FPSの評価

170527

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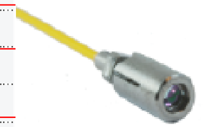
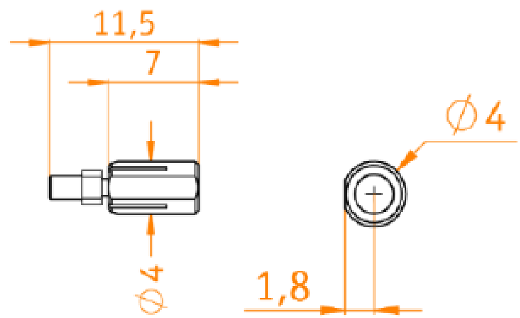
所仁志

Sensor	
number of sensor axes	3
working distance	0...3000 mm (depending on sensor head)
sensor resolution	1 pm
sensor repeatability	2 nm[1]
max. target velocity	2 m/s
measurement bandwidth	10 MHz
signal stability (WD: 20 mm)	0.286 nm (2σ)
Modes of Operation	
measurement modes	displacement, vibrometry
remote operation	USB2.0, ethernet port optional
output signal: electronics	USB, ethernet[2], AquadB, HSSL
output signal: displacement measurement	laser light
sensor alignment	semi-automated via USB
sensor initialization	fully automated, turnkey
Interfaces	
digital interfaces	AquadB, HSSL (real-time)
Controller Hardware	
chassis	48.2 x 26.5 x 4.5 cm^3
weight	1.9 kg
power supply	100/115/230 V, 50..60 Hz
power consumption	max. 100 W
Measurement Laser	
laser source	DFB laser (class 1)
laser power	150 µW
laser wavelength	1530 nm
wavelength stability	50 ppb

1) At 10 mm working distance (WD), 5 nm repeatability at 100 mm WD, in vacuum conditions.
2) upgrade option / SYNC.

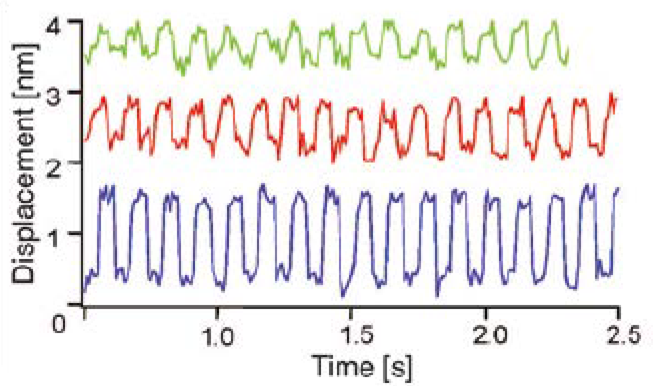




Environmental compensation unit – ECU

The environmental compensation unit enables sub-ppm accuracy in ambient conditions

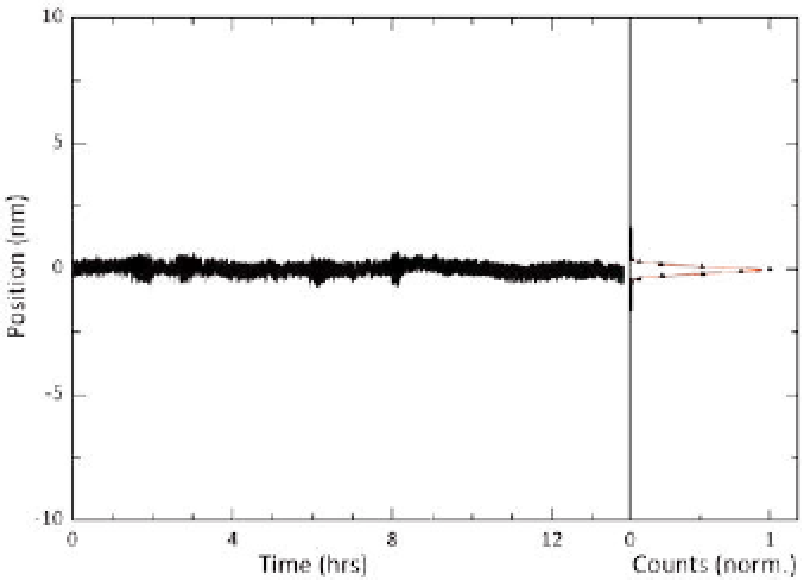
$4mm/10^7=0.4nm$なのだが・・



High resolution X-ray microscopy

When developing an X-ray microscope capable of nm resolution, careful design is a must. Thermal and mechanical stability of the components and assemblies has to be followed throughout the process. The attoFPSensor shows superior performance regarding its outstanding stability and its capability of measuring sub-nm displacements and is therefore the ideal supplement for the mechanical control of all components used in the described X-ray microscope setup achieving a resolution in the order of 40 nm.

