

DOWNLOAD PDF ALKALI LAYERED COMPOUNDS INTERFACES FOR ENERGY CONVERSION AND ENERGY STORAGE

Chapter 1 : Alkali layered compounds interfaces for energy conversion and energy storage - CORE

Alkali Layered Compounds Interfaces for Energy Conversion and Energy Storage [microform]: Final Report on NASA Cooperative Agreement NCC

The negative electrode, the positive electrode and the electrolyte include separate liquid materials within the container at an operating temperature of the battery. It relates especially to electrochemical energy storage cell devices or batteries having liquid components and enhanced current-carrying capabilities. The supply-demand mismatch causes systemic strain that reduces the dependability of the supply, inconveniencing consumers and causing loss of revenue. Since most electrical energy generation in the United States relies on the combustion of fossil fuels, suboptimal management of electrical energy also contributes to excessive emissions of pollutants and greenhouse gases. Renewable energy sources like wind and solar power may also be out of sync with demand since they are active only intermittently. This mismatch limits the scale of their deployment. Large-scale energy storage may be used to support commercial electrical energy management by mitigating supply-demand mismatch for both conventional and renewable power sources. One approach to energy storage is based on electrochemistry. Conventional lead-acid batteries, the cheapest commercial battery technology on the market, have long been used for large-scale electrochemical energy storage. Facilities housing vast arrays of lead-acid cells have been used to provide high-capacity electricity storage, on the order of 10 MW. However these facilities are neither compact nor flexibly located. The short cycle life of lead-acid batteries, on the order of several hundred charge-discharge cycles, limits their performance in uses involving frequent activation over a wide voltage range, such as daily power management. The batteries do not respond well to fast or deep charging or discharging, which lowers their efficiency and reduces their lifespan. An NAS battery incorporates molten sodium and sulfur electrodes opposed across a solid ceramic electrolyte. The electrolyte must be very thin in order to maximize sodium ion conduction, but this makes it mechanically fragile and imposes severe limits on the maximum size of an individual cell. This, in turn, affects scalability, i. There is, accordingly, a need for an energy storage device combining capacity, economy, flexibility and long life. In another embodiment, an electrochemical battery configured for exchanging energy with an external device comprises an open top container having walls and containing a positive electrode, a negative electrode and an intervening electrolyte. The electrodes and the electrolyte exist as liquid material layers within the walls of the container at the operating temperature of the battery, with one of the positive electrode and the negative electrode being disposed over the electrolyte. A lid closes the top of the container. A positive current collector is in electrical contact with the positive electrode. A negative current collector is in electrical contact with the negative electrode. The positive current collector and the negative current collector are adapted for connection to the external device to create a circuit through which current flows, and the current collector in contact with the electrode disposed over the electrolyte is suspended from the lid and comprises a composite electrically conductive structure. The structure includes a first member that holds the electrode disposed over the electrolyte spaced away from the walls and is of a first substance that is not wet by the liquid material of said one electrode; and a second, electrically conductive member within the first member that is of a second substance that is wet by the liquid material of said one electrode. In another embodiment a method of exchanging energy with an external device comprises providing an external energy exchanging device and a battery. In yet another embodiment, an electrochemical battery is configured to exchange energy with an external device. The battery comprises an electronically conductive molten positive electrode comprising an alkaline earth metal and an additional element; an electronically conductive liquid negative electrode comprising the alkaline earth metal; and a liquid electrolyte comprising cations of the alkaline earth metal, disposed between the positive electrode and the negative electrode to form respective electrolyte-electrode interfaces therewith. The positive electrode, the negative electrode and the liquid electrolyte exist as respective liquid layers of respective liquid materials in a vertical stack, and the alkaline earth metal is present in

