A NOVEL FBG SENSOR FOR *IN-SITU* HUMIDITY MEASUREMENT IN A POLYMER ELECTROLYTE MEMBRANE FUEL CELL

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Agenda

- Project description
- Water in a Fuel Cell
- FBG sensing principle
- Sensor fabrication
- Sensor calibration
- Results
- Future work

FBG Humidity sensor

- Working on it for four months
- Utilizing a lot of knowledge obtained by Prof. Peter Wilds FBG-group
- Using the FC-test station with help from Ph.D. student Nigel David who will continue my work and improve the design

Water management

- Now: can measure in –and outlet RH
- No *in-situ* measurements
  - Conventional sensors are too big
  - No way of knowing when the air saturates in the FC
- Too wet → flooding → blocking of pores in GDL or electrodes
- Too dry → loss of proton conductivity

Water management

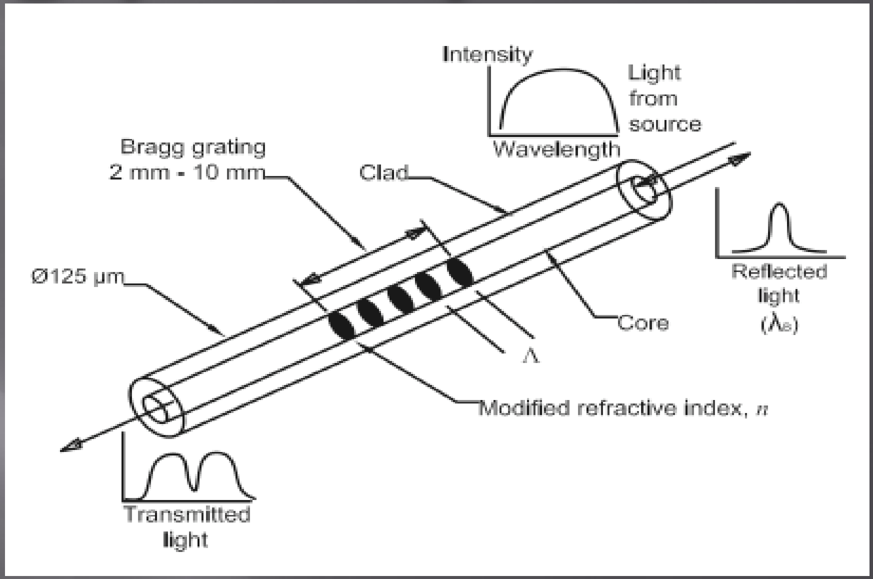
Temp (°C)	λ=1.5	λ=2	λ=3	λ=6	λ=12	λ=24
20					213	142
30				194	117	78
40		273	195	112	68	45
50	208	164	118	67	40	26
60	129	101	72	41		
70	82	65	46			
80	54	43	30			
90	37	28				

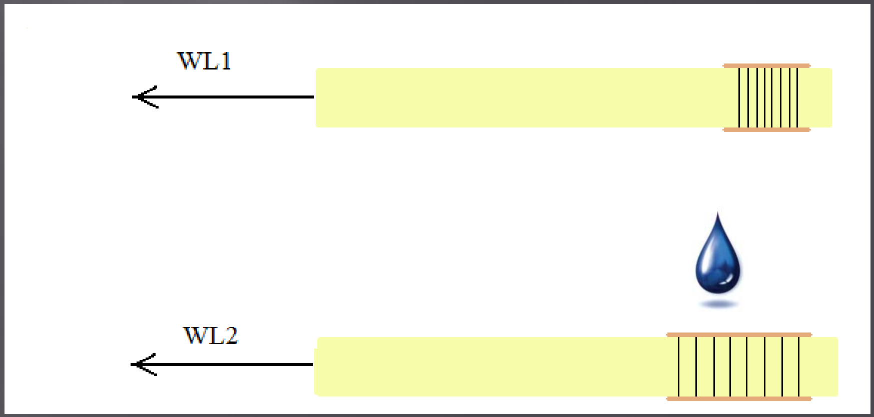
Larmine & Dicks, Fuel Cell Systems Explained

