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Development of 30 and 1000 Torr Full-Scale Optical Diaphragm Gauges

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Presently, for high accuracy near-atmosphere vacuum measurements, capacitive diaphragm gauges (CDGs) are the norm. However, for a number of demanding applications involving high temperatures, strong electromagnetic fields or high-energy radiation, optical diaphragm gauges (ODGs, [1] & [2]) would be much better suited alternatives.
In these ODGs, the sensor head incorporates a Fabry-Pérot interferometer, of which the cavity distance is pressure-dependent. As the cavity distance changes, the gap in time between the wave packages reflected from the planar surfaces on each side of the cavity changes as well. The light reflected from the sensor head is transported to the detector by means of an optical fibre. The detector's output signal is used to infer the cavity distance, which in turn serves as the basis for a pressure vs cavity distance calibration. By making use of such fibre optic technology to transport the measurement signal, it can propagate with minimal losses, so that even kilometer-scale sensor-detector unit distances become viable without additional signal amplification.
This inherently passive measurement arrangement provides major advantages over capacitive sensors, where for harsh environments, the electronics has to be placed at a distance adequately far away from the sensor head. For any real-life distances, the resulting electric signal quality degradation poses a major problem, as for these capacitive sensors, very low signal levels need to be measured with high accuracy.
At INFICON AG, Balzers, Liechtenstein, a feasibility study has been carried out on two sets of sensors with deflection ranges designed for 1000 and 30 Torr full-scale pressure readings, respectively. The ODGs' housings are composed from Al2O3 and sapphire, and the membrane is sapphire as well. The sensors were encased in housings regulated to a stable 100 ℃ temperature and operated using a CoreSens CSC-M multi-channel WLPI interferometer. The experimental evaluation of the sensors included the determination of the diaphragm cavity distance vs pressure characteristics, medium-term high vacuum drift behaviour, influence of atmospheric pressure and heater block temperature as well as signal recovery following atmospheric pressure exposure. The first results indicate ODG sensor performance on par with CDGs of equivalent full scale ranges.

[1] J.M. López-Higuera et al, "High-temperature optical fiber transducer for a smart structure on iron-steel production industry". Proceedings of SPIE - The International Society for Optical Engineering, Vol. 4328. http://dx.doi.org/10.1117/12.435541

[2] K. Totsu et al, "Vacuum sealed ultra miniature fiber-optic pressure sensor using white light interferometry", 12th International Conference on Transducers, solid-state sensors, actuators and microsystems, 2003, Boston, USA, pp. 931-934 vol.1., doi: 10.1109/SENSOR.2003.1215628

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