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respective disparate chemical potentials in the positive electrode and the negative electrode, thereby originating a voltage therebetween. The invention description below refers to the accompanying drawings, wherein identical reference numerals designate analogous functional elements, and in which: Features in the drawings are not necessarily to scale. With reference to FIG. The electrically conductive liquid layers 14, 16 and 20 are confined in an electronically conductive container 22 which illustratively provides mechanical support to an insulating inner sheath. The sheath 24 prevents shorting by electronic conduction between the negative electrode 14 and the positive electrode 16 through the container. The container 22 is covered by a lid 26 which is illustratively electronically conductive. An electrically insulating seal 29 electrically isolates the lid 26 from the container 22 and confines molten constituents and vapors within the container. A portion of the lid 26 in contact with the negative electrode 14 functions as a negative current collector 27, through which electrons may pass to an external source or sink not shown by way of a negative terminal 28 in contact with the lid. A portion of the container 22 in contact with the positive electrode 16 functions as the positive current collector 23 of the battery 10, through which electrons may pass to the external source or sink by way of a positive terminal 30 connected to the container. The placement of the negative terminal 28 and the positive terminal 30 may facilitate arranging individual cell units in series by connecting the negative terminal 28 of one cell unit to the positive terminal 30 of another cell unit 10 to form a larger battery. An inert gas layer 32 overlaying the negative electrode 14 may accommodate global volume changes in the three-phase system of the battery 10 during charging and discharging thereof or due to temperature changes. Optionally, the lid 26 or seal 29 incorporates a safety pressure valve not shown. The container 22 and the lid 26 are each of a material having the requisite electronic conductivity, mechanical strength, and resistance to chemical attack by the liquid electrodes 14 and 16 and electrolyte. The sheath 24 is of an electronically insulating material and may be corrosion-resistant against the two liquid electrodes 14 and 16 and the molten electrolyte. Boron nitride, aluminum nitride, alumina, and magnesia are candidate sheath materials. The seal 29 may be formed of one or more materials such as magnesia cement, aluminoborate glasses, and other high temperature sealants as known to those skilled in the art. The electrodes 14 and 16 and electrolyte 20 are constituted to establish chemical and physical properties compatible with simplicity and economy of construction, robustness, and rapid and efficient receipt and delivery of electrical energy. The use of electronically conductive liquids for electrodes 14 and 16 with a liquid electrolyte 20 facilitates facile oxidation and reduction of the active alkaline earth metal and its cation at the electrodes 14 and 16. The electronic conductivity of the liquid electrodes promotes high current density during operation of the cell 10 by enabling electron-transfer reactions to occur at sites over entire liquid electrode-electrolyte interfaces rather than being limited to triple-phase intersections. Furthermore, because reactions at both electrodes occur entirely in the liquid state, the reaction kinetics are not throttled by the nucleation of distinct product phases. The chemical compositions of the molten electrodes 14 and 16 are formulated conjunctionally to incorporate an active alkaline earth metal, such as beryllium, magnesium, calcium, strontium or barium at respective disparate thermodynamic activities, thereby generating voltage between the electrodes 14 and 16. In order to create thermodynamic activity disparity of the active alkaline earth metal between the negative 14 and positive 16 electrodes, at least one of the electrodes 14 and 16 includes one or more additional elements, other than the alkaline earth metal. Any additional element may be, e. The one or more additional elements are chosen to constitute the positive electrode 16 as an environment of relatively low thermodynamic activity of the active alkaline earth metal, compared to the negative electrode 14, when the cell 10 is in a charged state. In choosing additional elements, in addition to the active alkaline earth metal, for the electrodes 14 and 16, not only chemical equilibria and solution thermodynamics in the electrodes 14 and 16 but also their interactions with the electrolyte 20 must be considered, as well as their relative densities and liquid ranges. Any element in the electrodes 14 or 16 in addition to the active alkaline earth metal ideally should not interact with the ions in the electrolyte in a way that would provide a competing pathway for charge transport and circumvent the prescribed electrode reactions. Thus, elements that may be appropriate for incorporation in the alloy electrode 16 to reduce the activity of the active metal may include

