Nondestructive Evaluation of the Thermal Properties of Three-Layer Fuel Cell Electrodes using Photothermal Deflection Spectrometry

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Nondestructive depth profiling, i.e. obtaining information about the optical and/or thermal characteristics of a sample as a function of depth beneath its surface, is a unique capability of photothermal techniques. In photothermal deflection (PD) a temperature field at the sample surface is induced and the optical refractive-index gradient in the medium adjacent to the sample surface is probed. Using one-dimensional temperature distribution, together with Fresnel diffraction theory, we have developed the theory for continuous wave photothermal deflection and applied it to multilayer samples. Depth profiling of multilayer-structured materials can be performed by analyzing the effects of optical and thermal properties on the PD signals.

In this work, we applied the PD technique to fuel cell materials. We monitored the evolution of thermal diffusivity and thickness of a three-layer-structured half membrane-electrode-assembly (MEA), which consisted of a layer of proton conducting polymer membrane, a carbon supported Pt catalyst layer, and carbon cloth. The MEA is the core component of a proton exchange membrane fuel cell (PEMFC). Heat transfer must be considered when designing PEMFC stacks, and evaluation of thermal properties in the presence of water is of scientific and technological significance. Upon immersion in water, the membrane swells, and the PD signal evolves. Analysis of the PD signal indicated that the thermal diffusivity of the membrane evolves over time.