

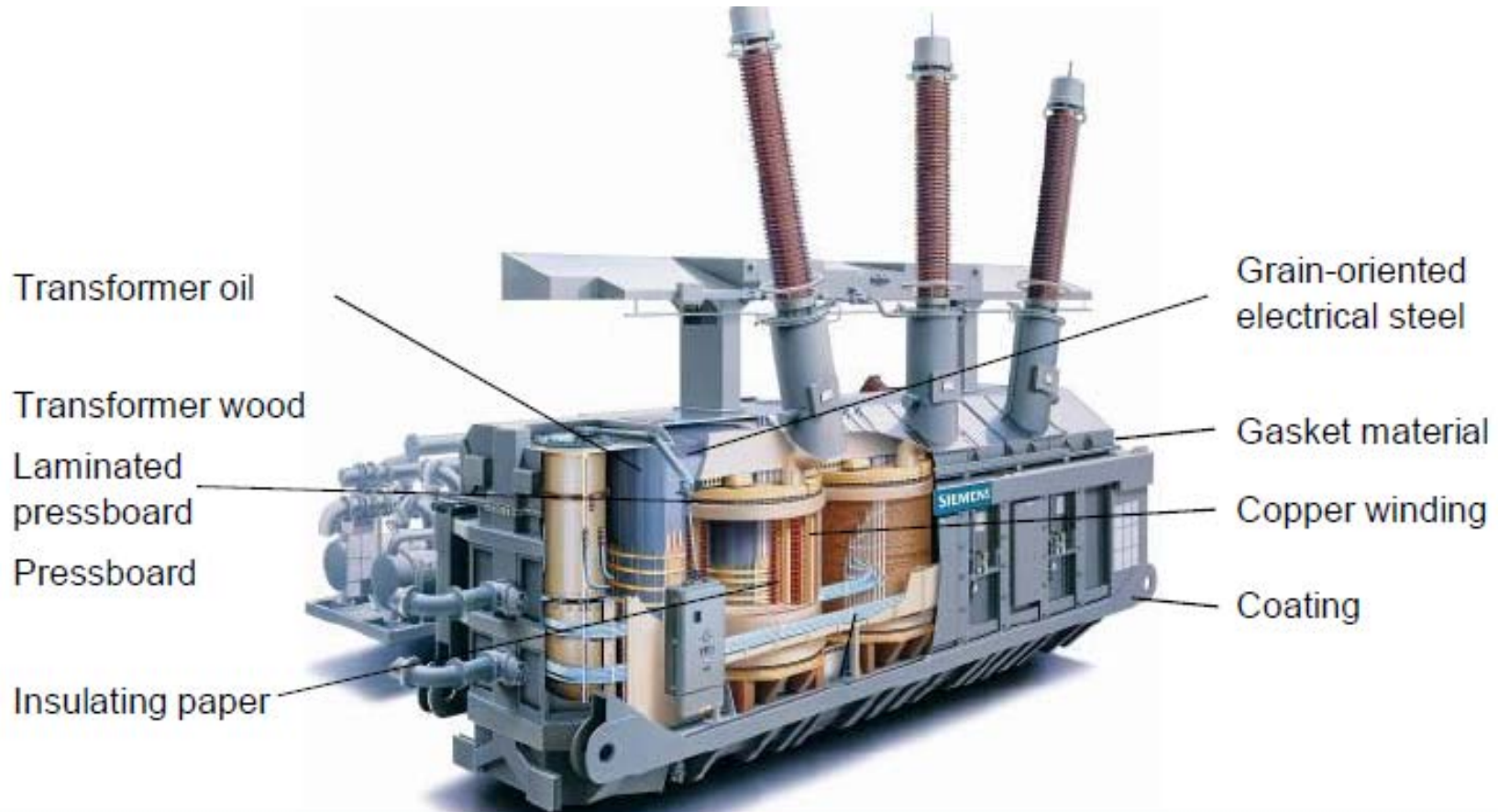
# **FiberOptics Sensor monitoring Moisture Transport in oil inside an Operating Transformer**