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aluminum, tin, lead, germanium, indium, pnictogens such as bismuth and antimony, and chalcogens such as tellurium and selenium. The electrodes 14 and 16 may include other species, for example, to tailor physical properties or enable electrochemical monitoring of the extent of discharge, as is known to those skilled in the art. The use of an alkaline earth metal, such as beryllium, magnesium, calcium, strontium or barium, in the electrodes 14 and 16 of the all-liquid alkaline earth metal ion energy storage batteries 10 may have several advantages over conventional battery materials. For example, the voltage generated by the illustrative calcium-metalloid couple in a single cell may be on the order of 0. Also, calcium and magnesium, for example, are relatively inexpensive compared to lead or alkali metals and are easier to manage than alkali metals in that they may be safely handled in open air, do not react violently with water, and can be held with bare hands. The electrolyte 20 of the battery 10 may be a molten salt, dissolving a cation of the active alkaline earth metal, also referred to herein as the active cation, and one or more supporting compounds. The electrical conductivity of the electrolyte 20 may be greater than 0. Illustratively the molten salt is a chloride, such as a chloride of the active alkaline earth metal. Alternatively, the salt of the active alkaline earth metal may be, e. The supporting electrolyte may comprise any of the aforementioned anions and a cation such as an alkali or alkaline-earth metal, an imide, amine, ammonium, phosphonium or pyrrolidinium. Other additives to the electrolyte 20 may reduce the viscosity, depress the melting point, alter the density, or reduce vapor pressure. The supporting electrolyte and any other additives illustratively have free energies of formation more negative than that of the reaction compound so that the cationic constituents of the supporting electrolyte and any additive electrodeposit at more extreme values of potential, or at higher values of cell voltage, than that associated with moving the active alkaline earth metal from the active metal electrode 14 to the alloy electrode 16, in order to limit the electrode reactions to the oxidation and reduction of the active alkaline earth metal. These and other considerations informing the choice of electrolyte composition are known to those skilled in the art. If the active alkaline earth metal is calcium, the electrolyte 20 may further include complexing ligands to reduce the solubility of elemental calcium in molten calcium chloride. For example, chloride anions introduced by addition of potassium chloride, sodium chloride, or other appropriate alkali metal-halide salts may lower the solubility of calcium metal in a calcium-halide mixture. Operation at temperatures greater than about, e. However, difficulties such as volatilization of cell constituents, structural weakness, chemical attack of ancillary materials, and power required to maintain liquidity of the electrodes 14 and 16 and electrolyte 20 become more likely as operating temperature increases. The electrodes 14 and 16 and the electrolyte 20 may be furthermore formulated so that their densities are ordered in accordance with their functions in the battery Embodiments having respective densities increasing, as shown in FIG. Energy storage in the alkaline earth metal ion battery 10 is not limited to any particular method of attaining or maintaining the operating temperature thereof. The constituents forming any of the layers 14, 16, and 20 may be melted in a separate heated chamber with sufficient superheat to allow transfer to the container. In another approach, external heaters not shown placed, for example, within the wall of the container 22 may be used before or during operation. Alternatively, the battery 10 may be self-heating during operation through applied overpotentials. Techniques for achieving and managing temperature profiles in molten constituents, and other practical aspects of electrometallurgical systems potentially helpful to implementing power storage using liquid alkaline earth metal electrodes, such as construction of apparatus for use with molten salts and liquid metals, are known to those skilled in the art and have been described, for example, in commonly owned pending U. The illustrative alkaline earth metal ion battery 10 receives or delivers energy by transporting an alkaline earth metal, referred to herein as the active alkaline earth metal, between the two molten electronically conductive electrodes 14 and 16 via an electrochemical pathway. The liquid electrolyte 20 comprising a cation of the active alkaline earth metal enables ionic transport of the active alkaline earth metal during charging or discharging. Before charging, the positive electrode 16 contains atoms of the active alkaline earth metal. The negative electrode 14 meets the electrolyte 20 at an active metal-electrolyte interface. The positive electrode 16 meets the electrolyte 20 at an alloy-electrolyte interface. During charging, electron current travels from the

