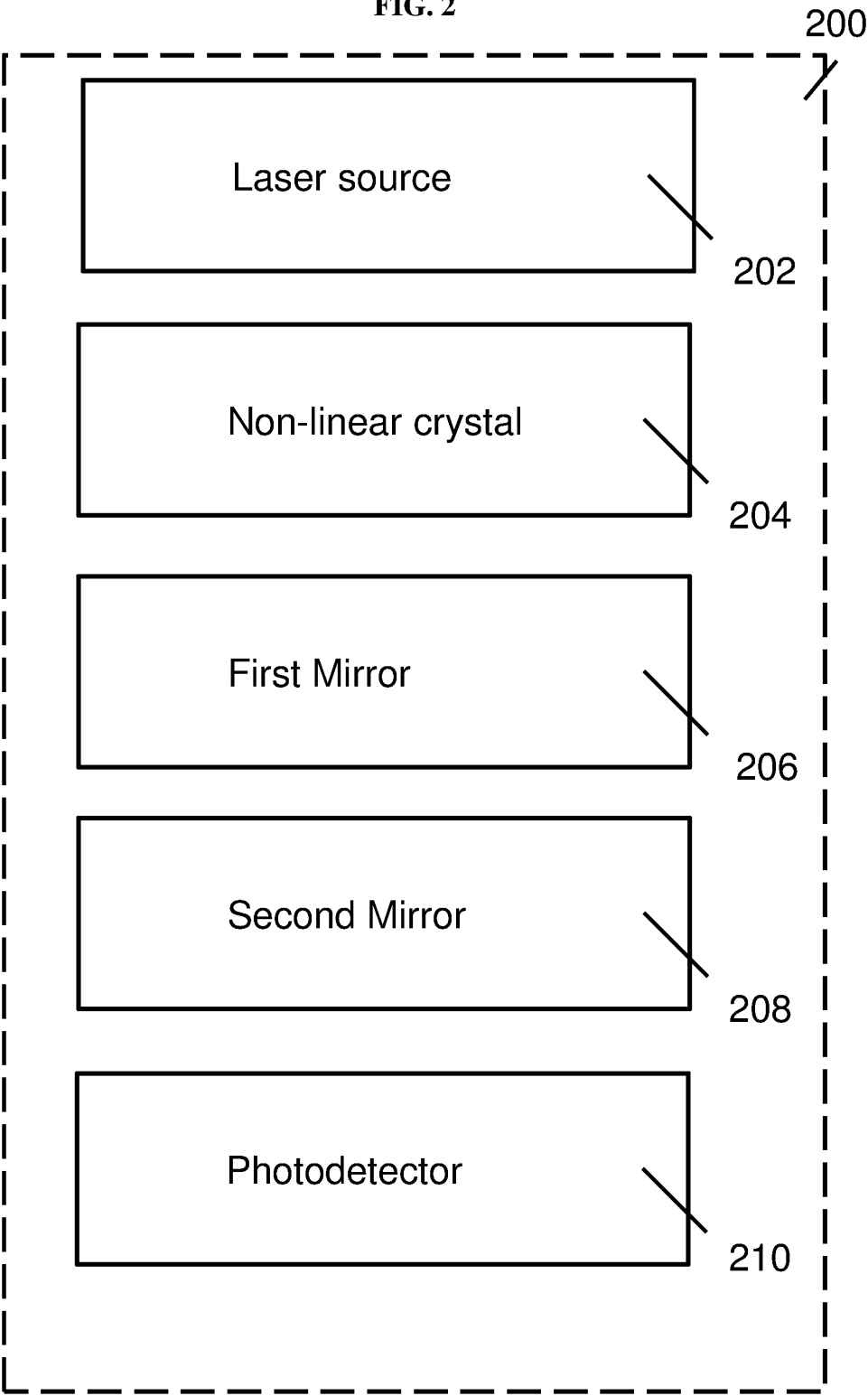