GOTF Cigre USA

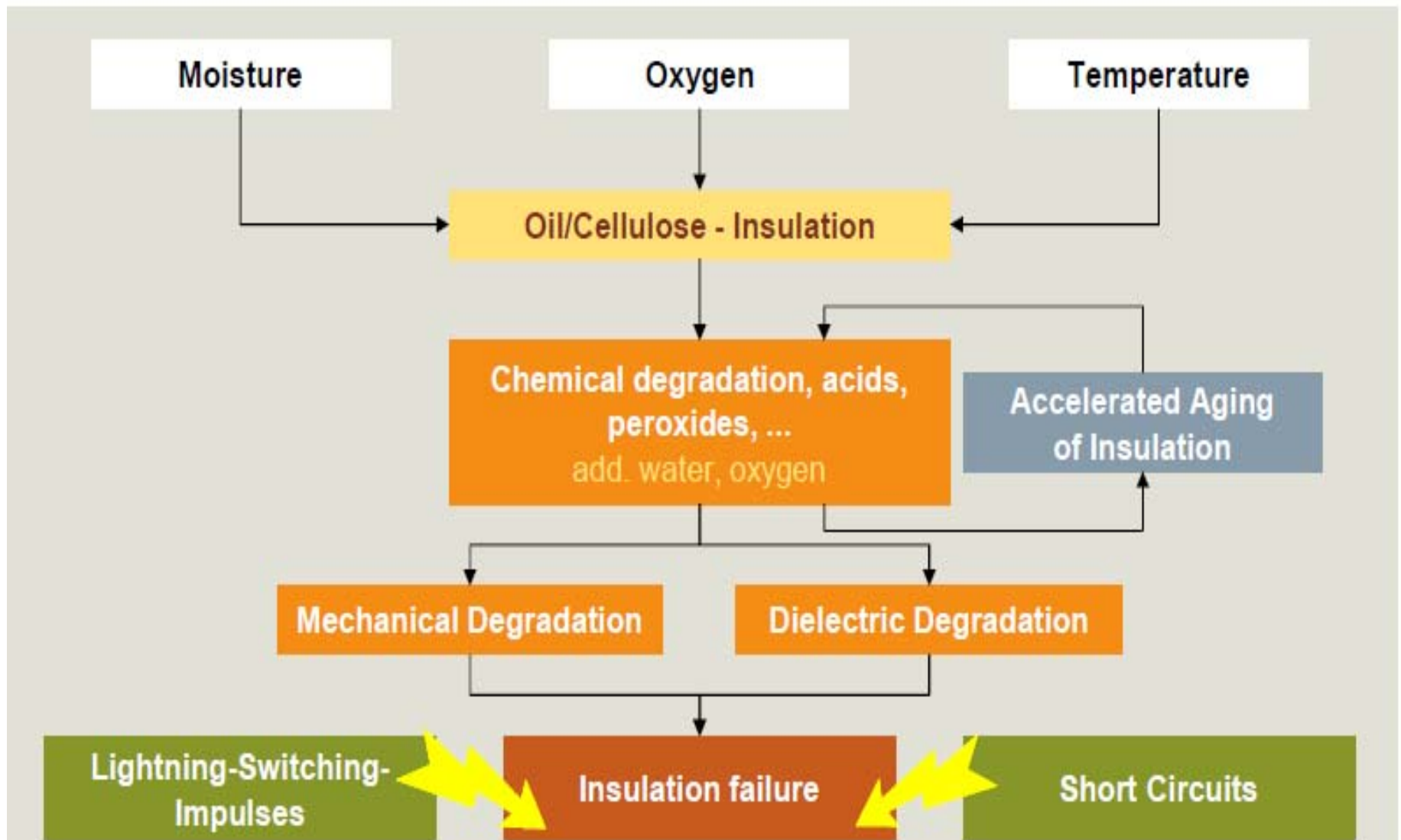
Cleveland, Ohio Oct 2017

By Peter Kung QPS

# What is inside a transformer?



- ▶ Transformers are comprised substantially of organic materials



- ▶ The ageing of oil and cellulose is strong depending from each other

# Moisture is something we cannot avoid



- Leaking gaskets and faulty water traps may expose the inside of the transformer to humid air
  - Exposure to humid air during site installation/ commissioning
  - Exposure to humid air during maintenance
  - Normal aging of cellulose produces water
  - Insufficient drying at manufacturing
- Typical moisture content in paper/pressboard:
    - New transformer: < 1%
    - Aged transformer: 2 - 4%
  - Normal increase of water content is typically 0.05-0.2%/year

# Threats are right inside

- The insulation in a power transformer consists of oil impregnated cellulose and oil.
  - 60 tons of oil with water content of 20 ppm) = 1.2 liter
  - 10 tons of cellulose with 3% water content = 300 liter
- Almost all water is in the cellulose!

Running the transformer at high temperature is like a person who likes to smoke





# Moisture in transformer is like Cholesterol in our blood

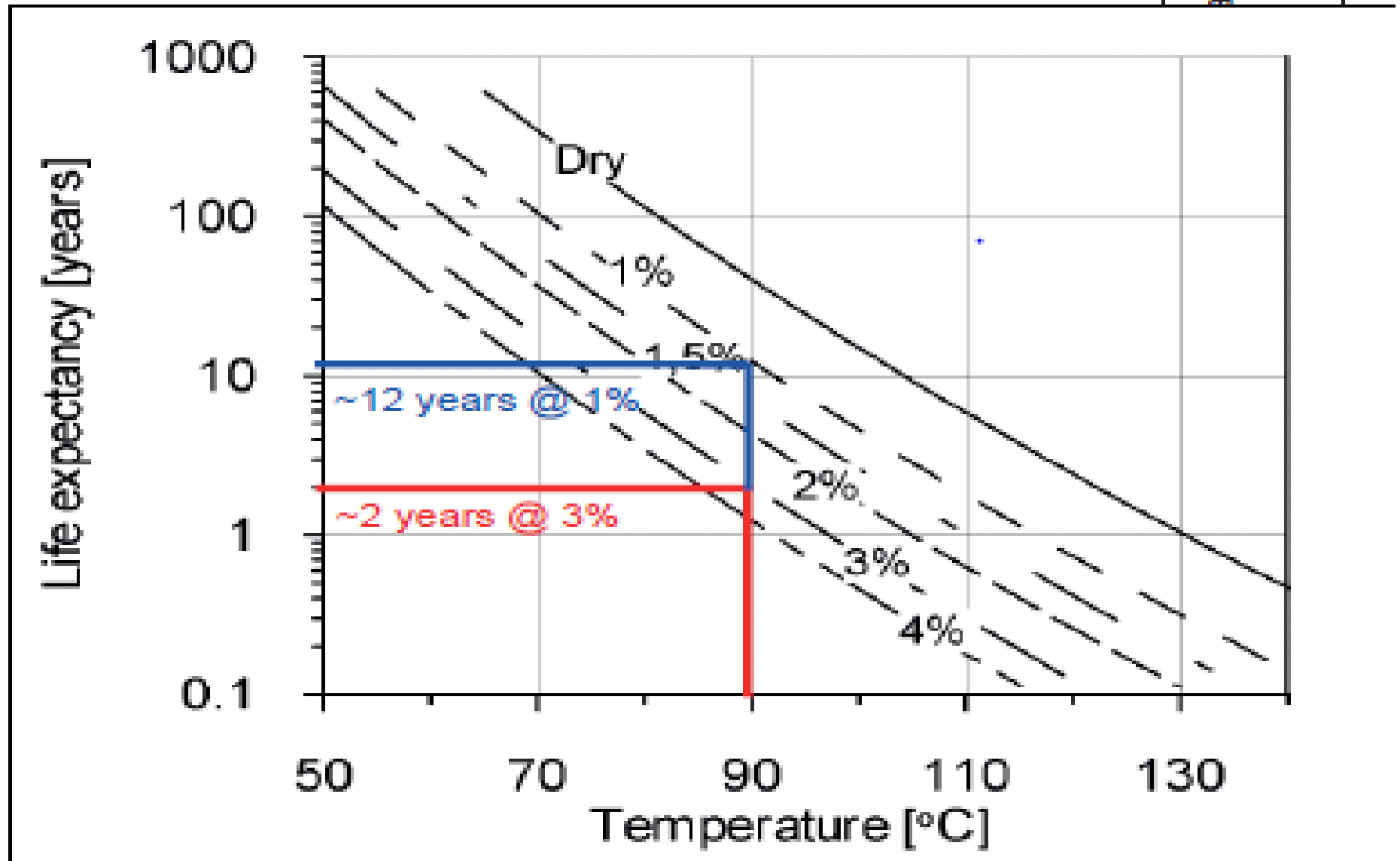


## Moisture affects productivity, performance and reliability

- Overloading leads to elevated temperature; moisture forms bubbles
- Weakened dielectric strength produces more PDs
- Transformer ages more rapidly