- Exit air RH, Inlet is 20°C and RH is 70%
- If FC is operated above 60°C, external humidification is needed
- Difficult to control RH and flooding occurs easily when no feed-back

FBG sensing principle

- A FBG is written into the core of the fibre using UV-laser.
- This induces a periodic modulation of the core refractive index
- Only one WL is reflected, the Bragg WL
- When fibre is strained, the Bragg WL shifts
- Possibility of multiplexing 100s of sensors on one fibre





Sensor fabrication

- Thin coating → fast response time but low sensitivity
- Trade-off
- Compensated for by etching fibre from 125 μm to 37 μm, reduces tuning force by a factor of 10

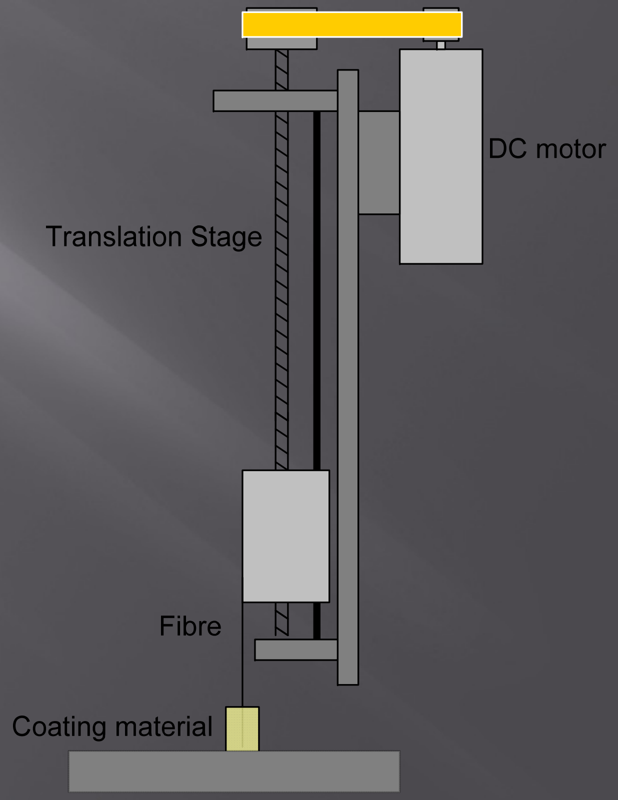
Coating of fibre

COATING STEPS FROM LITERATURE

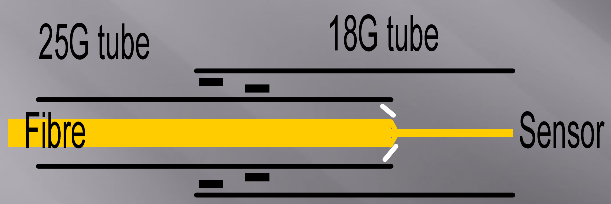
- Chose "Expensive" polyimide

1. Take off existing polyimide
2. Clean with isopropanol
3. Coat with adhesion promoter
4. Cure
5. Coat with Polyimide, multiple layers
6. Cure
7. DONE!