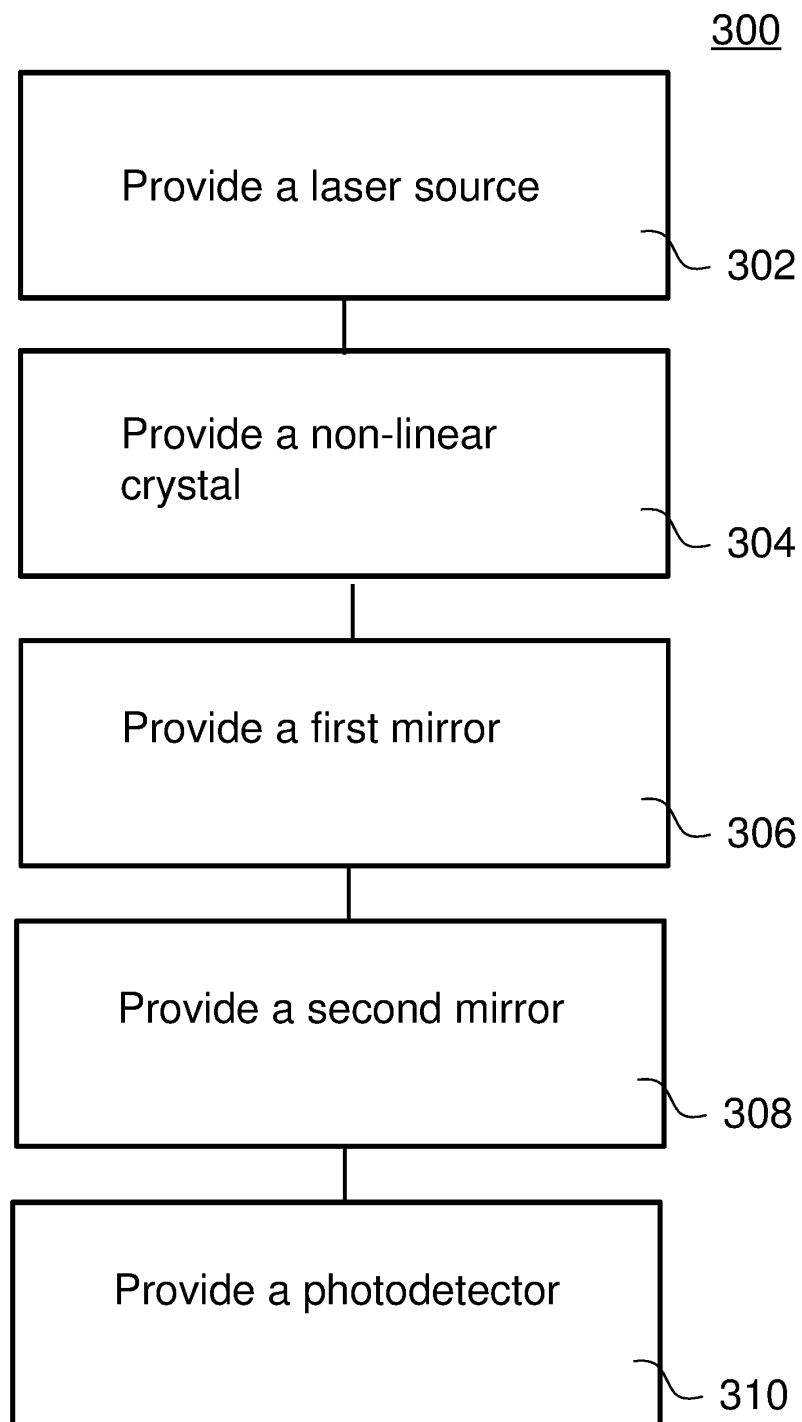
100e

