Using correlative techniques to understand the deposition mechanisms in diesel injectors

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Within the automotive industry there is a constant drive to achieve higher engine efficiency and to reduce harmful emissions into the environment. Much work has been done to optimise the engine design and, more specifically, the fuel injectors in diesel engines to improve performance and reduce emissions. However, the high performance of these injectors is now especially susceptible to build up of deposits causing sticking of moving parts. As a result of changes in injector design, fuel formulations and additives are being developed to reduce deposition. To fully understand how to develop fuels and additives it is necessary to have a fundamental understanding of the deposition process - how the surface affects deposition, the chemical composition of the deposit and the deposition mechanism. To investigate this we have taken engine steel substrates of steel and iron and heated them to various temperatures (up to 300°C) to mimic the average conditions an injector experiences in an engine. We have also created 'model diesel' and passed this across the substrate at the different temperatures to observe the initial steps of deposit formation and how this is affected by the underlying substrate.

The samples were analysed using secondary ion mass spectrometry (SIMS) and electron energy loss spectroscopy (EELS) in the transmission electron microscope (TEM), firstly to understand the substrate surface, then to understand the initial deposition layers formed from the fuel. Initial results show that once heated, the steel surface is oxidised forming an iron oxide layer. Between this and the steel interface, a chromium layer forms, at different depths depending on temperature. This was verified with both SIMS and EELS. Preliminary results suggest the surface chemistry plays a big role in determining the type and depth of deposit built up on the surface of the steel.