Internal diesel injector deposits - chemical and structural analysis at high resolution

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The maintenance of clean and efficient performance of diesel engines is becoming a major requirement in many developed countries. Numerous problems including reduction in engine efficiency, increase in emissions and, in the most severe cases, engine failure, can be caused by carbonaceous deposits forming on internal parts of diesel injectors. In the present study, we use advanced electron microscopy and associated spectroscopies to obtain detailed information on morphology and chemistry of internal diesel injector deposits from accelerated engine tests.

The initial bulk characterisation allowed for the selection of multiple regions of interest from which electron transparent cross-sectional lamellas were obtained using focused ion beam (FIB) milling. Next, higher resolution advanced techniques such as scanning transmission electron microscopy (STEM) combined with electron energy-loss spectroscopy (EELS) and energy dispersive X-ray spectroscopy (EDS), were performed on the cross sections.

Cross-sectional analysis of multiple regions shows the presence of a multilayer system composed of the deposit and coatings of diamond-like carbon (DLC) and chromium oxide on top of the steel. In a pristine, undamaged needle, only the DLC and steel surfaces are exposed to the fuel and deposits form on these surfaces. Further high resolution analysis of the deposit-needle boundaries reveals an additional intermediate layer present at this interface. EELS experiments revealed that this layer is composed of inorganic oxides. The combination of region specific preparation techniques and the application of advanced electron microscopy techniques has resulted in the construction of the most comprehensive model of diesel needle components to date.