FIG. 2



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FIG. 3

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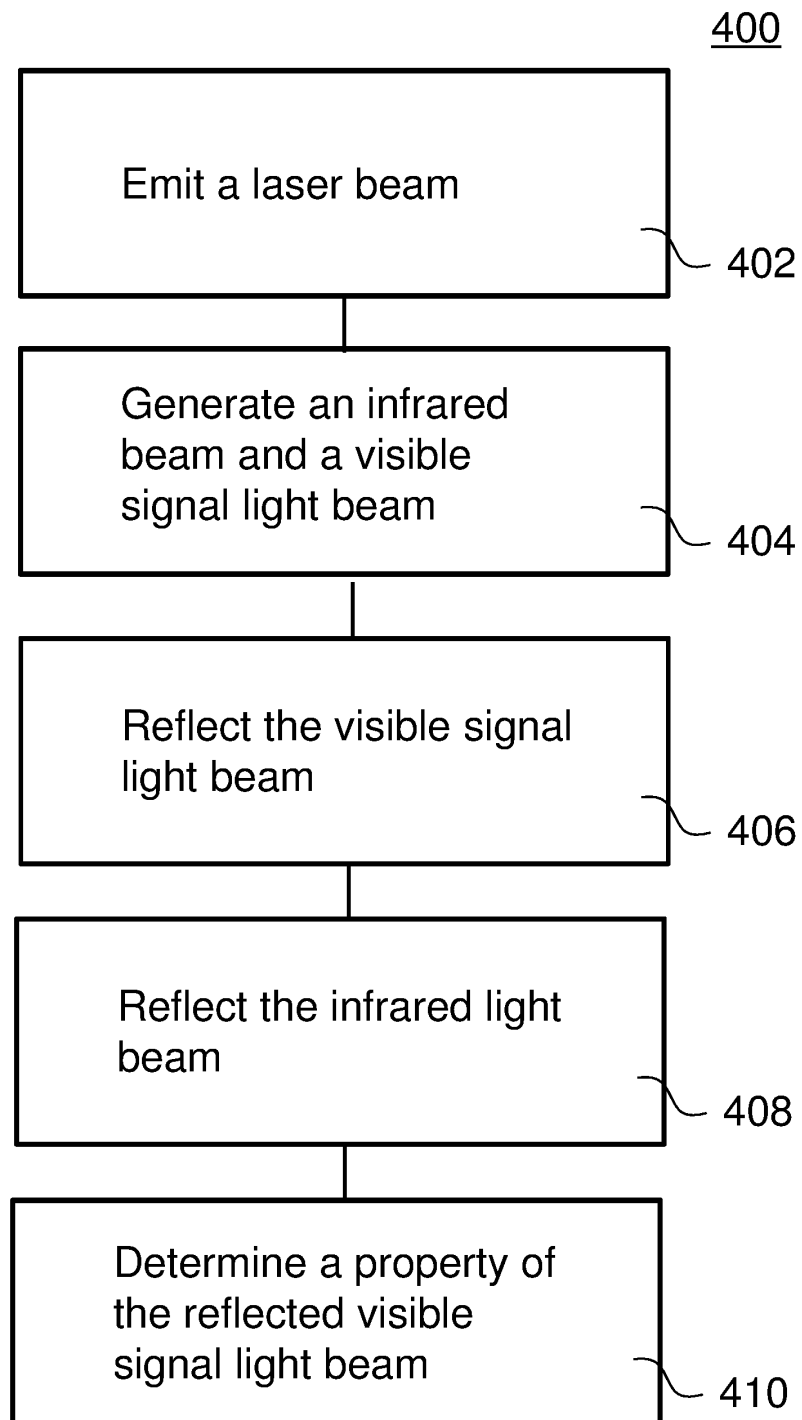
FIG. 4