# Temperature has the strongest impact

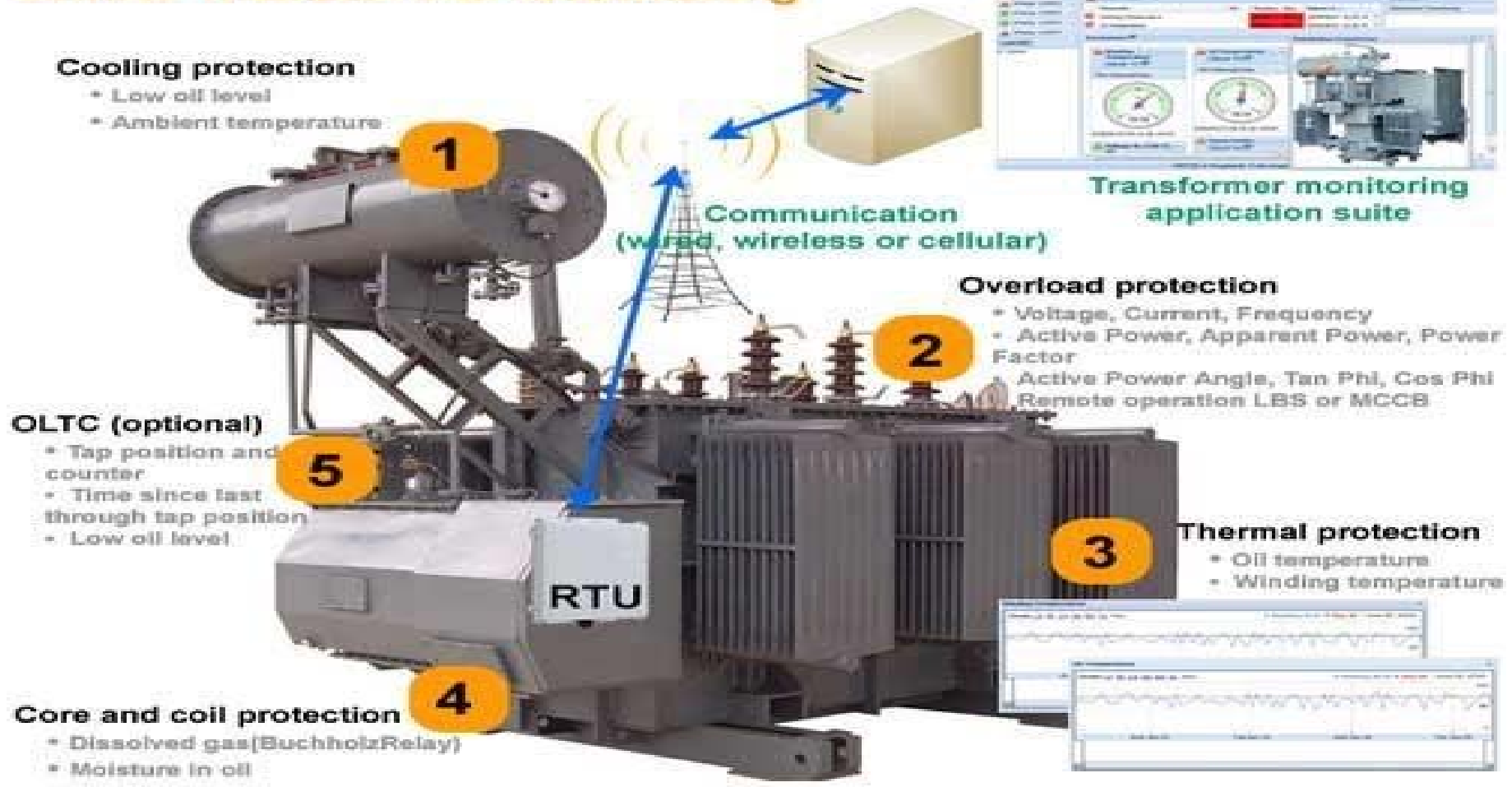


Transformer Oil and cellulose paper also age and lose its insulation ability