COATING SET-UP

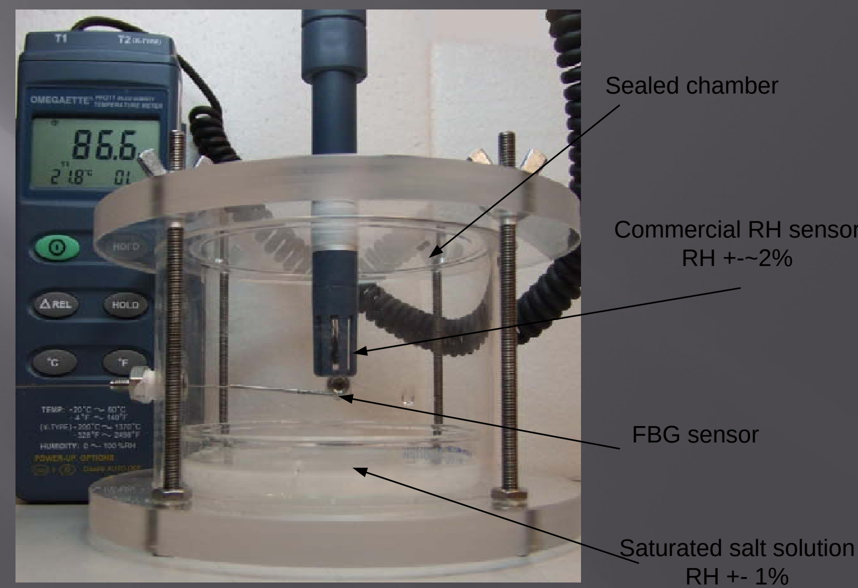


Calibration Humidity



ASTM 104 standard

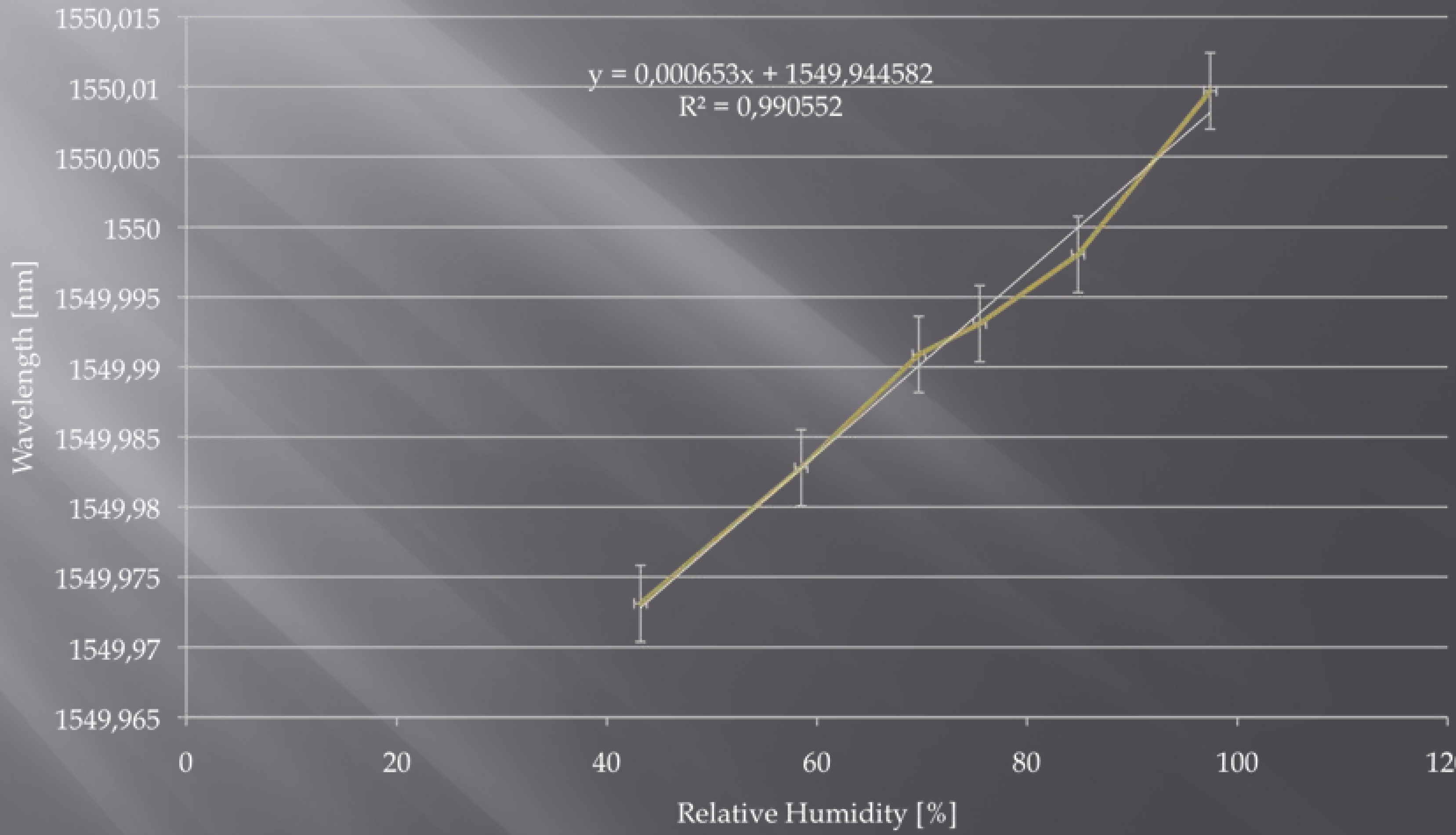
Salt	RH @ 20°C
K_2Co_3	43.2±04
NaBr	59.1±0.5
KI	69.9±0.3
NaCl	75.5±0.2
KCl	85.1±0.3
K_2SO_4	97.6±0.6



