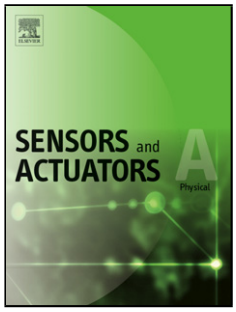

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PIEZOELECTRIC MEMS RESONANT DEW POINT METERS

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Highlights

- A new class of dew point meter is presented using piezoelectric MEMS resonators.
- Such dew point sensors can measure humidity just with a few monolayers of moisture.
- Fast and accurate dew point measurement at very low moisture levels is achieved.
- Durability of the sensor was evaluated with measurements as long as 35,000 cycles.

Abstract

This work presents a new class of dew point meters using Thin-film Piezoelectric-on-Silicon (TPoS) resonators. The proposed approach utilizes microelectromechanical resonant balances coupled with a cooling element in which a standard chilled surface technique is used to deposit layers of moisture on the resonator surface. Reducing the temperature causes the resonance frequency of the resonator to increase due to its negative temperature coefficient of frequency (TCF). However, when the temperature of the cooled resonator reaches the dew point (DP) of the surrounding environment, a thin layer of frost starts to form on the resonator surface causing an abrupt negative shift in the resonant frequency due to mass-loading. Therefore, the resonance frequency will be at its maximum value when the dew or frost starts to form i.e., at DP. A custom-made setup which includes a MEMS dew point sensor head, a dew point generator and a measurement/control/data collection interface is assembled to enable automated measurements. Using the proposed setup, dew points as low as -41°C i.e., a dry air containing 145 ppmv H_2O, are measured with a standard deviation of 0.1°C. Long-term reliability and accuracy of the sensors presented here are investigated by conducting 35,000 cycles of uninterrupted measurements. The long-term stability, precision, and durability of the presented dew point meters make them suitable solutions for a wide variety of industrial applications.

Keywords: Dew Point Meter, MEMS, Nano-balance, Piezoelectric Resonator, chilled surface.

1. Introduction

Trace-moisture measurements are needed in a variety of different industrial sectors, including pure gas supply, semiconductor manufacturing, atmospheric and climate research, aerospace and petrochemical processing as well as biomedical applications including the detection of humidity in respiratory system or vapor loss from the skin [1]–[3]. Moisture, in gas or liquid form, adversely affects product quality and harm operating instruments which in turn increases maintenance and operational costs [4]. Petroleum and gas industries are among sectors in which careful monitoring of the content of moisture are required with well-designed sampling systems. This moisture can corrode pipelines, affect pipeline flow capacity, and lead to pipeline blockage and filter, as well as valve and compressor damage. Water in natural gas also increases the cost of transportation in pipelines by introducing additional mass. The dew point temperature indicates how much moisture is present in the gas phase and its determination can help maintaining the gas at a temperature level that prevents condensation. As an absolute humidity unit, dew

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