(attocube application note SEN09, 2013)

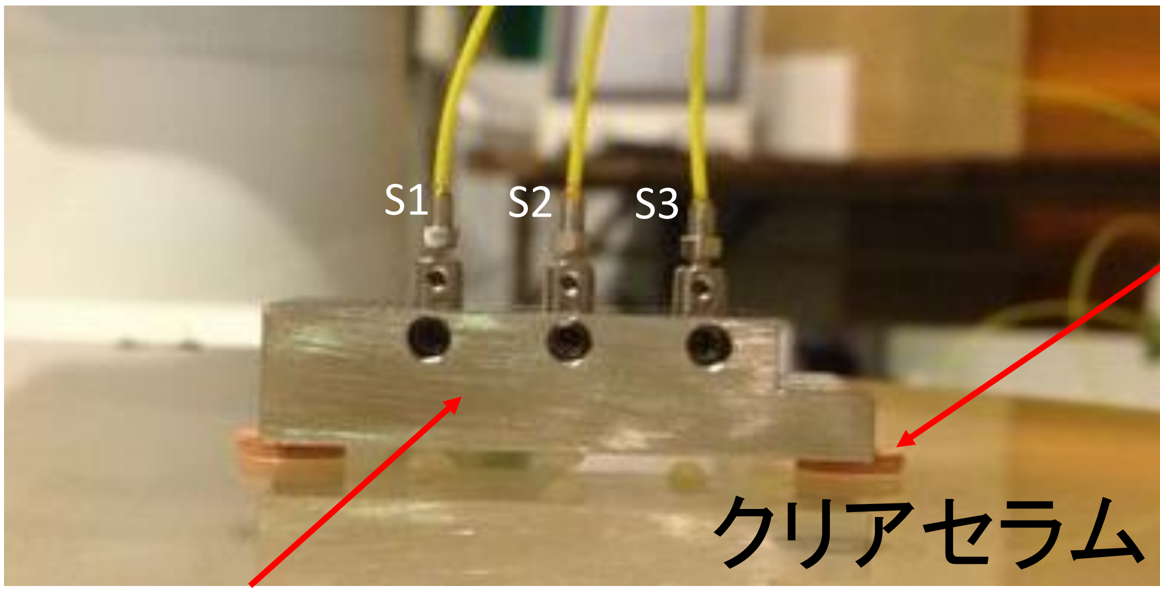


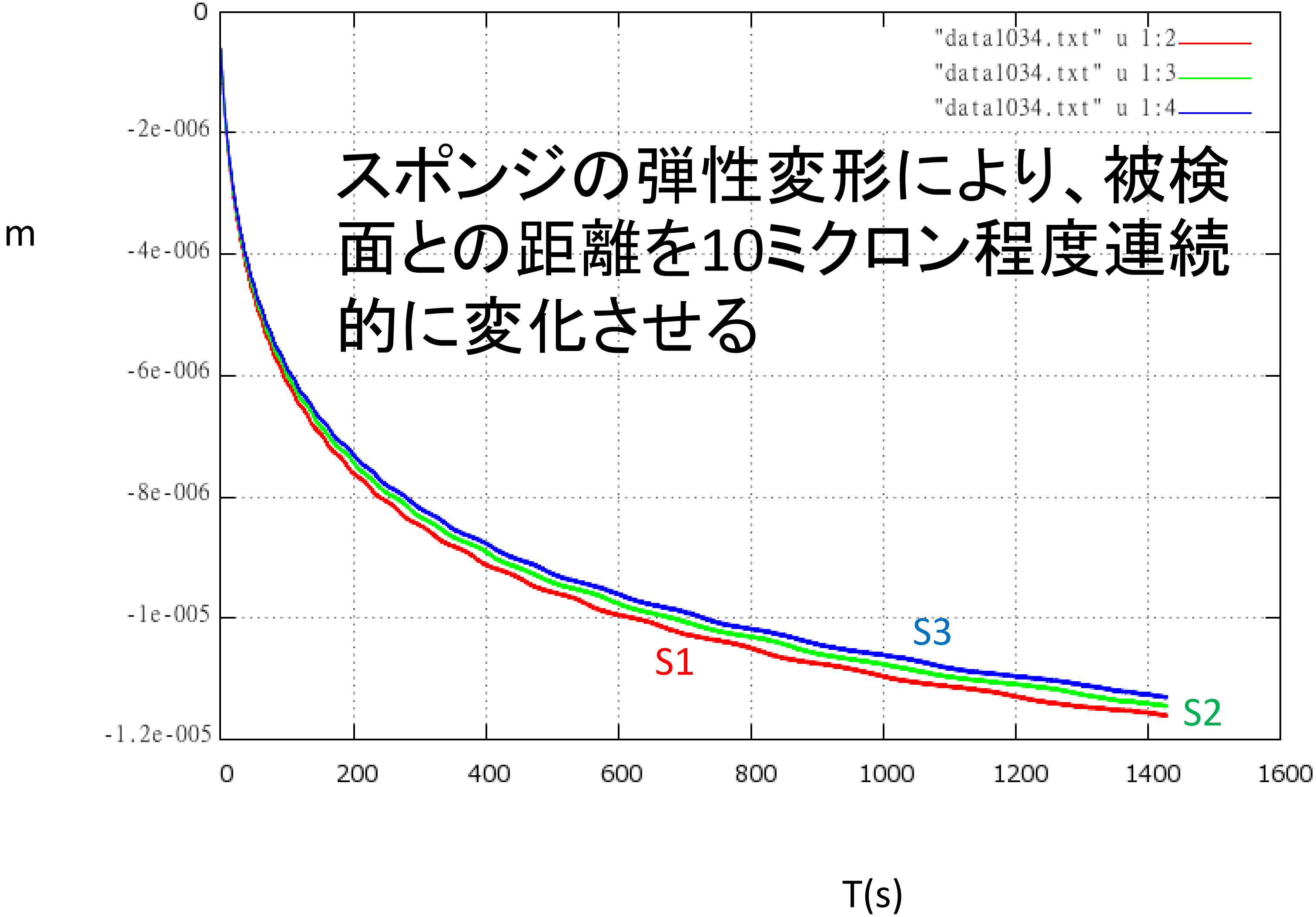
Measured Long-Term Signal Stability	
working distance [mm]	2σ [nm]
20	0.286
50	0.530
100	1.035
Measured Short-Term Signal Stability	
working distance [mm]	2σ [nm]
30	0.039

Long-term FPS signal stability as demonstrated on a 20 mm long Titanium vacuum reference cavity. The cavity is cooled to liquid helium temperature (-269 °C) in order to minimize thermal expansion/contraction. 68% of all position measurement data points lie within 286 pm, as measured at a 100Hz bandwidth over 12 hrs. Short-term data are recorded at 10Hz over 10 seconds.

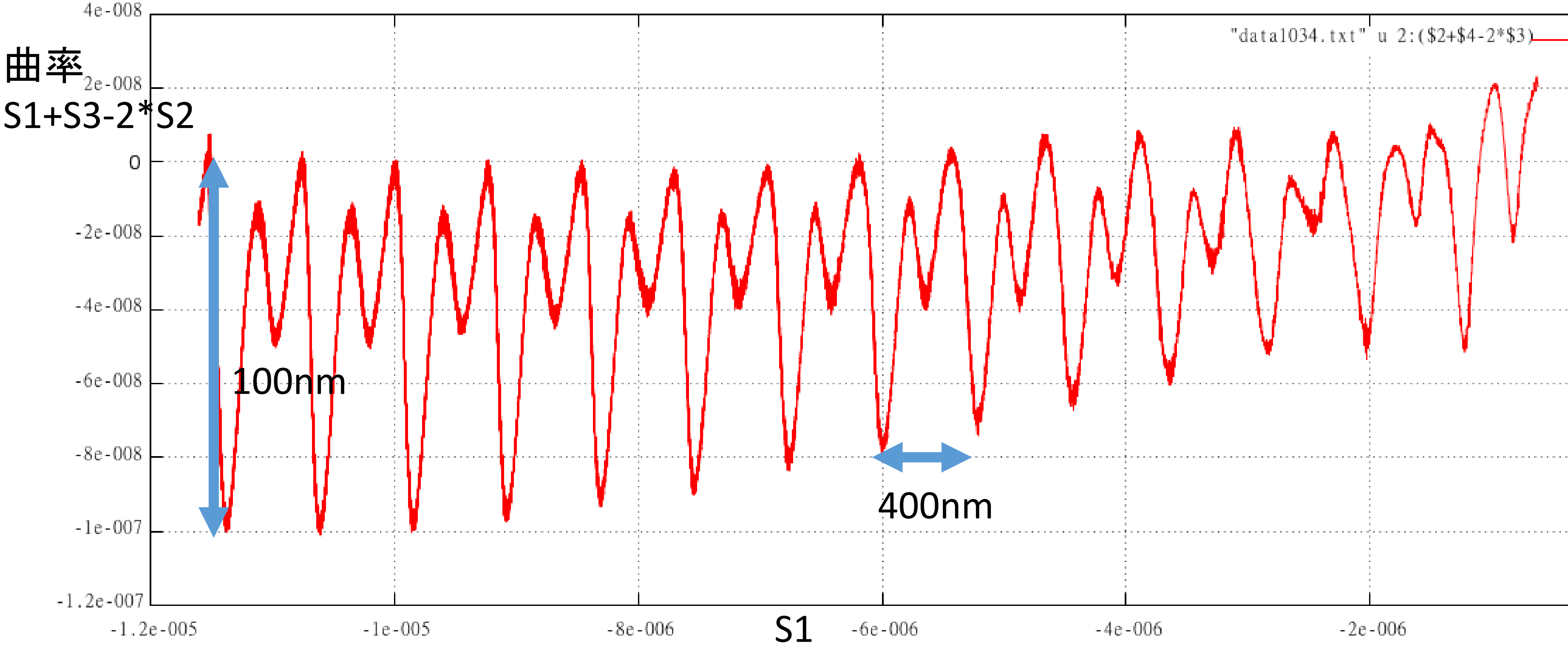
Experiment

3つのセンサで被検面の曲率をモニタ




スポンジの弾性変形により、被検面との距離を10ミクロン程度連続的に変化させる
"data1034.txt" u 1:2
"data1034.txt" u 1:3
"data1034.txt" u 1:4
S1
S2
S3
m
T(s)
0
-2e-006
-4e-006
-6e-006
-8e-006
-1e-005
-1.2e-005
0
200
400
600
800
1000
1200
1400
1600

周期400nm(使用波長の1/4)で強度100nmの周期誤差を確認(この間被検面の曲率は一定なので)



FPSに関連する論文

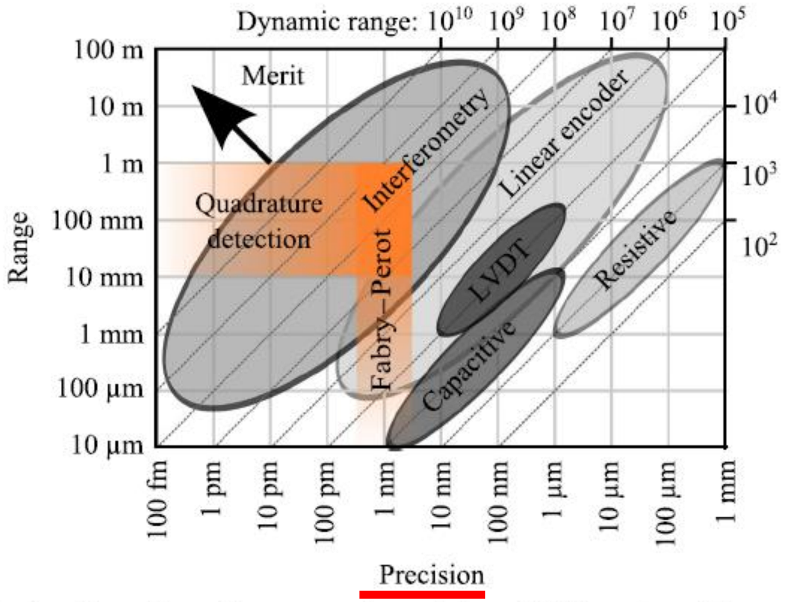


Fig. 1. Overview of range and precision of different position and displacement sensors. The horizontally and vertically shaded area classifies the presented Fabry–Perot interferometer, which uses a quadrature detection scheme to achieve measurement ranges up to 1 m.

