Development of graphene corrosion resistant coatings across porous stainless steel materials

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Abstract

The development of novel alternatives to current metal anti-corrosion technologies, including hexavalent chromium coating or electro-galvanization, are desperately sought to develop more environmentally friendly and cheaper corrosion resistant materials. These include new materials able to atomically bind with metals and able to improve interfaces with surrounding media or surface properties without compromising the metal thermal or electromechanical properties.

Graphene offers highly promising perspectives for the development of active platforms with potential applications in nano-electronics, molecular separation, high strength composite, and surface coating industries [1, 2]. Recently, graphene oxide (GO) and graphene, either deposited or directly grown onto pre-formed surfaces have shown to act as highly efficient impermeable barriers reducing adverse effects of ion or gas diffusion across materials prone to degradation by electro-chemical reactions [3, 4]. Metal based materials are particularly prone to surface oxidation at the liquid/gas interface and leads to premature degradation through surface erosion or de-alloying, changes of surfaces wetting and sharp loss of mechanical integrity.

In this paper, we demonstrated for the first time the growth of 3D networks of graphene nano-flakes across porous stainless steel substrates. The composition of two different austenitic stainless steel (SS) materials (SS304 and SS316) on the graphene growth stability and metal materials response to the growth conditions was also investigated.

We demonstrate the controlled formation of high purity graphene from single sheets (Figure 1) to complex nano-flakes by Raman spectroscopy, contact angle, XPS, Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (Figure 2) homogeneously across the porous stainless steel supports.

The presence of the graphene was shown to enhance the materials corrosion resistance by up to 3 fold and electrical conductivity by 2 folds without otherwise altering the properties of the stainless steel. This new approach is opening the route to the facile fabrication of advanced surface coatings with potential applications in thermal exchangers, separation, specific adsorption and bio-compatible materials fabrication.

References

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Figures

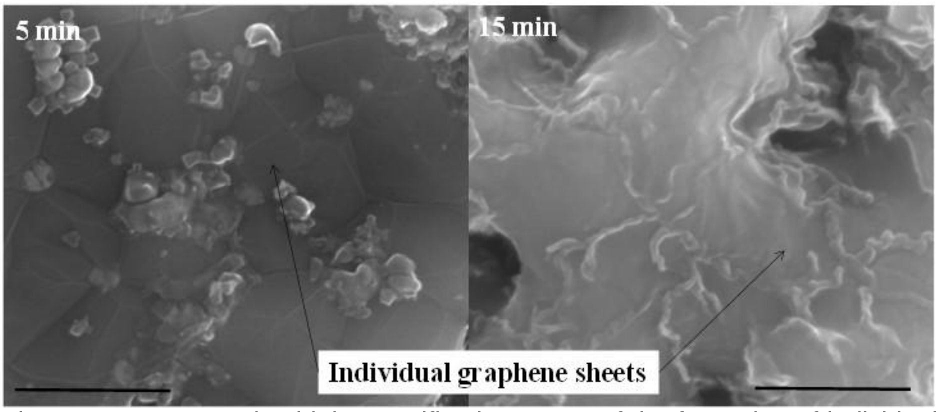

Figure 1 Representative high magnification SEMs of the formation of individual graphene sheets on the surface of the stainless steel. Scale bars are 500 nm

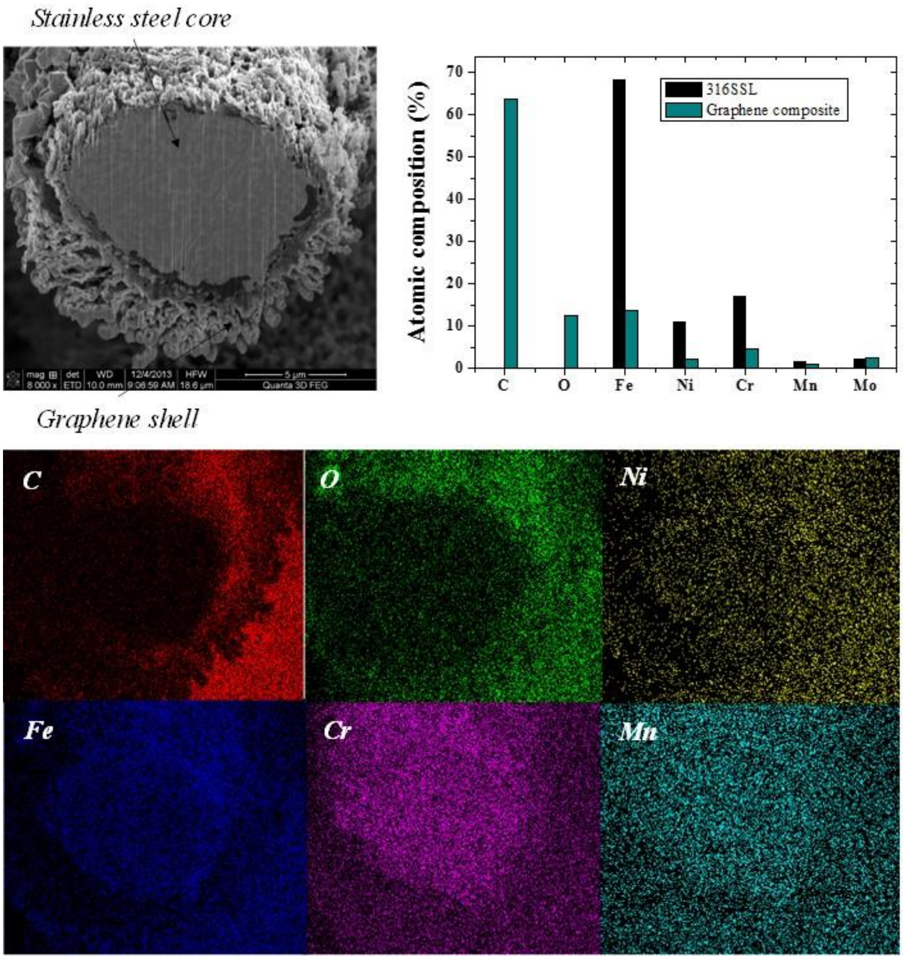

Figure 2 EDS mapping and SEM of a FIB milled cross section of a 900^{o}C, 15 min, 20 ccm hybrid stainless steel graphene sample. The scale bar on the SEM is 5 µm and all elemental maps are equally scaled up