Optical Fiber Sensor for Early Warning of Corrosion of Metal Structures

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***Abstract*—Long period fiber gratings (LPFGs) were over coated with iron (Fe) and subjected to oxidation in air and in solutions of water containing different sodium chloride (NaCl) concentrations. The formation of iron oxides and hydroxides was monitored in real time by following the features of the gratings attenuation band. Preliminary results show that Fe coated LPFGs can be used as sensors for early warning of corrosion in offshore and in coastal projects where metal structures made of iron alloys are in contact with sea or brackish water.**

Keywords—Long period gratings, Fiber optic sensor; Oxidation of iron, Real time monitoring of corrosion

I. INTRODUCTION

The consequences of the corrosion of iron and its *alloys* have become a problem of worldwide significance [1]. Corrosion causes plant shutdowns, waste of resources, loss or contamination of products, reduction in efficiency, endanger safety and imposes expensive maintenance. The exploration of sea resources, such as deep sea mining and aquaculture, requires metallic structures, often made of iron alloys, which are exposed to corrosion [2]. In addition, activities such as dikes and the flooding of coastal marshland can produce brackish water pools for freshwater prawn farming. Brackish water is also the waste product of the salinity gradient power process [3]. In all these instances the control and monitoring of corrosion effects can be of critical importance.

Optical sensors based on long period fiber gratings (LPFGs) including, sensing of strain, bending, temperature, chemical analysis, vapor detection, food quality control and recognition of bacteria have been reported. A review on the fundamentals and on the main achievements obtained concerning LPFGs can be found in [4-6] and references therein.

The physical properties of LPFGs rely on coupling light from the core mode of a single mode fiber into forward propagating cladding modes which translates in the appearance of attenuation bands in the transmission spectrum at specific wavelengths. The evanescent field of the cladding modes extends to the surrounding medium enabling refractive index measurements.

Sensors based on LPFGs over coated with different metal oxides were fabricated and characterized for refractive index sensing. It was reported that oxidation of Zn, Ni, Ti, Al, and Cr into well-known oxide states can be monitored in real time by following the features of the LPFG attenuation band [7, 8]. These kind of gratings coated with metal oxides with specific properties leads to wavelength sensitivity enhancement when comparing to a bare LPFG. This work reports a preliminary study on the real time monitoring of iron thin films subjected to oxidation in air and in water with different sodium chloride (NaCl) concentrations using LPFGs in a temperature controlled environment.

II. MATERIAL AND METHODS

Long period fiber gratings inscribed in single mode fiber (SMF28e, Corning, Inc.), were produced using the electric arc technique [4]. The period of the LPFG was 399 µm, a value chosen in order to obtain the asymmetric 6th order cladding mode resonance ($LP_{1,6}$) around 1.54 µm. A visibility value of ~25 dB for the $LP_{1,6}$ attenuation band of the bare LPFG was reached with a sensor length of 45 ± 5 mm. Depending on the oxidation process this attenuation band can shift down to around 1.51 µm.

A 40 nm thick film of Fe was produced around the grating region by thermal evaporation of pure metal (Goodfellow, U.K.) using an electron beam evaporator (Auto 306 from Edwards Ltd, U. K.) whose chamber was kept at ~2x10 6 mbar, fitted with a

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