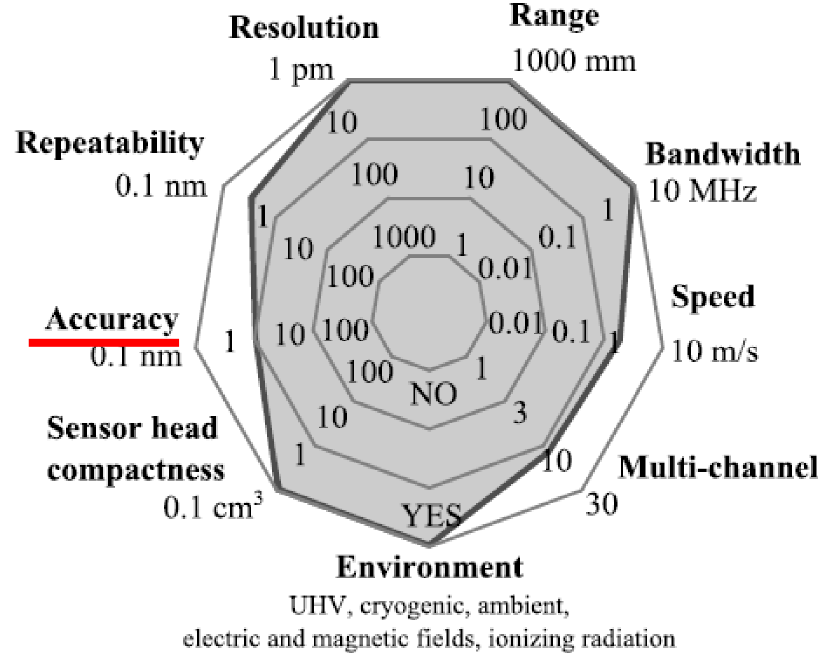
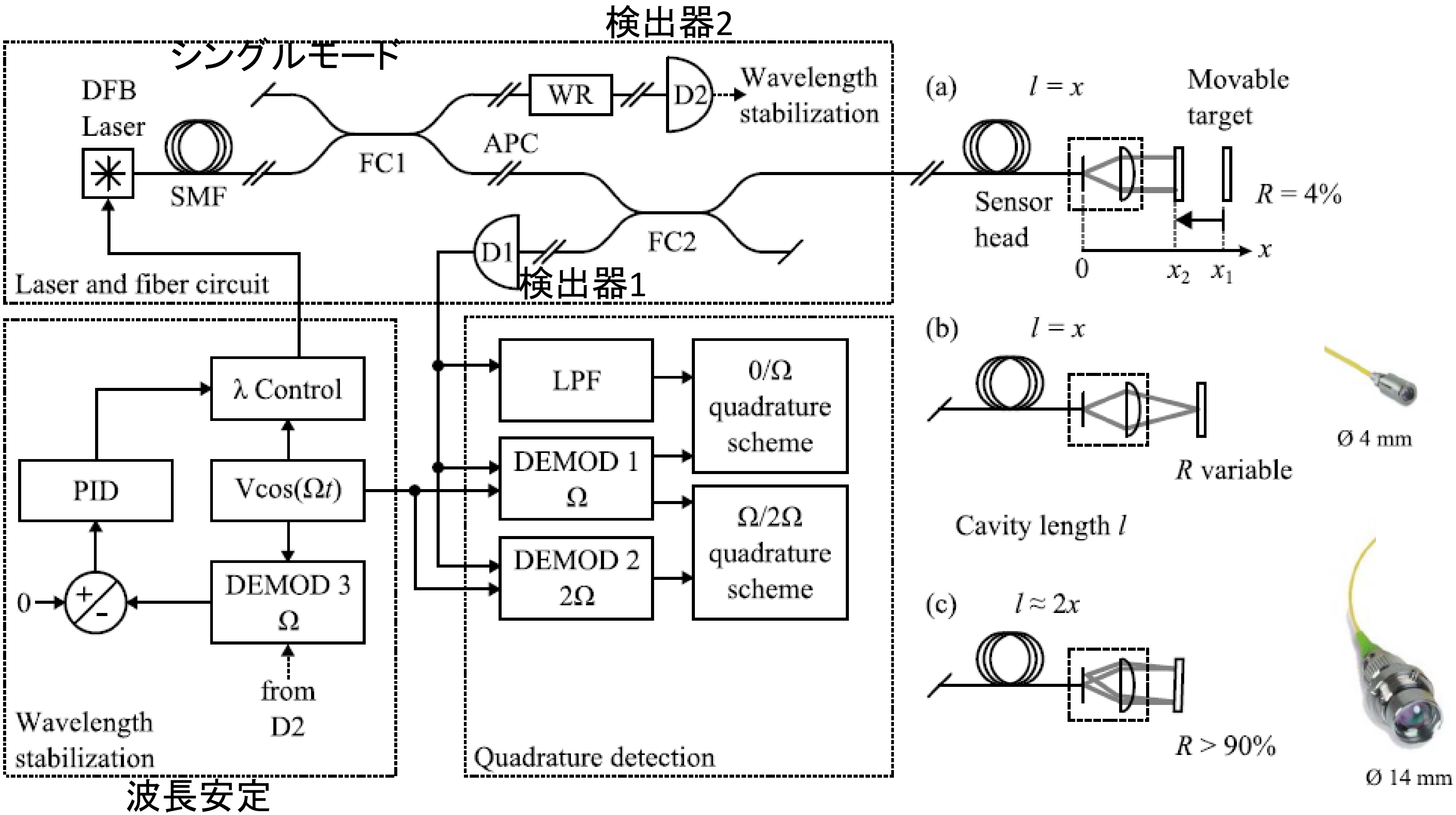


