

Low cost laser vibrometer for qualitative substrate sound measurements

Introduction

Analyzing substrate sound is telltale for detecting insects and discriminating species, but classical accelerometers tend to distort measurements by their mass and standard laser vibrometers are expensive.

Objectives

When a red laser pointer beam (~630 nm, ~2 mm \varnothing) gets reflected by a consumer type retroreflective foil (e.g. from reflective vests) with prism spacings in the order of 80 μm (Fig. 1), the reflected light generates an interference (speckle) pattern on surfaces around the laser beam. At ~1 m from the reflector, the speckles are spaced 1-3 mm (Fig. 2). If the reflector is tilted or translated, the speckle pattern moves fiercely. The concomitant modulation of the illuminance of a photodiode or of a pair of photodiodes is used to detect the movements of the reflector.



Fig. 1 Arrangement of prisms on retroreflective foil

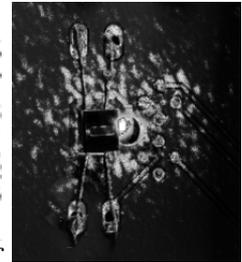


Fig. 2 Speckle pattern and detector chip with dual photodiode & amplifiers

Materials & methods

Based on standard class 2 laser pointers (Brennenstuhl, Eco-LED-Light FL DUO), two types of vibrometers were built. Type 1 uses continuous laser light, a pair of PIN photodiodes (Siemens, BPW 34) and an amplifier. One of the photodiodes serves as reference for the ambient light. Type 2 uses amplitude modulated (~70 kHz) laser light and a position-sensitive detector chip (IC-Haus, iC-OD OLGA OD4C, Fig. 2) with 2 adjacent photodiodes and corresponding photocurrent amplifiers with high pass function for ambient light suppression. The amplified difference of the demodulated photocurrents yields the output signal. Signals of both kinds of vibrometers were fed to the audio jack of a PC and analyzed with "soundcard scope" (http://www.zeitnitz.de/Christian/scope_de). Both types of vibrometers work reliably at ~1 m distance between with most retroreflective foils and fabrics tested (e.g. Selbstklebe-Produkte SKP Art.-Nr. 80141; IMOS Gubela, different types; pieces from randomly selected reflective vests). Type 1 is simpler, but more sensitive to ambient light.

Results

With the described kind of laser- and retroreflector-based vibrometers, quantitative amplitude measurements are not possible due to the principle of operation. To each rest position of the retroreflector (with respect to the laser and receiver) belongs another speckle pattern and a different kind of illumination change by a given movement.