SEM/EDS Analysis on Scratch Failure of PTFE Coated Stainless Steel Guide Wire

Coatings are used on a wide variety of substrates such as metals, alloys, semiconductors, polymers, biomedical devices for decorative or functional purposes. The adhesion behaviors of coatings are essential to their applications. Scratch test is one of the broadly used, fast, and effective methods to evaluate coating adhesion properties. During a scratch test, a stylus or scratch tip gradually penetrates into a coating under a progressive load while it also moves across the coating sample. The normal load at which the coating fails due to delamination or other separation mechanisms is called the critical load of interfacial adhesion failure. The critical load of interfacial adhesion failure is related to the practical adhesion strength of the coating to the substrate. One complementary technique for analyzing scratch failure of coating is Scanning Electron Microscopy (SEM) equipped with Energy Dispersive X-ray Spectroscopy (EDS). Working in tandem, SEM and EDS analyses can reveal a tremendous amount of useful information on scratch failure processes and mechanisms, as well as material anti-scratch properties. With the SEM system, micrographs can be taken for morphological inspection in order to understand how the scratch surface is forming and changing. The SEM micrographs of the scratch surfaces can reveal much more details as a result of SEM's larger depth of field, higher resolution and greater magnification than the optical microscope available on a scratch tester. In addition to SEM observations, the EDS system can further assist in identifying and quantifying the chemical compositions of the micro areas of interest by measuring the characteristic X-rays produced by atoms that are present in the coating and substrate materials.

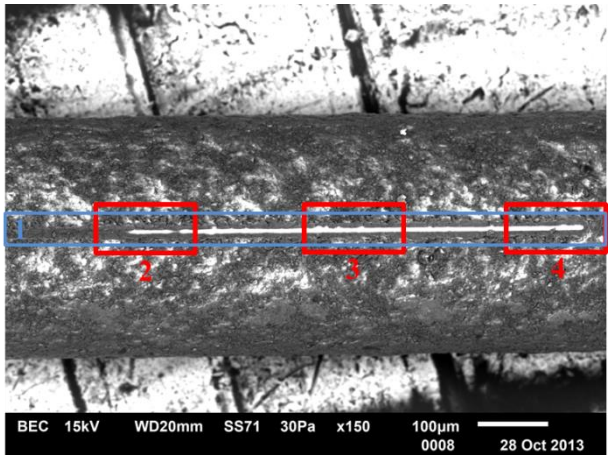

Figure 1. SEM image of a PTFE coated stainless steel guide wire after scratch test; scratch direction: left to right; scratch tip: 2µm diameter, cono-spherical diamond tip.

PTFE coated stainless steel guide wires are popular in many medical applications. PTFE coatings are applied to the wire surface for smooth surface finish, reduced friction, increased lubricity and durability of the guide wire. Obviously the PTFE coating adhesion to the guide wire is critical not only for the desired functionalities but also for the health and safety of the patient to whom

the guide wire is to be used. An undesired issue would be flaking of the coating material due to adhesion problems, which could lead to blockage of a passage or clogging of blood vessels. Figure 1 is an SEM image of a PTFE coated stainless steel guide wire after scratch test. Blue color box Zone 1 includes scratch before interfacial adhesion failure, transitional Zone 2 in which adhesion failure occurred, steady scratch Zone 3 and scratch end Zone 4. The bright scratch track in Zones 2-4 indicates non-existence of the PTFE coating and exposure of the stainless steel substrate.

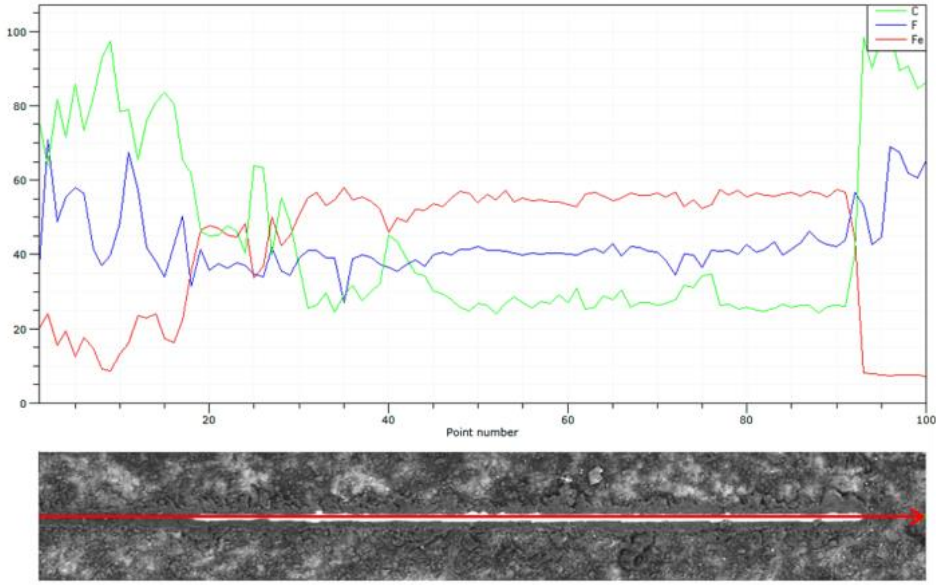

Figure 2. EDS elemental concentration profiles along the red scan line in Zone 1.

Figure 2 shows the elemental profiles of Zone 1 with the EDS line scanning across the entire scratch. The EDS compositional analysis has verified the morphological interpretations of the SEM image; the coating has in deed delaminated in Zone 2 where element Fe from stainless steel substrate increases and C and F from the PTFE coating decreases. The zoom-in SEM images and EDS elemental Hypermaps of the Zones 2-4 presented in Figure 3 provides further details of the elemental distributions of the coating and substrate materials along the scratch.

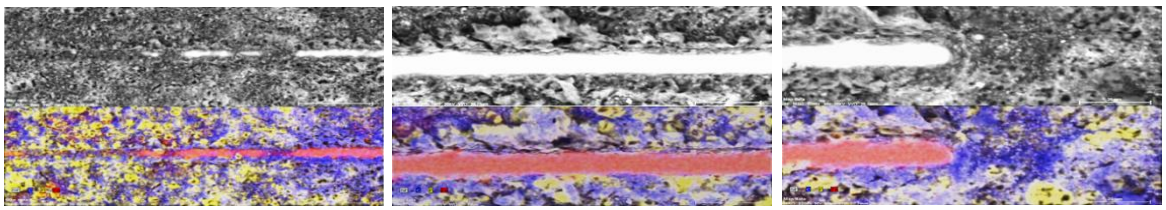

Figure 3. SEM images (top) and EDS elemental Hypermap (bottom) of Zones 2-4; C (blue), F (yellow) and Fe (red).