Dental caries persists to be the most predominant oral disease in spite of remarkable progress made during the past half-century to reduce its prevalence. Early diagnosis of carious lesions is an important factor in the prevention and management of dental caries. Conventional procedures for caries detection involve visual-tactile and radiographic examination, which is considered as “gold standard”. These techniques are subjective and are unable to detect the lesions until they are well advanced and involve about one-third of the thickness of enamel. Therefore, all these factors necessitate the need for the development of new techniques for early diagnosis of carious lesions. Researchers have been trying to develop various instruments based on optical spectroscopic techniques for detection of dental caries during the last two decades. These optical spectroscopic techniques facilitate non-invasive and real-time tissue characterization with reduced radiation exposure to patient, thereby improving the management of dental caries. Nonetheless, a cost-effective optical system with adequate sensitivity and specificity for clinical use is still not realized and development of such a system is a challenging task.

Two key techniques based on the optical properties of dental hard tissues are discussed in this current thesis, namely laser-induced fluorescence (LIF) and diffuse reflectance (DR) spectroscopy for detection of tooth caries and demineralization. The work described in this thesis is mainly of applied nature, focusing on the analysis of data from in vitro tooth samples and extending these results to diagnose dental caries in a clinical environment. The work mainly aims to improve and contribute to the contemporary research on fluorescence and diffuse reflectance for discriminating different stages of carious lesions. Towards this, a portable and compact laser-induced fluorescence and reflectance spectroscopic system (LIFRS) was developed for point monitoring of fluorescence and diffuse reflectance spectra from tooth samples. The LIFRS system uses either a 337 nm nitrogen laser or a 404 nm diode laser for the excitation of tooth autofluorescence and a white light source (tungsten halogen lamp) for measuring diffuse reflectance.

Extensive in vitro studies were carried out on extracted tooth samples to test the applicability of LIFRS system for detecting dental caries, before being tested in a clinical environment. Both LIF and DR studies were performed for diagnosis of dental caries, but special emphasis was given for early detection and also to discriminate between different stages of carious lesions. Further the potential of
LIFRS system in detecting demineralization and remineralization were also assessed.

In the clinical trial on 105 patients, fluorescence reference standard (FRS) criteria was developed based on LIF spectral ratios (F500/F635 and F500/F680) to discriminate different stages of caries and for early detection of dental caries. The FRS ratio scatter plots developed showed better sensitivity and specificity as compared to clinical and radiographic examination, and the results were validated with the blind-tests. Moreover, the LIF spectra were analyzed by curve-fitting using Gaussian spectral functions and the derived curve-fitted parameters such as peak position, Gaussian curve area, amplitude and width were found to be useful for distinguishing different stages of caries. In DR studies, a novel method was established based on DR ratios (R500/R700, R600/R700 and R650/R700) to detect dental caries with improved accuracy. Further the diagnostic accuracy of LIFRS system was evaluated in terms of sensitivity, specificity and area under the ROC curve. On the basis of these results, the LIFRS system was found useful as a valuable adjunct to the clinicians for detecting carious lesions.