

Corrosion Detection by Using Raman Spectroscopy with Mobile Sensing Technique

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ABSTRACT

Offshore structures are exposed to various environmental conditions such as seawater, rain, etc. For this reason, offshore structure has many corrosion problems. In order to protect and maintain offshore structures, the chemical compounds of corrosion parts need to be known. Raman spectroscopy is a well-known technique to measure oxide compounds such as steel corrosion. In this study, a new Raman spectroscopy system was developed for offshore structures and preliminary testing was carried out for steel corrosion samples.

1. INTRODUCTION

Steel is a common structural material that is used for bridges, buildings, railroad tracks, wind towers, offshore platforms, and many other applications. Steel naturally corrodes in different atmospheric environments, which results in costs for corrosion protection, prevention and maintenance. The corrosion on steel elements is identified by optical examination, which does not provide information on the material characteristics. Studies have shown that Raman spectroscopy can identify the corrosion products of steel and differentiate between iron oxides and hydroxides (de Faria et al. 1997; Hanesch 2009; Pineau et al. 2008; Thibeau et al. 1978). The purpose of this is to develop the systemized mobile Raman spectroscopy for the effective sensing and detection of steel corrosion

2. RAMAN SPECTROSCOPY AND RAMAN PIEZOSPECTROSCOPY

Raman spectroscopy is a technique that relies on the vibrations, rotations and other low frequency modes of molecules for material characterization. A monochromatic light source, such as a laser, is used to excite the sample. Most of the light is reflected at the frequency of the incident beam (Rayleigh scattering), while a

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portion is reflected at frequencies which represent a shift from that of the incident beam (Raman scattering) as illustrated in Figure 1.

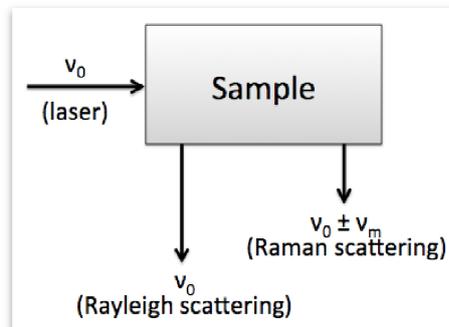


Fig. 1. Illustration of Rayleigh and Raman scattering (Ferraro et al. 2003)

The Raman shifts occur from the excitation of the molecules in the sample which absorb or emit photons and result in reflected light at a lower or higher frequency than the incident light. The spectrometer reads the frequency of the scattered light which is converted to wave-number ($\tilde{\nu}$) by Equation 1 (Ferraro et al. 2003).

$$\tilde{\nu} = \frac{\nu}{c} = \frac{1}{\lambda} \quad (1)$$

where c is the speed of light and ν is the frequency. The unit for the wave-number is $[L^{-1}]$ which is commonly cm^{-1} . The change in energy (ΔE) of the molecule is related to the wave-number by Equation 2 (Ferraro et al. 2003).

$$\Delta E = hc\tilde{\nu} \quad (2)$$

where h is Planck's constant. The change in energy of the photon as the molecule changes its state is then directly proportional to the wave-number that is recorded by the charge-coupled device (CCD) in the Raman spectrometer. The Raman spectrum is recording of the shift in the frequency of the initial photon from its change in energy relative to its original frequency.

Raman scattering is activated by the change in polarizability (α) of the electron cloud of the molecule in response to the vibration and rotation caused by the electric field of the incident laser. When an atom or molecule is exposed to an electric field, its electron cloud can be distorted by a change in shape, size or orientation. The ease of this distortion is defined as the polarizability (Carter 2010; Cox and Reuser 2010).

3. DEVELOPMENT OF MOBILE SENSOR USING RAMAN SPECTROSCOPY

3.1 Prototype

The prototype consists of 3 probe heads, a fiber optic cable and probe main parts. In order to collect Raman spectra from the target sample, this system needs to connect with commercial Raman spectrometer and laser device. The schematic drawing and picture images are shown in the following figures: