

## Hydrogen Absorption into Titanium under Cathodic Polarization: An *In Situ* Neutron Reflectometry and EIS Study

Significant hydrogen (H) absorption into titanium can result in a substantial reduction in mechanical properties. The H of concern is electrochemically generated at the metal surface through corrosion processes or cathodic protection. In order for hydrogen to penetrate the oxide on the titanium surface (which is otherwise a barrier to hydrogen ingress), the oxide must be reduced to a degree ( $Ti^{IV} \rightarrow Ti^{III}$ ). This increases the conductivity of the film and facilitates electron transport across the oxide/solution interface, permitting the reduction of protons and subsequent uptake of H. In this work, the authors used neutron reflectometry to probe hydrogen uptake into the metal, combined with electrochemical impedance spectroscopy to probe the nature of the metal oxide. Two threshold potentials were identified at which significant changes took place—the first at approximately  $-0.37 V_{SCE}$  and then the second at  $-0.6 V_{SCE}$ . The first threshold was found to be related to the onset of local oxide conductivity and the underpotential deposition of  $D_{ads}$  on the metal surface and its subsequent absorption into the metal. At the second threshold, the oxide is reduced (*i.e.*,  $TiO_2 \rightarrow TiOOH$ ) and rendered ineffective as a hydrogen permeation barrier, allowing significant hydrogen uptake to take place. This work represents the first instance where the  $-0.37 V_{SCE}$  potential regime has been identified as a threshold related to hydrogen uptake.

From: *J. Electrochem. Soc.*, **160**, C414 (2013).

## Electrochemical Detection of Amyloid-Beta Aggregation in the Presence of Resveratrol

Amyloid- $\beta$  is a generic term describing abnormally fibrillated proteins possessing a  $\beta$ -pleated sheet conformation. The formation and deposition of amyloid fibril plaques are known to be associated with Alzheimer's disease. A better understanding of the pathway to the fibrillization is highly desired and important for finding effective treatments for the disease, but efficient methods to monitor the process are still lacking. In the recent *J. Electrochem. Soc.* focus issue on organic and biological electrochemistry, researchers from the University of Toronto Scarborough reported an electrochemical method to detect amyloid- $\beta$  aggregation using electrochemical impedance spectroscopy (EIS). In this method, a gold electrode surface was first modified with N-hydroxysuccinimide-activated lipoic ester that could subsequently bind amyloid monomers covalently. The electrode was then incubated in solutions containing free amyloid monomers under different conditions while the charge transfer resistance of the electrode was monitored with  $[Fe(CN)_6]^{3-/4-}$  as the redox probe. The EIS result indicated the inhibition effect of resveratrol, a polyphenolic bioflavonoid compound, on amyloid aggregation. This effect was also confirmed with Thioflavin T fluorescence assay and

transmission electron microscopy. Compared with the established fluorescence method, the EIS technique is label-free and easy to prepare. Its potential application lies in the area of fast screening drug candidates for Alzheimer's disease.

From: *J. Electrochem. Soc.*, **160**, G3097 (2013).

## Silicon CMOS Ohmic Contact Technology for Contacting III-V Compound Materials

A crucial technological development for full integration of both silicon-complementary metal-oxide semiconductor (CMOS) and templated III-V optoelectronic technology involves ohmic contacts that need to be mutually compatible. A suitably complementary and functional ohmic contacting metallurgy could potentially enable seamless planar monolithic integration of these disparate technologies. Researchers at Massachusetts Institute of Technology have developed routes towards CMOS-compatible ohmic contacting technologies to buried III-V films using silicidic metallurgies. Specifically, they report on the use of NiSi/Si/III-V dual heterojunction contact structures. A benefit of this approach is the ability to control contact resistivities by the Si/III-V interface, and also prevent unwanted interactions between the deposited metal and the buried III-V layers. The group demonstrated the approach with Si-encapsulated III-V device layers based on Si/In<sub>x</sub>Ga<sub>1-x</sub>As and report low contact resistivities in these test structures. Additionally, they demonstrate the feasibility of CMOS compatibility of III-V layers using NiSi/Si/III-V interfaces, by fabricating a GaAs/Al<sub>x</sub>Ga<sub>1-x</sub>As laser with NiSi top contacts that performed equally well compared to those fabricated with a traditional III-V metallization strategy. The researchers posit that similar methods could be extended to phosphide- or nitride-based films to widen the range and improve flexibility of Si/III-V interfaces and ohmic contact metallurgy for full monolithic integration.

From: *ECS J. Solid State Sci. Technol.*, **2**, P324 (2013).

## Electrochemical Properties of $Li_3Fe_{0.2}Mn_{0.8}CO_3PO_4$ as a Li-Ion Battery Cathode

High-throughput ab initio computation has identified carbonophosphates as candidate materials for intercalation cathodes in higher energy density lithium ion batteries. Interest has centered on  $Li_3MnCO_3PO_4$ , which has a high theoretical specific capacity of 231 mAh/g and average voltage of 3.7  $V_{Li/Li^+}$ , but has exhibited capacity degradation in practice; and  $Li_3FeCO_3PO_4$ , which has high cyclability, but a lower theoretical capacity. The authors, from Massachusetts Institute of Technology, suspected the poor cyclability of  $Li_3MnCO_3PO_4$  may arise from residual sodium ion (~17%) after the Li-Na ion-exchange method is applied to the sodium-containing precursor made in the lab. Since the lab-made  $Li_3FeCO_3PO_4$  product contains no residual sodium, the authors set out to substitute iron for some manganese

in the  $Li_3MnCO_3PO_4$  material in an attempt to improve both capacity and cyclability performance. A  $Li_3Fe_{0.2}Mn_{0.8}CO_3PO_4$  product was made and tested, delivering slightly better capacity than  $Li_3FeCO_3PO_4$ . Because of its higher discharge voltage, the new material also has a greater practical energy density. The researchers were able to demonstrate stable capacity retention for cycles 4 through 25. The reason why the Fe-doped Mn form of the carbonophosphate performs better remains unknown. Nonetheless, the authors suggest that these results show promise for employing doping and structural tuning strategies in carbonophosphates for performance improvements.

From: *ECS Electrochem. Lett.*, **2**, A81 (2013).

## Passivation Properties of a UV-Curable Polymer for Organic Light Emitting Diodes

Organic light-emitting diodes (OLEDs) are used in a variety of commercial applications, particularly in displays for mobile phones and smart phones. One of the key technological challenges for OLED displays is that device performance degrades in the presence of water and oxygen. Glass encapsulation of the devices provides excellent long-term protection against the harmful effects of moisture and air ingress. Recently, researchers from Jilin University in China described the elegant use of a commercially available UV-curable polymer (NOA63 from Norland Products) to provide barrier protection of OLED devices during pre-commercial stages, including research, development, fabrication, and testing. The authors report that a simple spin-coating process, followed by a 50 mW/cm<sup>2</sup> UV cure, produced a barrier coating that did not diminish luminance-voltage and current-voltage characteristics. Further, the barrier coating was shown to have a water vapor transmission rate of only 0.031 g/m<sup>2</sup>/day, among the best reported for a single polymer barrier coating. Finally, the long-term luminance of the OLEDs, while only 60% that of OLEDs protected by a glass encapsulant, was approximately 7-fold better than unencapsulated devices. The authors conclude that this approach would be powerful for protecting OLEDs during short-term studies in the laboratory, or as an elementary moisture barrier prior to implementing more sophisticated, long-term encapsulation strategies.

From: *ECS Solid State Lett.*, **2**, R31 (2013).

*Tech Highlights was prepared by Zenghe Liu of Google Inc., David Enos and Mike Kelly of Sandia National Laboratories, Colm O'Dwyer of University College Cork, Ireland, and Donald Pile. Each article highlighted here is available free online. Go to the online version of Tech Highlights, in each issue of Interface, and click on the article summary to take you to the full-text version of the article.*