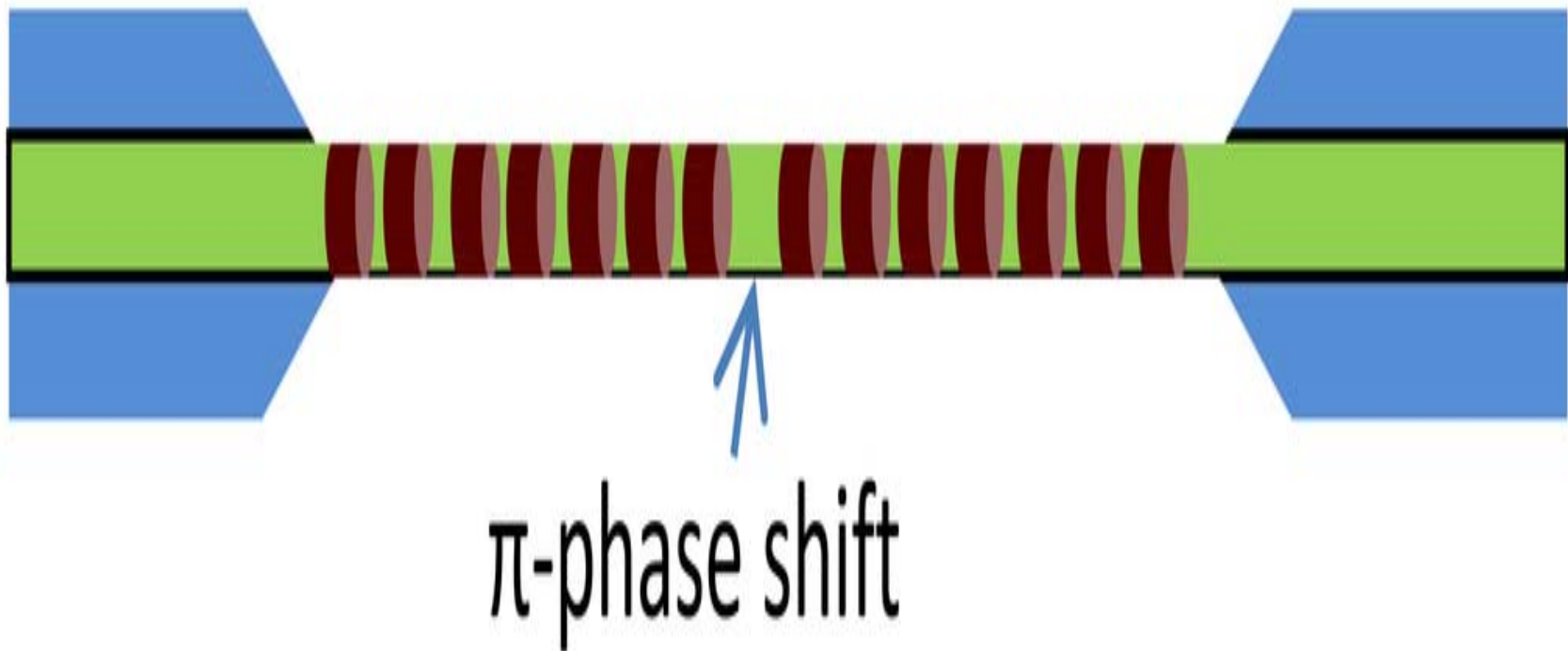


# Moisture measured by sampling of the oil does not give a clear picture

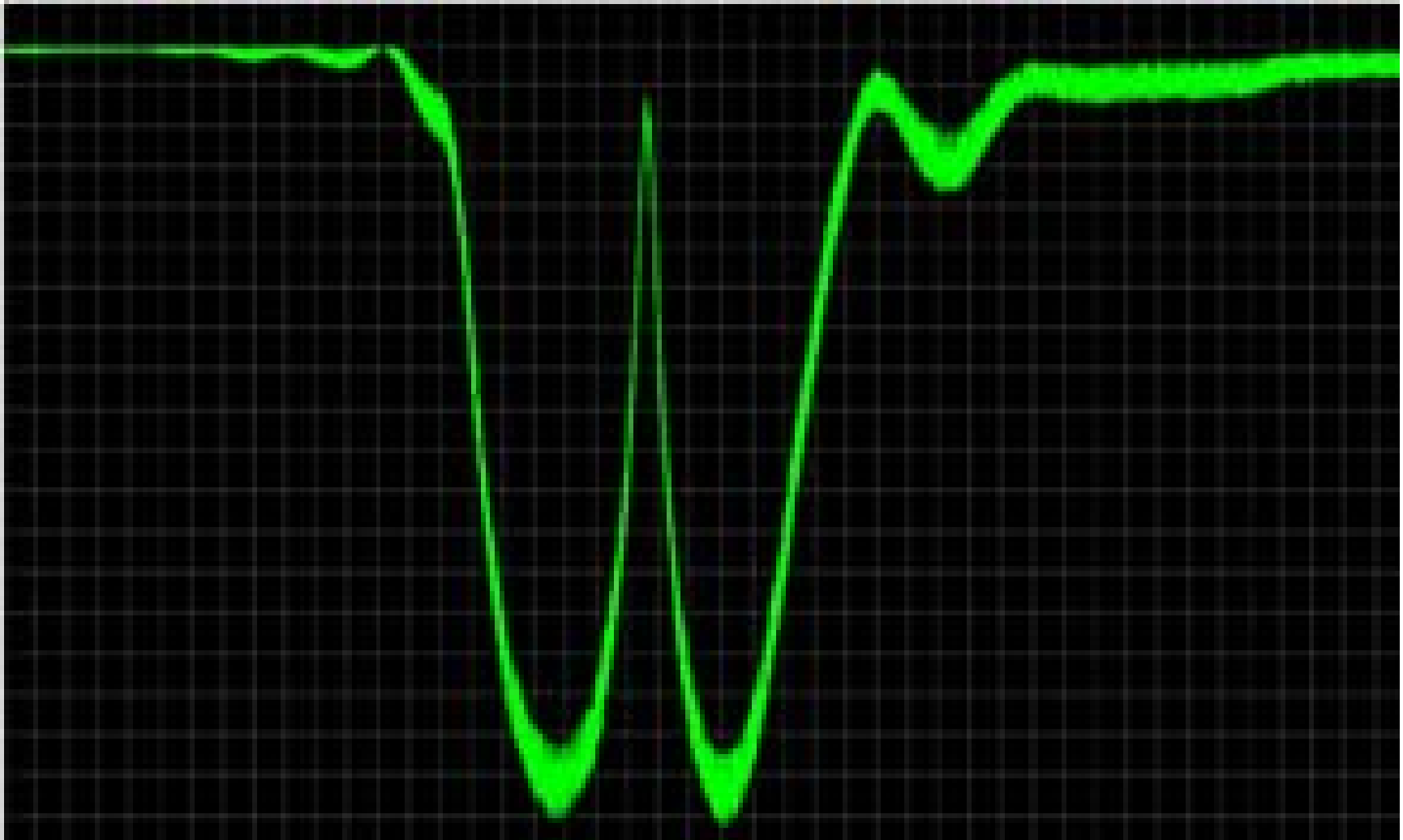
