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## Improving lock-in thermography detection of microgaps located at the tooth-filling interface using a phase versus amplitude image signal extraction approach

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**Abstract.** The aim of this study was to investigate the adhesion between some dental fillings and the dental hard tissue by two non-destructive techniques: lock-in thermography and optical microscopy. In this regard 10 non-carious human teeth were sealed with experimental and commercial sealants and then longitudinally sectioned in slices that were then examined. In the mean time some cavities were restored with some new dental fillings (giomers) and their sealing ability was analyzed by the two above mentioned techniques. Both amplitude and phase images obtained after lock-in detection procedure bear information on the presence of the gaps, carried out by small perturbations of amplitude or phase of propagating subsurface thermal waves. An image processing algorithm based on the laplacian of the amplitude and phase images highlights the edges of the crack, leading to the localizations of cracks with a very good contrast. No difference between the adhesion capacity of sealants to dental enamel was observed. The phase image seems to be more appropriate for retrieval of micro-gaps than the amplitude image. Lock-in thermography technique together with the image processing procedure proved their capacity in evaluating dental interfaces.

**Keywords:** lock-in thermography, optical microscopy, filling-tooth interface, micro-gaps detection, image processing, non-destructive evaluation

### 1. Introduction

Dental caries are one of the most common diseases in both children and adults, but are largely preventable. In order to prevent or stop the dental caries process before it reaches the ends stage of the disease, fissure sealants can be applied to the top face of the teeth. The sealant forms a protective layer that keeps food and bacteria away from the pits and fissures of the teeth. Dental sealants are a safe and cost-efficient dental procedure for patients prone to cavities, such as children and teenagers. The lack of adaptation between a dental filling and tooth structure has for many years been a major problem in dentistry. In order to obtain a good dental adhesion, a perfect adaptation of the sealant and/or filling to the tooth is required. This is why the evaluation of a dental restoration in a non-invasive way is of paramount importance in clinical practice. In dentistry there are only two investigation techniques currently used for the evaluation of marginal adaptation of different

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