

TECH HIGHLIGHTS

Quantification of Accelerated Corrosion Testing of Coated AA7075-T6

When applied properly, the corrosion mitigation systems used to protect aluminum alloys are highly effective. While this result is desirable, it hinders attempts to assess the relative performance of such corrosion protection systems due to the long periods of time that are required before significant degradation of these materials is observed, even under accelerated, aggressive environmental conditions. A particular area of interest for structural applications of aluminum is where dissimilar metal fasteners are used to join together panels of treated metal. The underlying coating may be damaged, hindering its effectiveness. In this work, the performance of a series of corrosion protection schemes (including a chromate conversion coating and a chromate-containing epoxy primer) were evaluated using a new test sample geometry, which was demonstrated to be effective for screening such materials. Dissimilar metal fasteners (SS316 and Ti-6Al-4V) were attached to a treated aluminum panel after first scoring the coating in the region where the fastener contacts the panel. The galvanic coupling current between the fasteners and the panel was then monitored as a function of time. The data were then combined with a visual assessment of the nature of the resulting corrosion, to define a metric for assessing the aggressiveness of the test conditions expressed as an acceleration factor relative to a test panel where no fasteners were present.

From: J. Electrochem. Soc., 161, C42 (2014).

Analysis of Ketamine Using Electrogenerated Chemiluminescence

Ketamine is used as an anesthetic (usually in combination with a sedative) in human and veterinary medicine. It also is a drug that is used illicitly, and as such is a controlled substance in the United States and an illegal drug in other countries as well. As a result, analysis methods for sensitive, reproducible determinations of ketamine are very important. Researchers at Robert Gordon University in the United Kingdom and Mahasarakham University in Thailand recently reported an analysis method based on electrogenerated chemiluminescence (ECL). The method is based on the electrochemical oxidation of tris-(2,2'-bipyridyl) ruthenium(II), abbreviated as $[\text{Ru}(\text{bpy})_3]^{2+}$, to $[\text{Ru}(\text{bpy})_3]^{3+}$, which reacts with ketamine through a complex pathway to produce an excited state of $[\text{Ru}(\text{bpy})_3]^{3+}$. When this excited state species decays to the ground state, the accompanying light emission ($\lambda_{\text{max}} = 610 \text{ nm}$) serves as a useful analytical signal because it is proportional to ketamine concentration. The reported linear dynamic range (50–2000 ng/mL) and detection limit (39 ng/mL) for ECL

determination of ketamine is comparable to that for liquid chromatography-mass spectrometry (LC-MS), which makes it amenable to analyses for high concentrations of ketamine. However, gas chromatography-mass spectrometry (GC-MS) and related techniques are preferred for lower concentrations due to their vastly superior detection limits compared to ECL.

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Partial Wetting of Silicon Nanopillars

Aqueous solutions have traditionally been used in cleaning steps in semiconductor manufacturing. Patterned nanostructures introduce challenges in that they can appear to be more hydrophobic than a planar surface having the same chemical functionalization. Researchers from Belgium and the United States set out to investigate this phenomenon. In this article published in a Focus Issue on Semiconductor Surface Cleaning and Conditioning, the authors prepared nanopillar Si samples having different aspect ratios and treated with various functionalizations via self-assembled monolayers (SAMs). They measured apparent contact angles and plotted them against contact angles of these SAMs on planar surfaces. The experimental results were compared to theoretical predictions of three wetting models: Hemi-wicking, Wenzel, and Cassie-Baxter (which describes the “lotus effect”). The transition between hydrophilic and hydrophobic behavior occurred in the $\theta = 60\text{--}80^\circ$ range, noticeably below the $80\text{--}100^\circ$ range described by the Wenzel wetting model. These samples were etched and their cross sections imaged to observe the extent of wetting. Furthermore, attenuated total reflection infra-red spectroscopy was employed to monitor the displacement of gas in the instrument cell by the solution wetting the surface. Both results, albeit not in complete agreement, led the authors to postulate that trapped gas, forming nanobubbles, gave rise to the unpredicted wetting behavior.

From: ECS J. Solid State Sci. Technol., 3, N3095 (2014).

Design of Substrate-Integrated Lead-Carbon Ultracapacitor and Experimental Validation

Medical gadgets in remote areas and underdeveloped countries are primarily powered by portable electrochemical devices. Ultracapacitors have a distinct advantage as they can be rapidly charged when the intermittent power from the grid becomes available. In this work, the substrate-integrated lead-carbon ultracapacitor is employed for the first time for a low power medical application by simulating a grid power deficient duty cycle. The substrate-integrated ultracapacitors are hybrid ultracapacitors (HUCs) comprising a lead acid battery and a carbon-based ultracapacitor. Lead dioxide is formed on

the surface of the lead plate to make the substrate integrated positive electrode. The HUC was assembled using an absorbent glass mat separator, lead plate and activated carbon-coated graphite electrode. The 12 V HUC bank was assembled using five sets of HUCs. The performance was tested under several constant current loads between 0.3 A and 1.5 A. The ultracapacitor bank can work for about 14 min at constant current of 1.5 A until the cutoff voltage of 10 V under a 30 W load. The charging time for the HUC is 16 min. This is the first ever attempt to successfully assemble the HUC, design and develop the HUC bank, and validate its use for powering a 30 W medical gadget.

From: ECS Electrochem. Lett., 3, A1 (2014).

Channel-Length-Dependence of Strain Field in Transistor Studied via Scanning Moiré Fringe Imaging

A collaboration between Samsung Electronics in Korea, and JEOL and Osaka University in Japan has demonstrated that scanning Moiré fringe imaging is a powerful tool for the quantitative measurement of the strain fields formed in transistor channel regions at nanometer-scale spatial resolution. Researchers used scanning transmission electron microscopy (STEM) to create an effective scanning Moiré fringe (SMF) imaging method to quantitatively measure the strain introduced in n-type channel transistors that were fabricated with embedded SiC in the source and drain. The tensile strain parallel to the channels was revealed with nanometer scale spatial resolution. In addition, the strain field in transistors with various channel lengths scaled down to 25 nm was measurable. For instance, the collaboration showed that the strain in the channel decreases to 0.55% when the channel dimensions are scaled from 35 nm to 25 nm. The authors propose that this complementary microscopy technique will contribute to the optimization of layout design for the strain field formed during transistor fabrication. This capability could be useful for transistor design and the electrical performance in sub-25 nm channel length transistors in general, but may find application in strain engineering for transistor channels in other high mobility next-generation CMOS technologies.

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