FIG. 5A

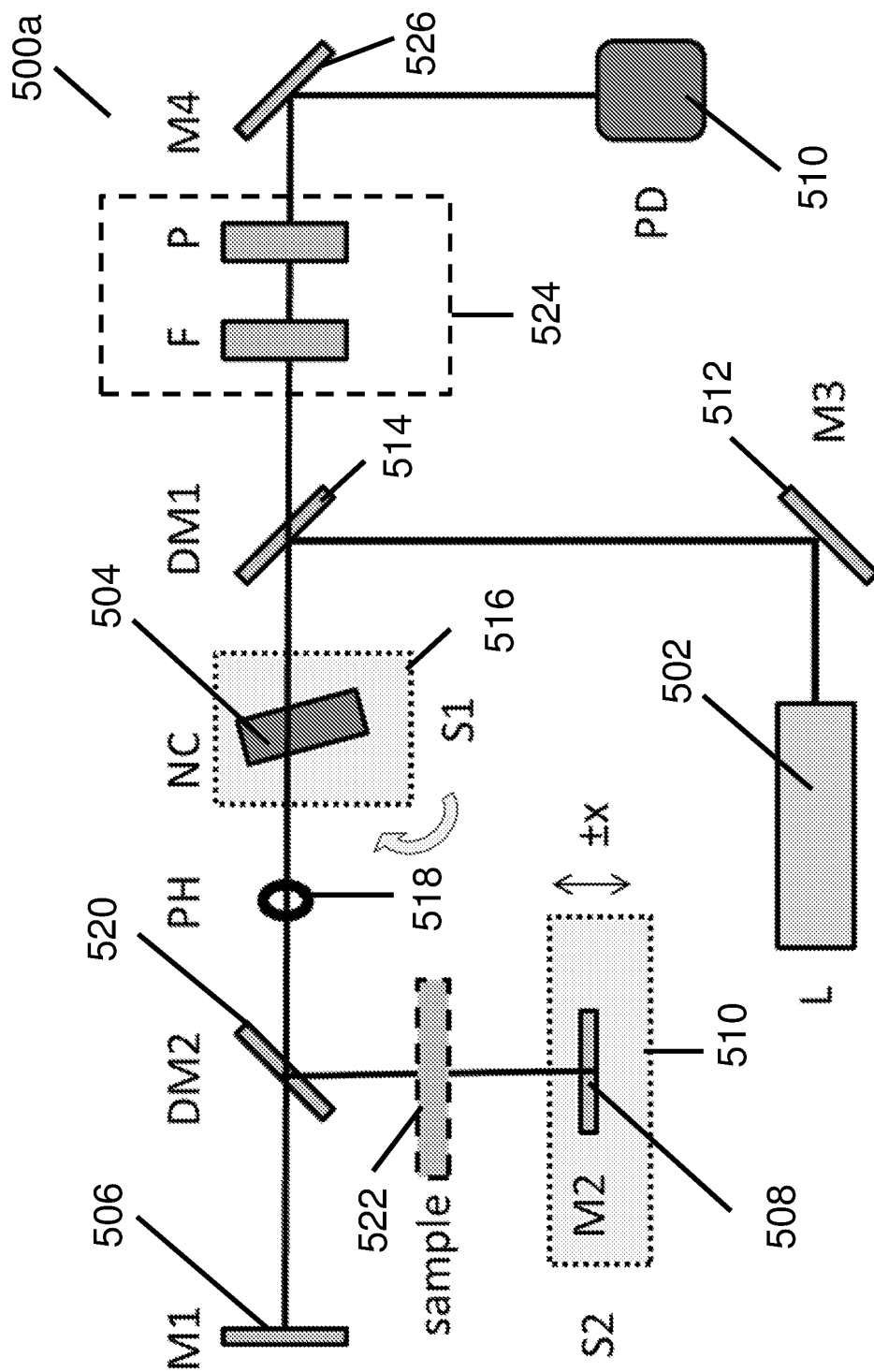


FIG. 5B