Fig. 2. Specification map of the presented interferometer.

Thurner et al. 2015

Abstract

high magnetic fields and supports multichannel applications. The interferometer achieves a repeatability of 0.44 nm (3σ) at a working distance of 20 mm, a resolution of 1 pm, and an accuracy of 1 nm. © 2015



検出器2
シングルモード
DFB
Laser
SMF
FC1
WR
D2
Wavelength
stabilization
APC
FC2
D1
検出器1
Laser and fiber circuit
(a)
l = x
Movable
target
Sensor
head
R = 4%
0
x2
x1
x
(b)
l = x
R variable
Ø 4 mm
Cavity length l
(c)
l ≈ 2x
R > 90%
Ø 14 mm
λ Control
PID
Vcos(Ωt)
DEMOD 3
Ω
0
+
-
from
D2
Wavelength
stabilization
LPF
DEMOD 1
Ω
DEMOD 2
2Ω
0/Ω
quadrature
scheme
Ω/2Ω
quadrature
scheme
Quadrature detection
波長安定

$$I(\Phi) = \frac{I_0}{2} + \frac{I_0}{2} C \cos(\delta\Phi \sin \Omega t + \Phi).$$

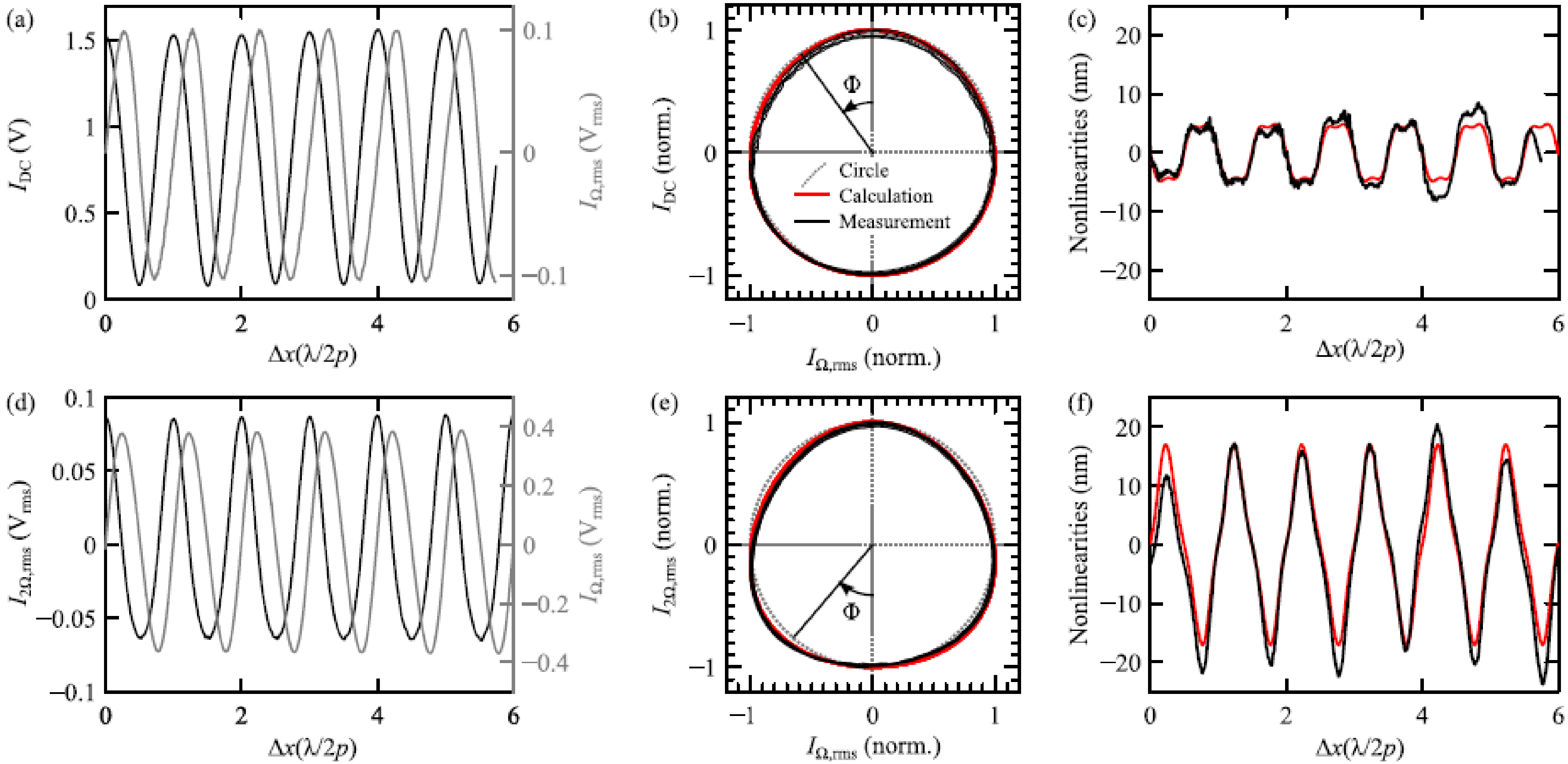


Fig. 5. Comparison of two quadrature detection schemes applied to a low-finesse Fabry–Perot interferometer. The first scheme (top) uses the filtered detector signal (I_{DC}) and the demodulated signal at the modulation frequency Ω (I_Ω), whereas the second scheme (bottom) uses the demodulated signals at the modulation frequencies Ω (I_Ω) and 2Ω ($I_{2\Omega}$). (a) and (d) show the raw quadrature signals. (b) and (e) show the corresponding Lissajous figure after normalization of the raw signals. The deviation from a circle (dashed line) results in periodic nonlinearities, which are shown in (c) and (e).

nearities decrease. The high reproducibility of the nonlinearities enables their correction by means of a look-up table deposited in the position processor. In this way, the accuracy of the interferometer can be enhanced up to 1 nm.

	D4/F8	SI-F
スポットサイズ µm	70@8mm	20
直径mm	4	2
波長 nm	1440	700あたり
アライメント　度±	0.35	1
分解能 nm	0.001	1
安定性 nm	0.286	
再現性 nm	2	
リニアリティ nm/FS		200
サンプリング　Hz	10M	5k
計測レンジmm	6-10	0.05-1.1