A Microwave Reentrant Cavity Resonator for the Measurement of Mixture Dew Points

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Microwave cavity resonators measure the dielectric permittivity of a sample and detect dew points by an inflection in the permittivity as an isotherm or isochore is traversed. Here, we present a new microwave cavity, recently put into operation at NIST, which has been optimized for the determination of dew points. The basic design is that of a "bulb" forming an annular gap with the main "body" of the measuring cell, thereby forming a capacitor. While this basic form is common in the literature, several novel modifications have been implemented. We used finite element modeling to design a specific cavity geometry wherein specific regions of the cavity have distinct resonant modes. The 1.0 mm annular gap between the bulb and body, with resonances at 2.26 GHz and 4.20 GHz, primarily measures the permittivity of the bulk fluid sample. An 8.0 mm diameter extension at the bottom of the bulb forms a 0.5 mm gap with the body and has a resonant frequency at 3.40 GHz. This feature is an adaptation of the "post/well" geometry introduced by May et al. in 2003; as with the May design, condensation occurs first in this region. In contrast to May's actively cooled post/well design, ours responds rapidly to changes in the bath temperature by means of a copper fin that extends into the thermostat bath; in effect, it is passively cooled when operating along an isochore. Condensation forms first at the bottom, but changes in the permittivity occurring in the annulus provide a means to quantify adsorption/precondensation as the dew point is approached. The design, together with careful attention to high-frequency cabling, yields low-noise signals. The instrument implements a high degree of automation and operates over a temperature range of –45 ˚C to 150 ˚C, with pressures to 10 MPa. We present validation data on pure propane and first mixture results.