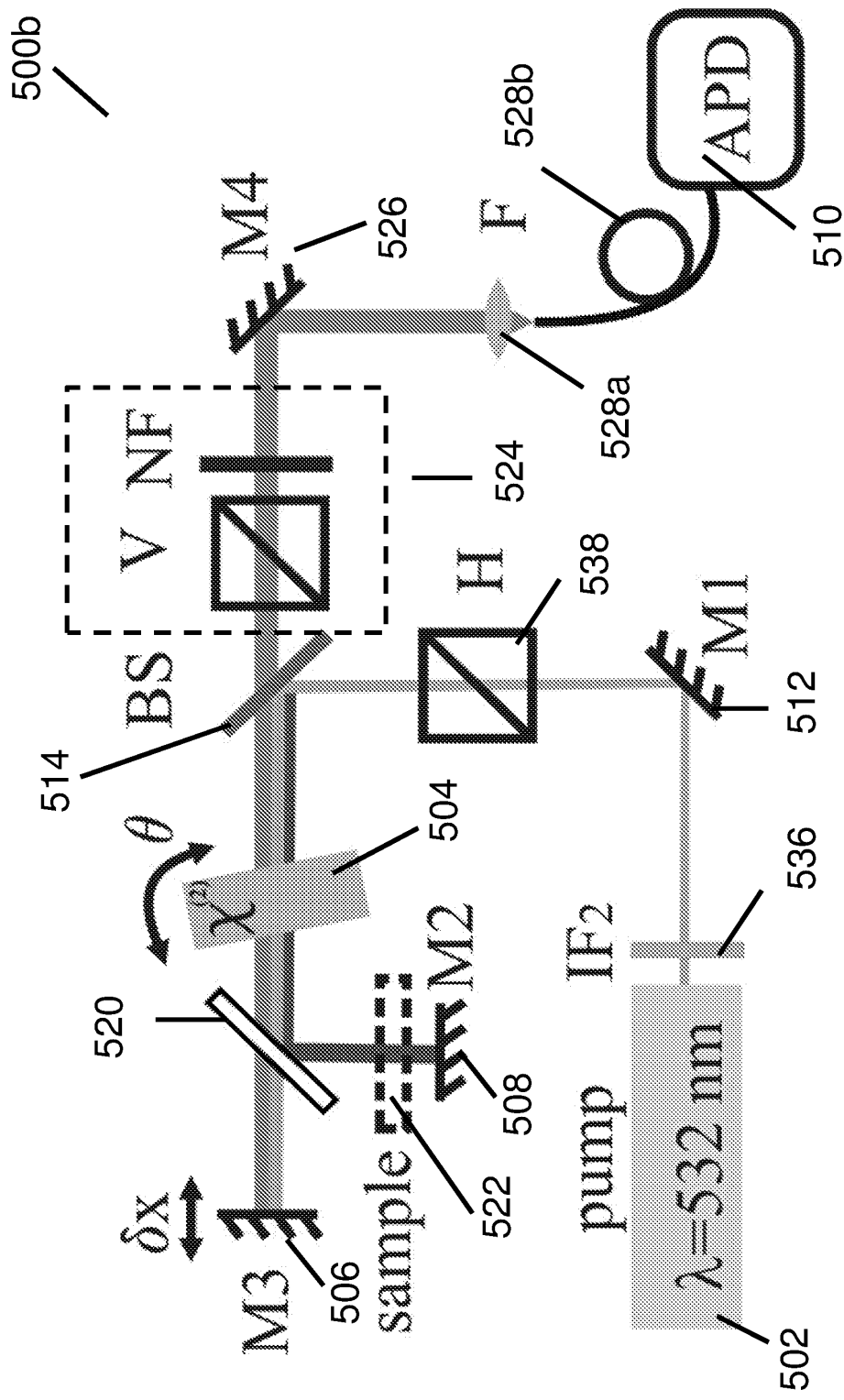
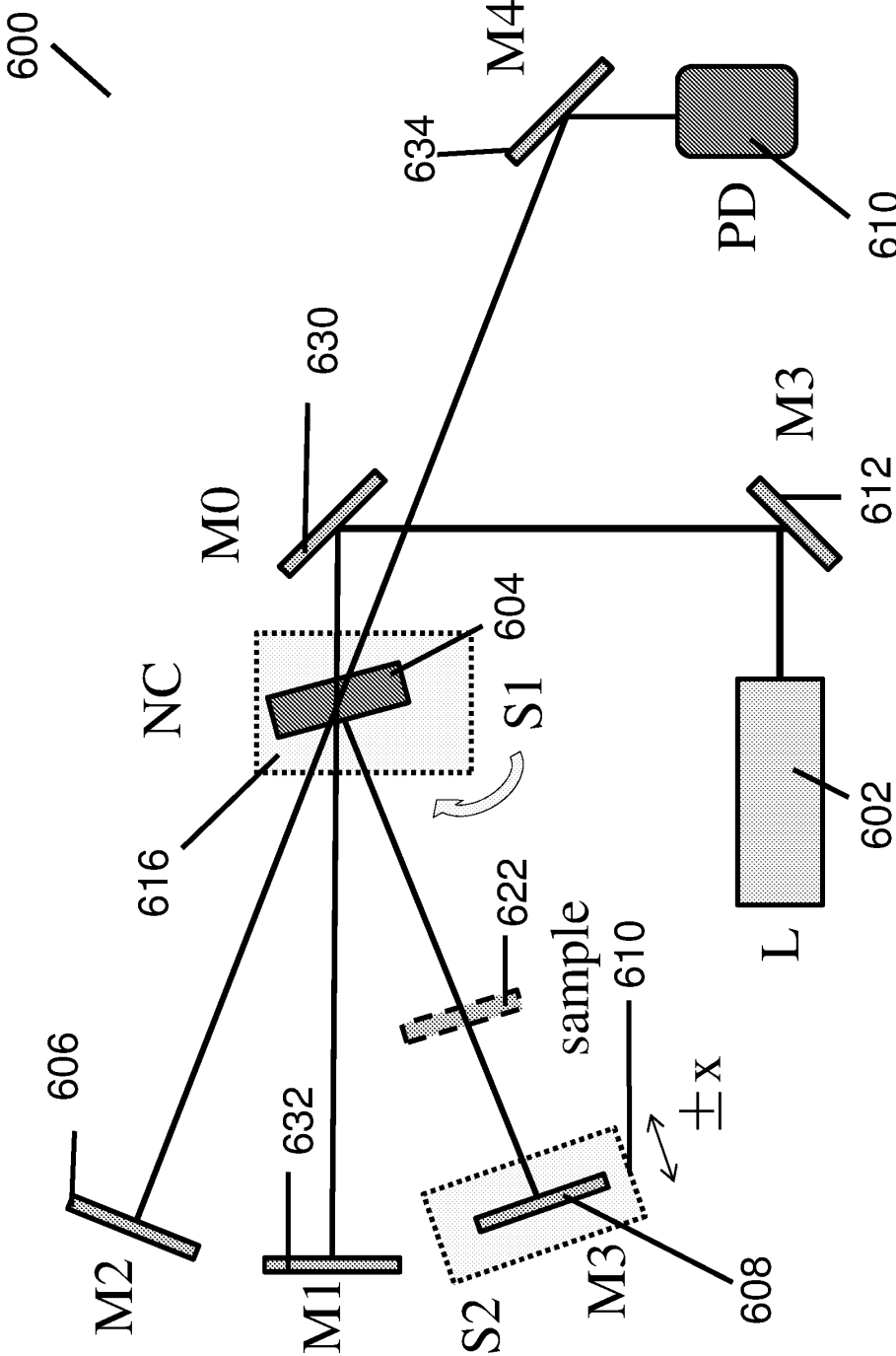