external circuit through the negative current collector 27 into the negative electrode 14 and to the active metal-electrolyte interface. The neutral active alkaline earth metal atoms M created in the half-cell reaction accrue to the negative electrode. As the active alkaline earth metal M accumulates in the negative electrode 14, the active metal-electrolyte interface 42 moves further away from the negative current collector. Oxidation of the active alkaline earth metal atoms M shrinks the positive electrode 16, and the alloy-electrolyte interface 46 moves toward the positive current collector. Charging has changed the composition of at least the positive electrode 16 by loss of atoms of the active alkaline earth metal. The alloy electrode 16 may in principle be nominally free of the active alkaline earth metal, and therefore not actually be an alloy, mixture or compound at this point in the charge-discharge cycle. The thickness of the negative electrode 14 has grown at the expense of the positive electrode. Since the charging process is conservative with respect to the active cations, the thickness of the electrolyte 20 is ideally unchanged. The active alkaline earth metal deposited in the molten active metal electrode 14 represents stored electrical energy which may persist indefinitely, as long as no external electronic path joins the two electrodes 14 and 16. The half-cell reactions in the cell 10 generate liquid-phase products that remain at the electrodes 14 and 16, in contact with the electrolyte. While the electrodes 14 and 16 and electrolyte 20 are at a liquid range temperature, the active alkaline earth metal and the active cation remain available to mechanize discharge via an electrochemical pathway. This reversibility suits the active alkaline earth metal ion batteries for energy storage. During discharge the active alkaline earth metal moves spontaneously from the negative electrode 14, through the electrolyte 20 as active cations, and reverts to neutral metal at a lower chemical potential in the positive electrode. Electron current travels into the cell through the positive current collector 23 and the positive electrode 16 to the alloy-electrolyte interface. The neutral active alkaline earth metal atoms M produced accrue to the positive electrode. As the active alkaline earth metal M accumulates in the positive electrode 16, the alloy-electrolyte interface 46 moves further away from the positive current collector.

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Chapter 2 : Publications | Chunsheng Wang

Abstract: During year one a new ultra-high vacuum, an Ar(+) ion sputterer, a low energy electron diffraction (LEED) system, an Auger electron spectrometer (AES), a work function measurement device with a Kelvin probe, and related accessories were used.