## Online Transformer Monitoring



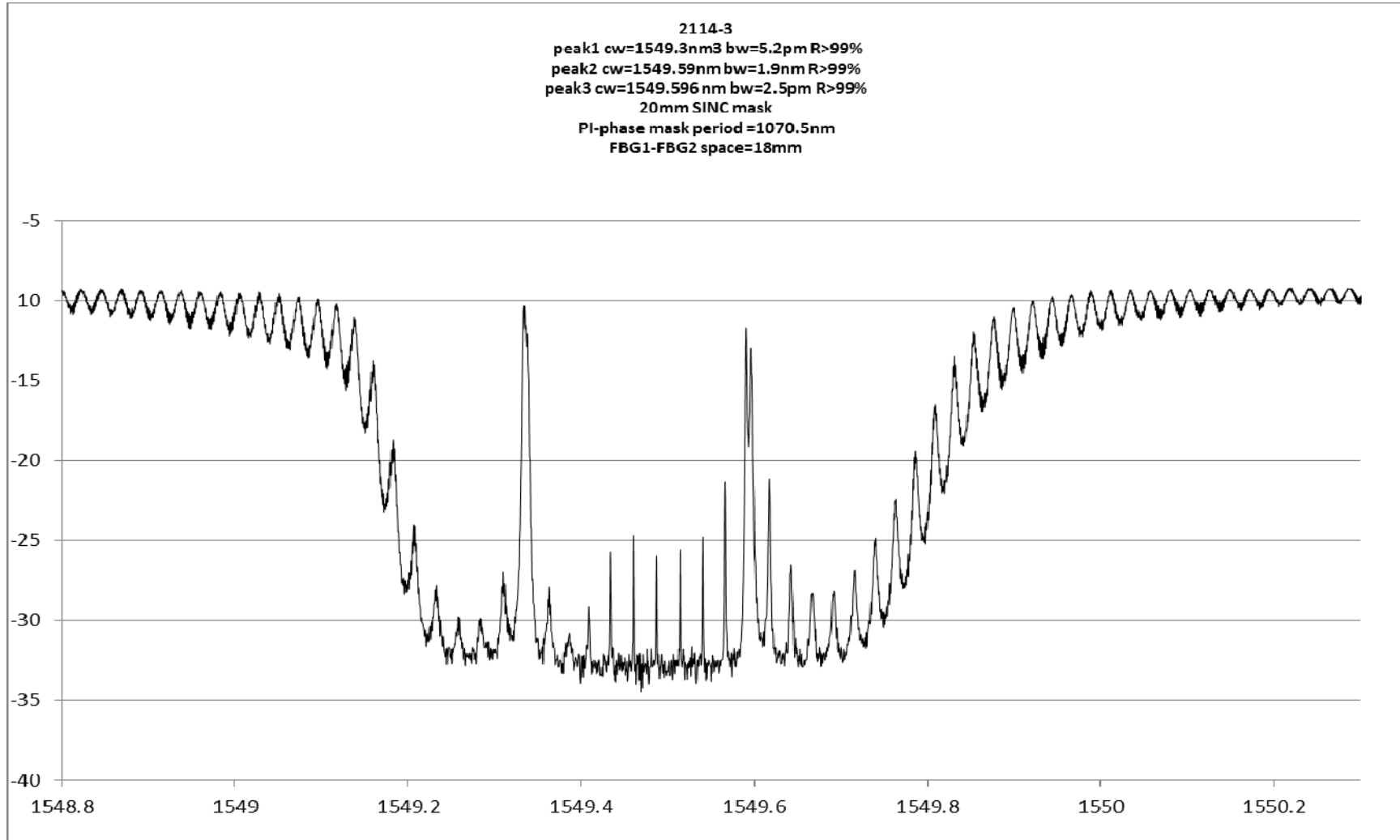
The Phase Shifted Gratings recoated with multilayers of Polyimide forms a moisture sensor