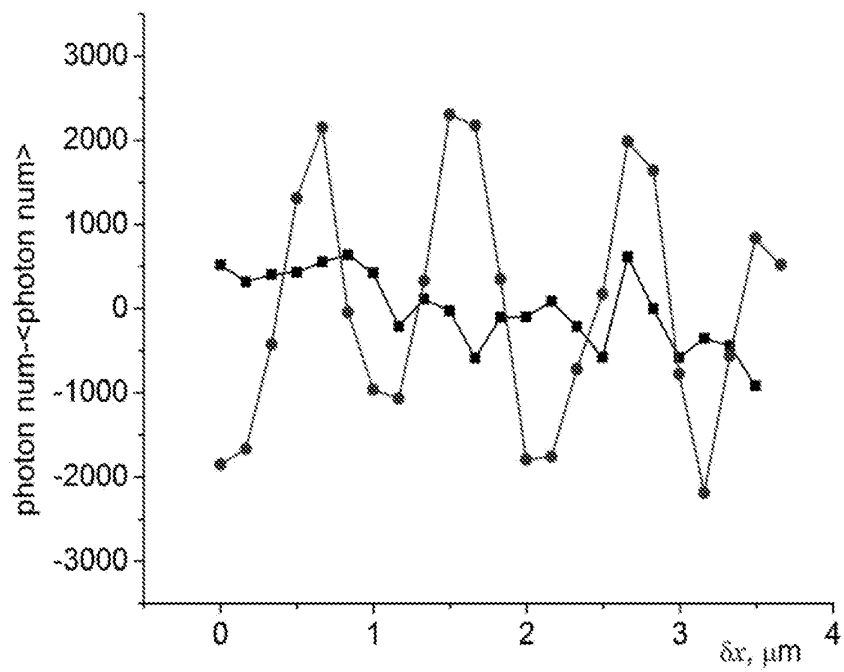