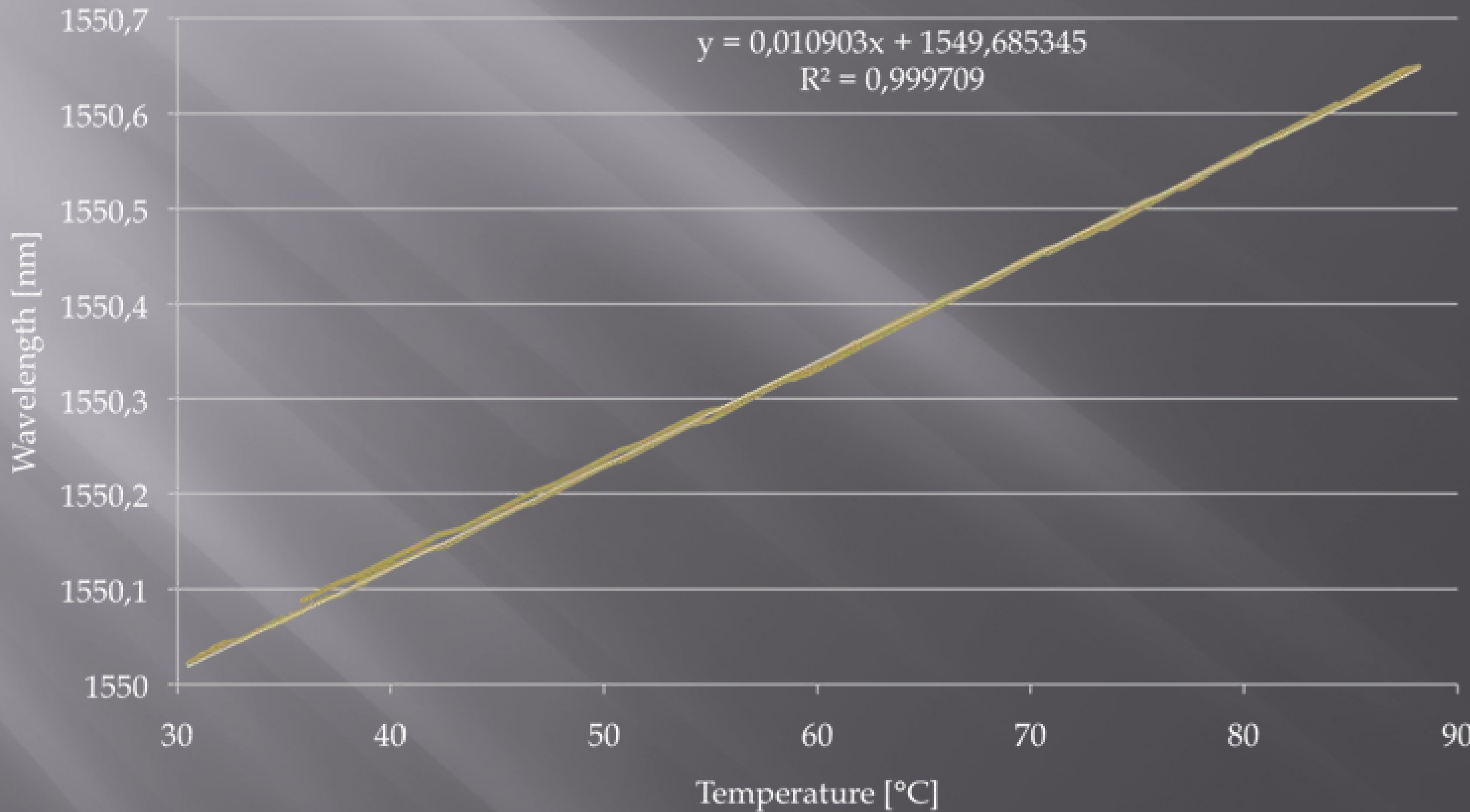
Calibration Temperature

- Fibre is more than 10 times more sensitive to T than RH
- Dry air (<2% RH)
- Heated to 90°C and cooled