# Spectrum of the Phase Shift Gratings



# We created two peaks, one showing temperature, another moisture

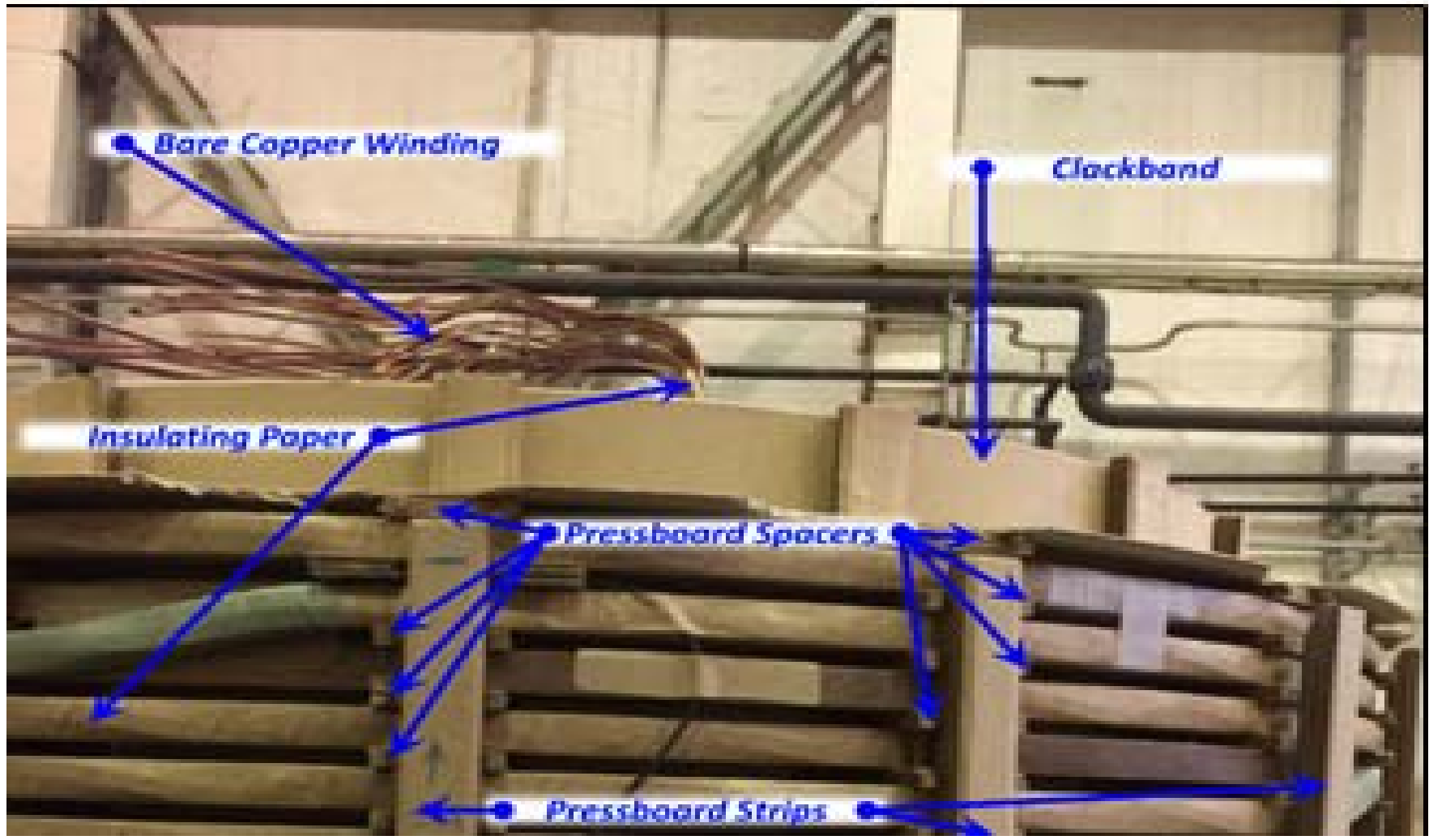




Connecting cable is a Polyether ether ketone (PEEK) Spiral (no air bubble)



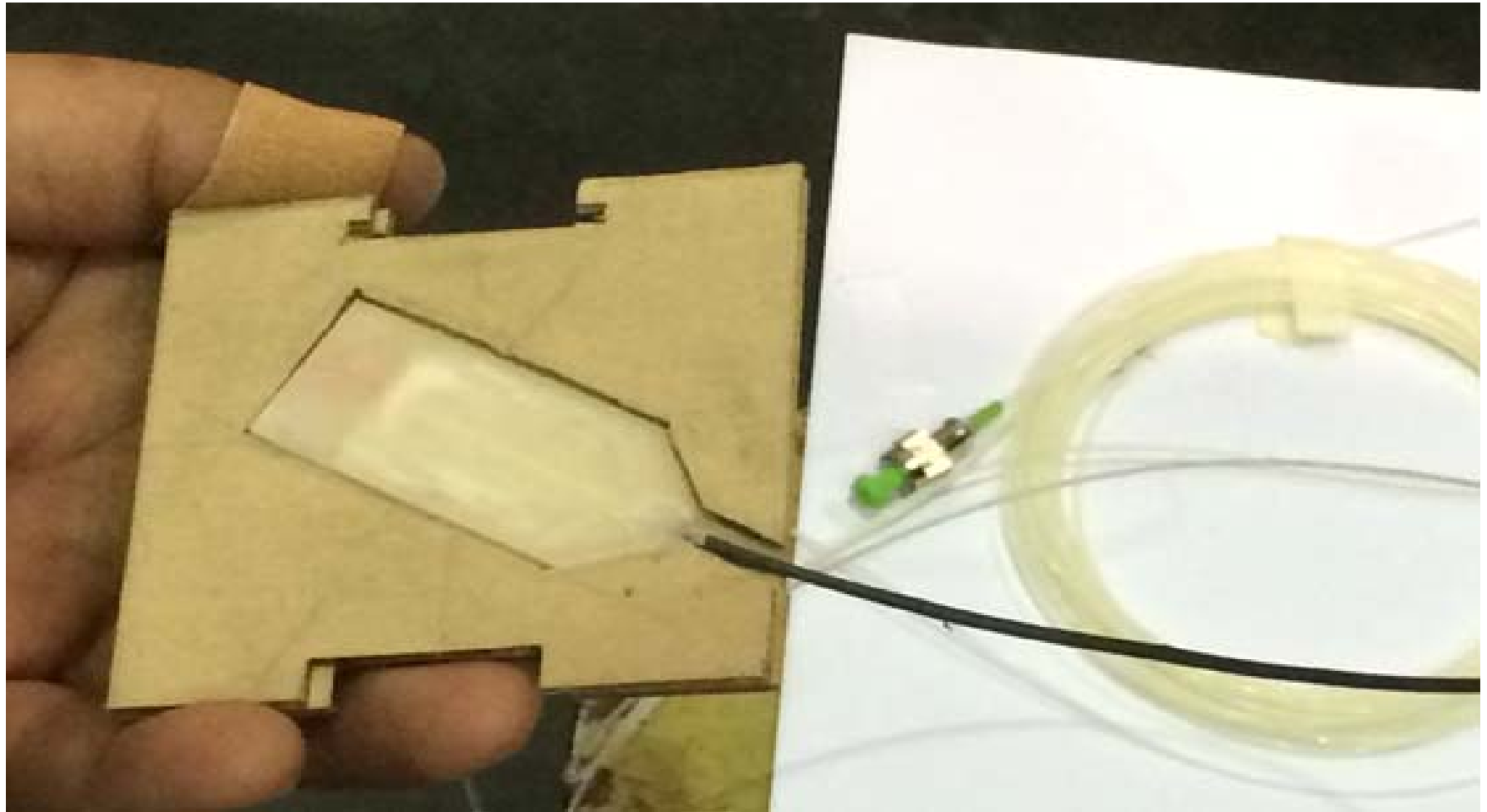
Ready to install anywhere inside the transformer