FIG. 6

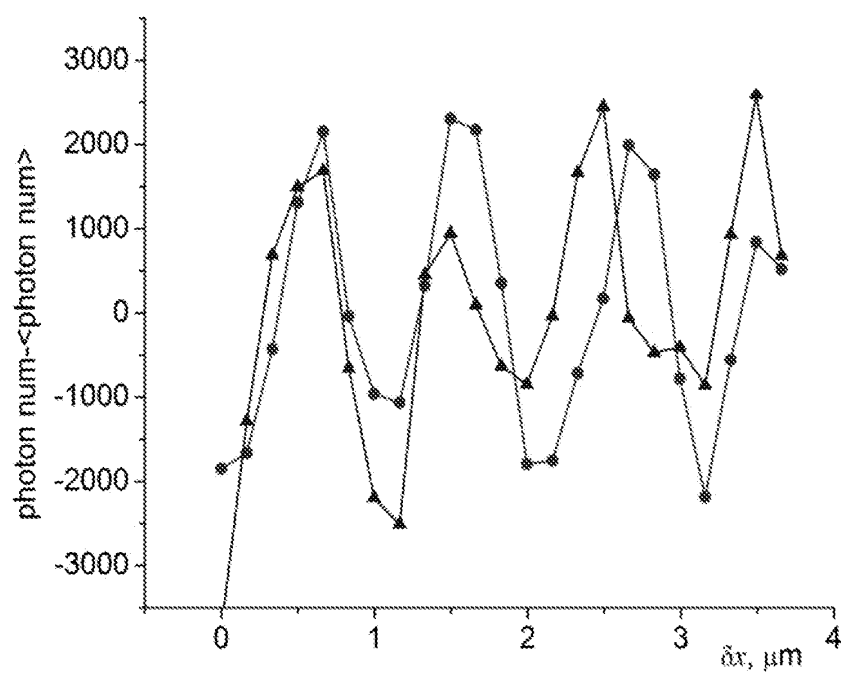


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FIG. 7A

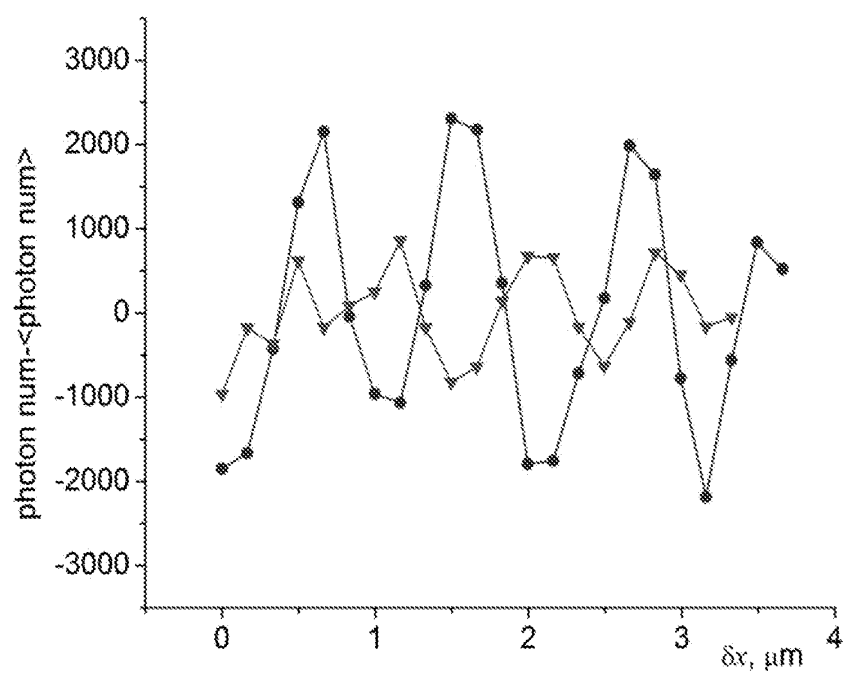
700a

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FIG. 7B700b

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FIG. 7C

700c

700d

FIG. 7D

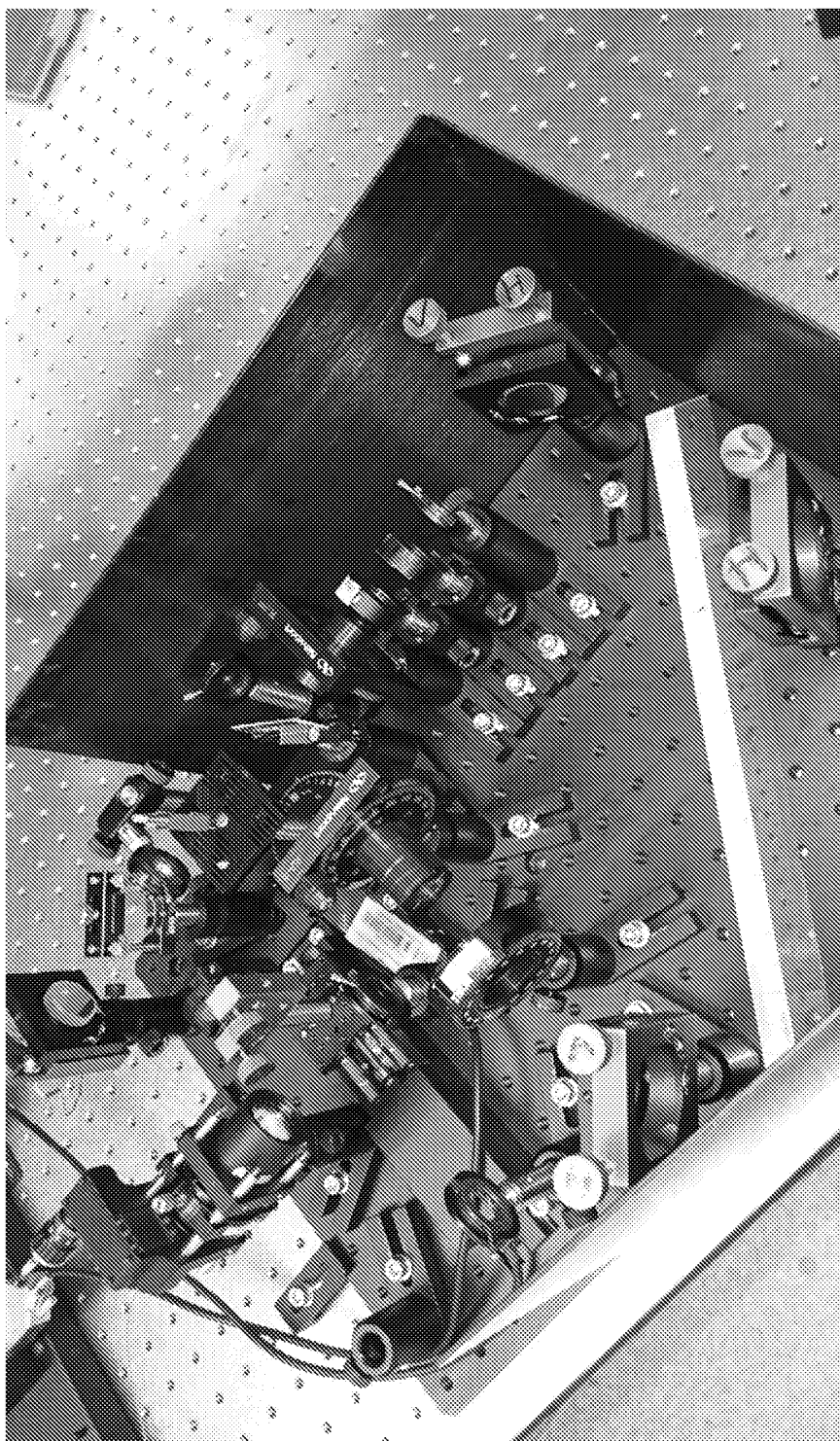


FIG. 8A 800a

	Competing design 1 D. Kalshnikov et al.	Competing design 2 Lemos et al.	Proposed design
Application to spectroscopy	Demonstrated	Not demonstrated	Demonstrated
Knowledge of sample properties in visible	Required	Not Required	Not Required
Large interaction length	Limited	Not limited	Not limited
Necessity of using a CCD camera	Required	Required	Not required
Complexity of the setup	Complex	Complex	Simple
Footprint of the setup	Bulky	Bulky	Compact
Tunability	Yes	Yes in principle (not shown)	Yes

FIG. 8B 800b

Feature	Prior art 1	Prior art 2	Prior art 3	Proposed
Only one crystal is used	X	X	X	V
Collinear regime	X	X	V	V
Separated IR-beam	X	V	V	V
Use of point detector	X	V	X	V
No interaction with pump	X	V	V	V
Single pump beam	V	X	X	V
Compact (folded) design	X	X	X	V
Easy to align	X	X	X	V
Implementation of multi-pass	X	hard	hard	easy

FIG. 9A
900a

Technique	FTIR	Direct Spectroscopy	Raman Spectroscopy (a complementary method rather than a competing method)	Proposed Solution
Principle of operation	Direct light absorption	Direct light absorption	Inelastic light scattering	Interference of down-converted light
Absorption coefficient / accuracy	Yes High	Yes Very high	X IR active vibrations cannot be detected	Yes Very high
Refraction coefficient / accuracy	Yes Indirectly Moderate ($\sim 10^{-2}$)	Yes Indirectly Moderate ($\sim 10^{-2}$)	X	Yes Directly High ($\sim 10^{-6}$)
