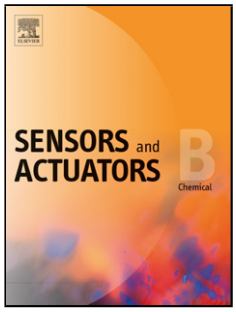

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Humidity Responsive Photonic Sensor based on a Carboxymethyl Cellulose Mechanical Actuator

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Abstract: We describe an intuitive and simple method for exploiting humidity-driven volume changes in carboxymethyl cellulose (CMC) to fabricate a humidity responsive actuator on a glass fiber substrate. We optimize this platform to generate a photonic-based humidity sensor where CMC coated on a fiber optic containing a fiber Bragg grating (FBG) actuates a mechanical strain in response to humidity changes. The humidity-driven mechanical deformation of the FBG results in a large linear change in Bragg resonance wavelength over the relative humidity range of 5 % to 40 %. The measurement uncertainty over this relative humidity range is ± 2 % (k = 1).

Introduction: Measurement of humidity refers to a determination of the amount of gaseous water within a local environment.[1-4] Often the water-vapor content is expressed in units of relative humidity (RH) which is simply the ratio of water vapor partial pressure to the saturation water vapor partial pressure at a specific temperature.[1] Like temperature, humidity is an important parameter for controlling the quality of manufactured goods from starting materials to usage across a diverse array of industries including semiconductor and pharmaceutical manufacturing. In pharmaceutical production and storage, uncontrolled changes in humidity can lead to pseudo-polymorphic transitions[5] of the drug substance resulting in a form of the active ingredient that could have widely different and inappropriate pharmacokinetics.[6] On a more prosaic level, good humidity control in building environmental conditions is important for the comfort and well-being of the occupants and in the detection of possible mold-growth conditions. Consequently, the development of novel humidity sensors, whether based on electrical or optical devices, is necessary to facilitate the desired environmental controls for industrial and residential settings. Optical sensing methods encompass direct absorption spectroscopy, cavity ring down spectroscopy, fluorescence spectroscopy, light attenuation measurements, interferometric interrogation of Fabry-Perot cavities, strain induced shift in Bragg resonances, and refractive index sensing using evanescent coupling of waveguide field.[1, 7] Molecular spectroscopic measurements provide the most definitive measurements,[8] but the instrumentation cost, size and complexity can be a hindrance for routine application. Simple fiber-based humidity sensors such as those relying on polyimide-mediated strain transduction in fiber Bragg grating (FBG) sensors provide a cost-effective means for optical measurement of relative humidity over a wide humidity and temperature range.[9-10]