Investigations of automotive aftertreatment component aging by focused ion beam (FIB) milling: the catalyst-substrate interface and intra- and inter-layer interactions

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ABSTRACT

The combined focused ion beam/scanning electron microscopy/energy dispersive X-ray spectroscopy (FIB/SEM/EDX) system is a novel tool for the automotive catalysis field. Automotive emissions such as SO_x, NO_x, and particulate matter (PM) are regulated to various extents throughout the world, requiring the use of multiple aftertreatment components such as the diesel particulate filter (DPF), diesel oxidation catalyst (DOC), three-way catalytic converter (TWC) and selective catalytic reduction (SCR). While these aforementioned aftertreatment components are generally multifunctional and robust in design, thermal and chemical aging over the components' useful lifetimes results in significantly degraded performance leading to increased engine emissions levels and decreased fuel economy. While the component sizes themselves are generally large (10s of cm to ≈1/2 m), component aging mechanisms usually dominate on the nm-µm scales. In particular, this study has used the FIB/SEM/EDX system to investigate the aging of the diesel particulate filter (DPF) due to engine lubrication-derived ash accumulation. Ash is comprised of incombustible, inorganic lubrication additives which are carried to the DPF via carbon nanoparticles (soot), and have been shown in this study to be complex structures of Ca, Zn, and Mg in the form of oxides, sulfates and phosphates. The FIB/SEM/EDX system has been used in the automotive aftertreatement field for the first time with many surprising and significant findings. Although the samples used in this study are quite different to those typically found in FIB studies, The authors have shown that the FIB/SEM/EDX system is a valuable tool in this research area, especially for the investigation of µm-size intraparticle structure and nm-µm interfacial details at the aged catalyst surface.