Broadband operation	Yes (6000 - 300 cm^{-1}) ¹⁾	Yes (20,000 - 3000 cm^{-1})	Defined by FT/DT spectrometer	Yes (7,000 ~ 700 cm^{-1})
Spectral resolution	Very High ($\sim 0.25 \text{ cm}^{-1}$)	High ($\sim 4 \text{ cm}^{-1}$)	High ($\sim 4 \text{ cm}^{-1}$)	High ($\sim 4 \text{ cm}^{-1}$)
Need for IR equipment: source, detector, optics	YES	YES	YES	NO

FIG. 9B 900b

	$\Delta\lambda$, cm^{-1}	Spectral range, cm^{-1}	Advantages	Disadvantages
Direct spectroscopy	3.5	20 000~ 3,000	• Direct measurement of the spectra • Straightforward design • High signal to noise ratio (SNR) typ > 50,000:1 • Double beam configuration → removes artifacts	• Need for IR source, optics, detector → extra cost (over 50K \$) • Needs precise calibration • Sequential wavelength scan → Slow acquisition • Requires a slit → low signal
FTIR	0.25	6,000~ 300	• Fast parallelized readout across broad spectrum (Fellgett advantage) • Does not need a slit → Good SNR typ > 30,000/1 (Jacquinot advantage) • High accuracy due to interference of a broadband light (Connes advantage)	• Requires IR source, optics, detector → extra cost (over 20K \$) • Humidity and CO2 controls necessary → requires Nitrogen purging • Artefacts arising from interferogram • Requires a locking laser • All components are detected at the same time → extra noise
Nonlinear interferometer	4	20,000~ 7,000 (extendable to THz Range)	• Directly reveals refractive index and absorption coefficients • No need for IR equipment → Economical • Does not need purging with Nitrogen from source to the detector • Extendable towards THz range (Far-IR)	• The operation range is limited by IR absorption in a nonlinear crystal • Sequential wavelength scan • Sample should be transparent in VIS • Knowledge of refractive index in visible • Pump laser may damage the sample • Limited sensitivity