To measure moisture oil, Insert the sensor into a spacer



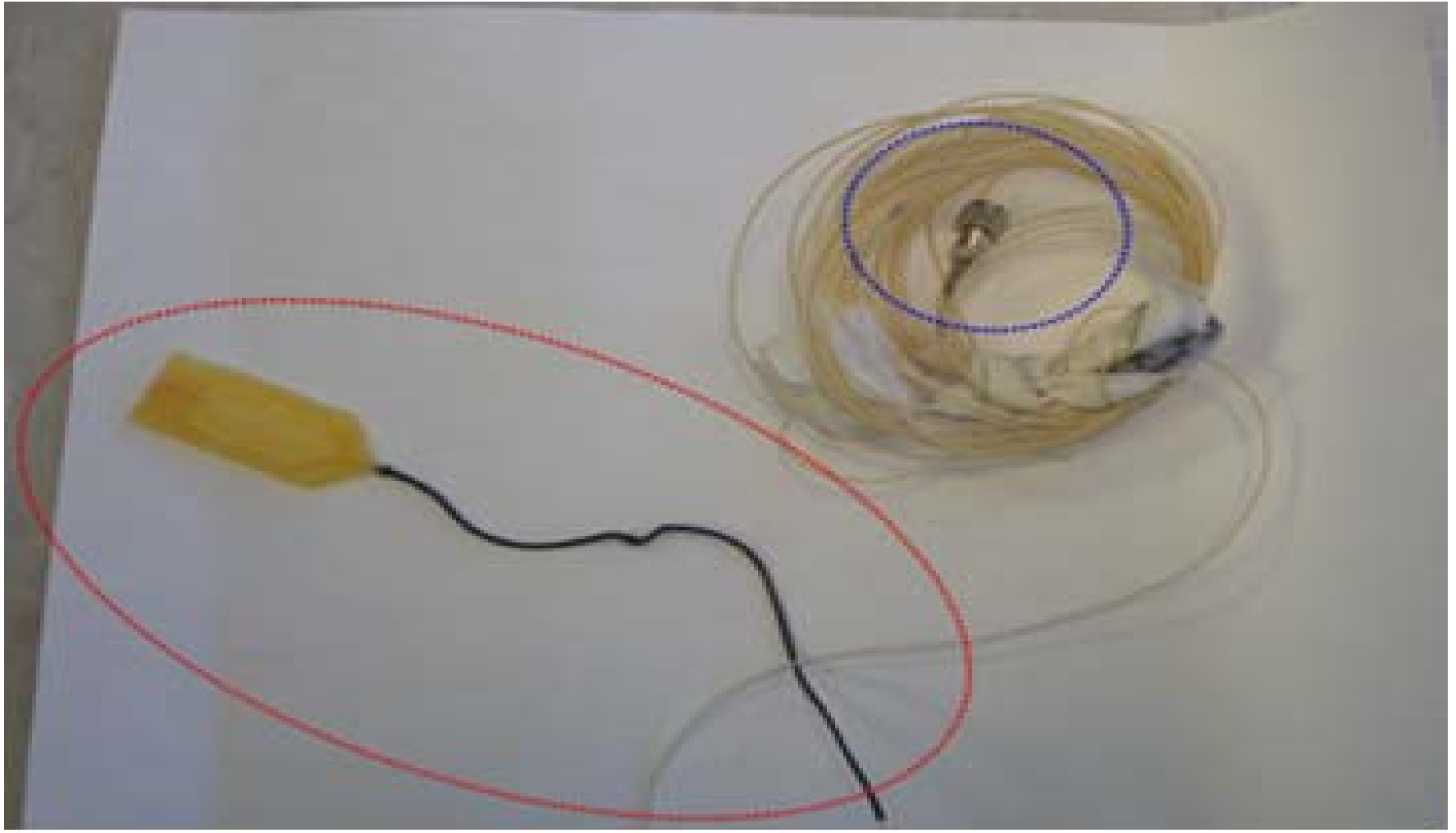
It would not affect cooling oil flow



# Sensor installed in a field Test

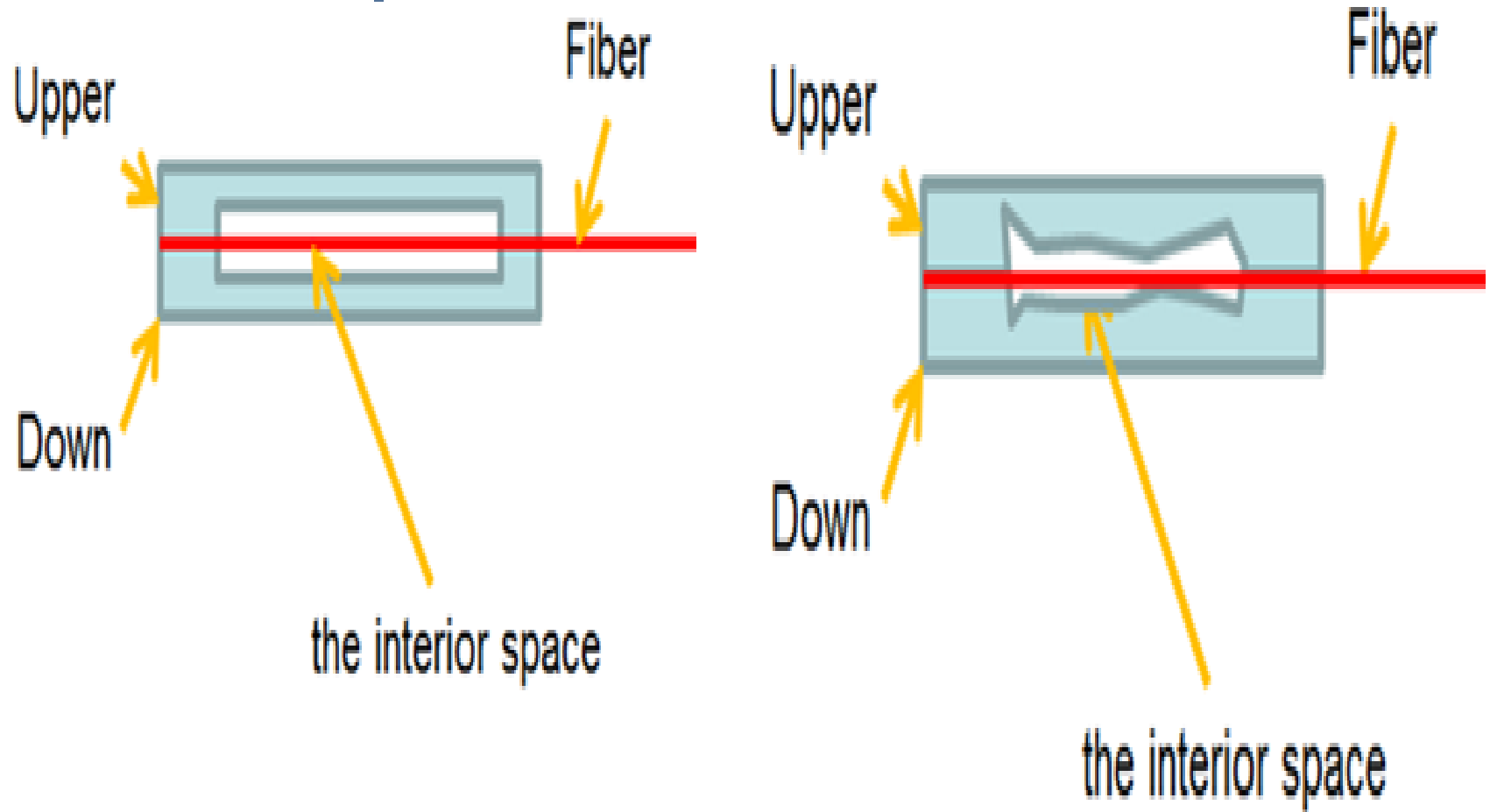


In a previous Field test: Our Vibration Sensor failed during the high temperature vacuum bake





# Failure Analysis

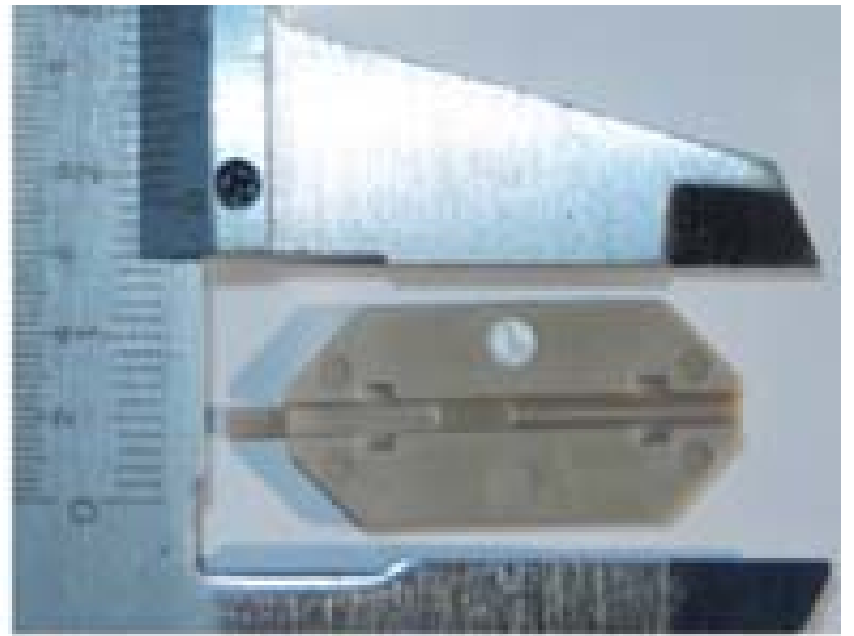


**Length**

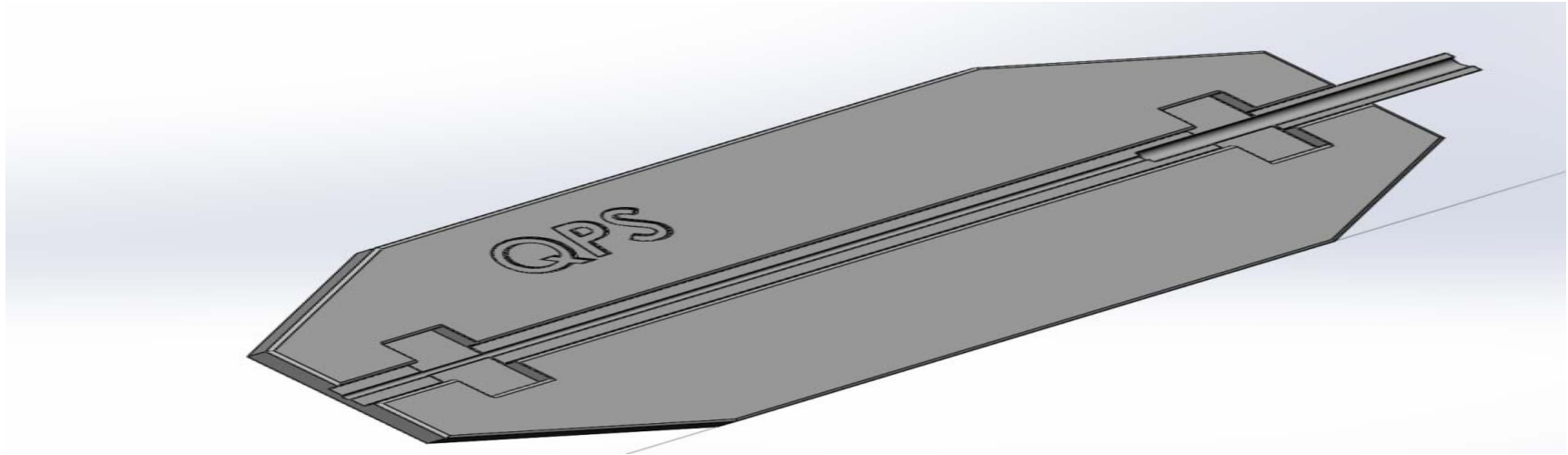
**Width** →



**Thickness** →



# The Moisture/Temperature sensor



Length \* width \* thickness

50mm \* 20mm \* 2mm

(Material PEEK ) can work at high  
temperature up to 300 degrees C

Working on moisture/ temperature Calibration ,  
ready for a field test at Northern Transformer ,  
Toronto in January, we welcome participation  
from others OEMs , let's work together !

Please contact Peter Kung for more discussion

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