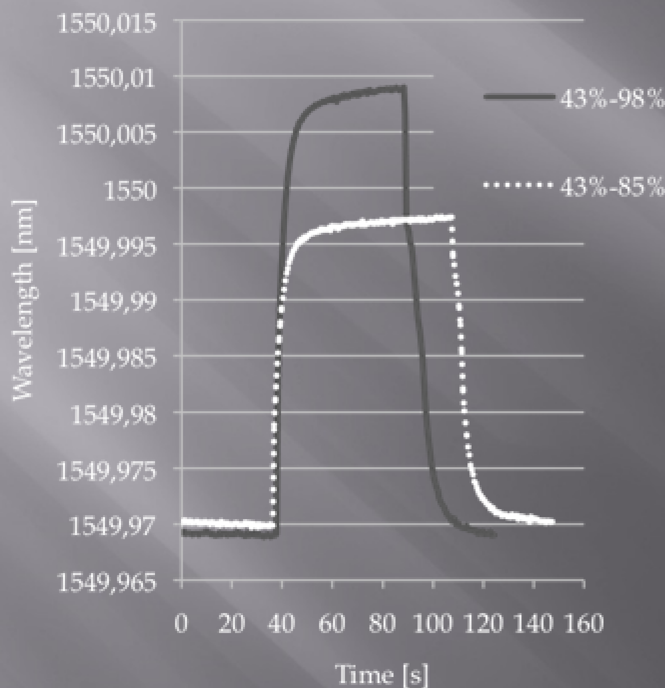
Results
Humidity calibration



Results
Temperature Calibration

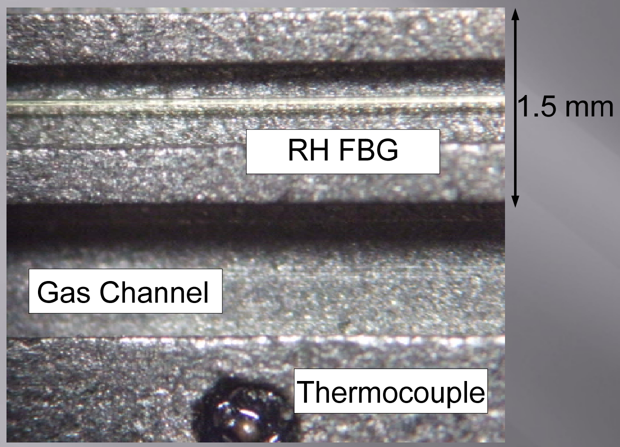


Results
Response time

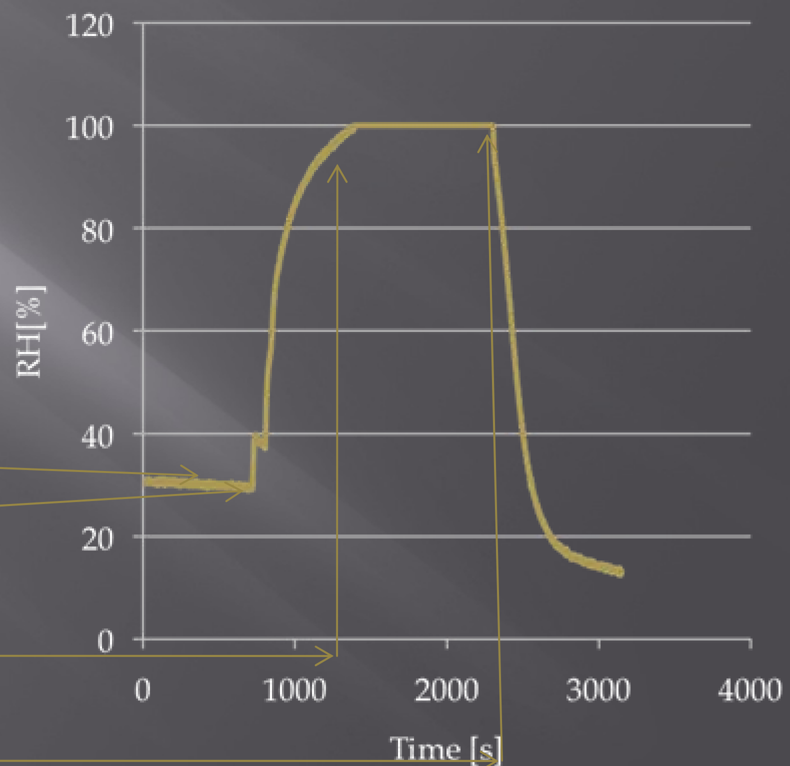


- 43-85%: 8s increasing RH, 14s decreasing
- 43-98%: 9s increasing RH, 14s decreasing
- (t_{90})
- Compared to literature: 18 min

In-situ non-operating

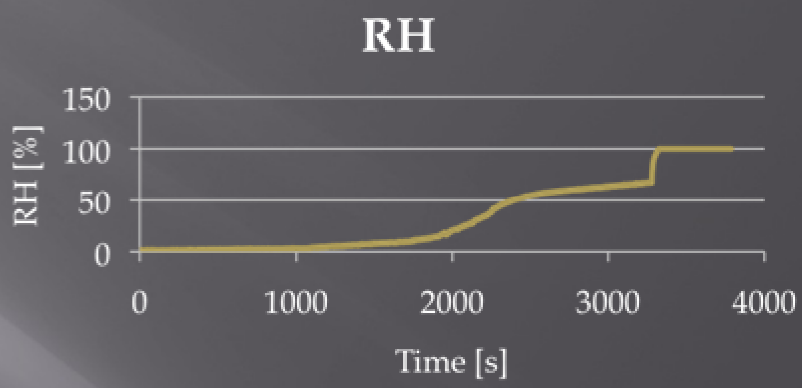


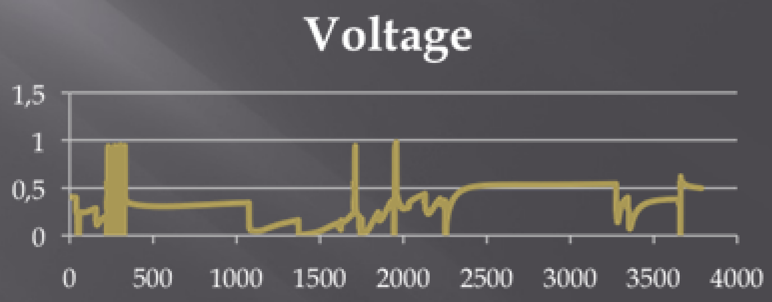
- No air flow
- ~12%RH air through hum. RT
- Humidifier 40°C
- ~12%RH

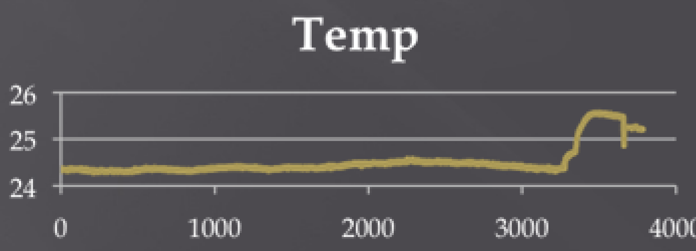


In-Situ Operating

- Sensor @ outlet
- 0-3300s: <2% RH air
- 3300: 12%RH air
- Long start-up
- Slow humidification







Conclusions & future work

- Coating recipe updated
- 9s response-time
- 0.65 pm/%RH
- 10.9 pm/°C
- Good repeatability

$32,350 from Vytran

- New fixture
- Calibrate for more RHs
- Calibrate in constant temperature
- Compare models to measurements
- Multiplexing
- Smaller FBG


Thank you for your attention