

APPLICATION OF FIBER COUPLED INTERFEROMETERS FOR LENGTH MEASUREMENT UNDER CRYOGENIC CONDITIONS

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Investigations at superconductive magnets and magnet system require an extensive sensor technology to measure different types of physical values like temperature, pressure, mechanical stress, elongations etc. The measurement conditions are superior: magnetic fields in the order up to 10 Tesla, temperature range up to 4 K, isolation vacuum and electric potential differences between sensor and electronic unit. The electric potential of the magnetic coils during discharge can be raised against measuring potential up to some kilovolt.

Optical measuring principles are insensitive against changes of electric potential, magnetic fields and electric/magnetic interferences. Length measurements from the micron range for testing of magnets up to the centimeter range for estimation of expansion at coils under cryogenic conditions become more and more important.

Laser interferometers are well established at room temperature and air conditions to realize precision length measuring tasks. Full fiber coupling is an important requirement for application under cryogenic conditions. Such a fiber coupled miniature interferometer was developed in the Institute of Process Measurement and Sensor Technology of Technische Universität Ilmenau [1].

To achieve cryogenic applicability all optical components of the interferometer head, like beam splitter, prisms, optical fibers including fiber connectors, were tested at 10 K and vacuum conditions. After this a complete

miniature interferometer was assembled and then tested in a special interferometer testing equipment even under cryogenic conditions.

The He-leak rate of a commercial fiber optical feed-through was better than the detection limit of the leak detector of 10^{-9} mbarl/s. A less expensive self developed feed-through was in the range $< 10^{-6}$ mbarl/s. The fiber optical feed-through was packaged with fiber connectors at SIOS Messtechnik GmbH.

In the end full functionality of the fiber coupled miniature laser interferometer under cryogenic conditions was demonstrated with several series of measurements. We could not find a change of sensitivity of the interferometer between room temperature conditions and 10 K. In conclusion we proved laser interferometer accuracy of length measurement under cryogenic conditions in combination with high interference resistance against electrical and magnetic disturbances.

[1] G. Jäger, E. Manske, T. Hausotte, R. Füßl, R. Grünwald, H.-J. Büchner, W. Schott and D. Dontsov: Miniature interferometers for applications in micro- and nanotechnology, SPIE-Symposium San Diego, Proceedings, Vol. 5190, S. 185 – 192, August 2003

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