The great urgency of finding new energy sources resulted in an upsurge in the electrocatalysis and battery research. However, optimization and improvement of various energy conversion and storage systems require a better understanding of the electrochemical processes limiting their performance. Thus, further development of new in-situ characterization methodologies is of great importance. This technique can be easily combined with other commonly used methods. The rapid illumination of the electrode surface results in an increase in its temperature directly influencing the inner Helmholtz plane of the electric double layer. As a consequence, one observes current transients whose sign, in the simplest case, corresponds to the sign of the excess electrode surface charge. The LICT is also a relatively simple technique of evaluating the potential of maximum entropy PME and, closely related to it, the potential of zero charge PZC - the fundamental properties of the electric double layer. This indicates that the complexity of intercalation mechanisms of alkali metal cations into the films might be oversimplified. Further, we demonstrate the influence of the electrolyte pH on the net charge of the pure Pt poly electrode surface. All the obtained data emphasize the role of the electrolyte composition for the kinetics and mechanisms of the interfacial processes. Secondary ion mass spectroscopy SIMS is a characterization technique with ultra high chemical sensitivity and high depth resolution, widely established for materials analysis in the field of semiconductors. Recent advances, including the reduction of the lateral resolution to ca. We investigate the impact of different analysis conditions which unravel the impact of the analysis conditions Bi analysis beam, sputtering with large Oxygen clusters on various artifacts induced by the ion-beam such as sputtering process, topographic ion yield variations, charging effects and bias-induced electro-migration of mobile cations. This allows us to establish the correlation between the electrical and the chemical inhomogeneities in the materials and identify the role of nanoscopic non uniformities. Shokoufeh Rastgar, Gunther Wittstock Affiliations: Interfaces between two immiscible electrolyte solutions ITIES are a promising model mimicking some functional biomembranes in nature charge carrier separation by two interacting photocenters-z-scheme and offer novel opportunities for catalyst regeneration or exchange at the interfaces of liquids [1]. Polarizable interface represents molecularly sharp platform suitable for assembling of nanostructured semiconductor photocatalysts which have been proposed as a novel approach, generating charge carriers electron-holes pair reactants in either side of interface, involving in photo-induced charge transfer reactions at liquid-solid-liquid boundaries [2]. We studied O₂ evolution by hyperbranched nanocrystalline BiVO₄ at chemically polarized ITIES by [Co bpy 3] PF₆ 3 as an electron-acceptor compound in organic phase [3], which dramatically inhibits fast unfavorable electron-hole recombination, similar to z-schemes in natural photosynthesis [4]. Then, it clearly influences the efficiency of the parallel reaction of photo-generated hole-driven water oxidation by increasing the O₂ evolution rate. This systems also allows to interrogate the photoelectrochemical reaction by oxidation of [Co bpy 3]²⁺ as a photo-induced electron transfer product in an organic phase of interface by utilizing detector microelectrode ME in the organic phase in a scanning electrochemical microscope SECM. Furthermore, interfacial polarization effects on the photogenerated charge transfer reactions were investigated by recording regeneration of the reduced form of [Co bpy 3] PF₆ 3 in organic side of the BiVO₄ layer in SECM feedback approach curves and detection of O₂ as main product of water photo-oxidation in aqueous side in the generation collection mode. Firstly, the micropipette can be prepared with orifices much smaller than the Au ME so that very high collection efficiencies for [Co bpy 3]²⁺ is attained. This mode allows quantitative assessment of adsorbed hydroxyl radicals OH[•]. In the interrogation step, the ME-generated titrant Co²⁺ reacts with adsorbed hydroxyl radicals. Interface, 10, C, , Charging and discharging of nanometer-sized and

tunable-shaped objects are very important to fundamental research as well as to potential applications. For instance, isolated external charges can be used as an electrostatic gating for material transport in the nano-channels. On the other hand charging and discharging of objects provide a powerful tool to studying the electrostatic properties on the nanometer scale. Here, we report on the charging of individual graphene oxide GO sheets with varied degrees of reduction by using electrically biased atomic force microscope AFM tips. AFM measurements indicate that the apparent height of reduced GO rGO sheets increases sharply after charging, while the charging ability is enhanced when the GO sheets are deeply reduced. Charging on isolated areas with tunable shape and size on single-layered GO has been achieved. In addition, charge transfer between rGO sheets separated in hundreds of nanometers on insulating substrates was investigated. It was found that the rGO sheet collects charges from the adjacent charged rGO sheet through the dielectric surfaces. The efficiency of charge transfer between the separated rGO sheets is dependent on their separation distance, gap length, and the substrate type. The findings suggest that the charge interflow should not be neglected in a graphene circuit. Ying Wang, Yi Zhang Affiliations: Local dielectric property detecting is of great importance in many scientific research and application. In the last two decades, many scanned probe microscopy SPM techniques have been developed to fast detection of surface dielectric properties of nanoscale materials. Here, we report a novel method for characterization of local dielectric property based on surface adhesion mapping by atomic force microscopy AFM. We use two dimensional 2D materials—graphene oxide GO and partially reduced graphene oxide rGO sheets, which have similar height but large difference in dielectric property, as the model systems. By comparing with scanning polarization force microscopy SPFM, our approach is found to have higher sensitivity and lateral resolution. It is expected to provide a better and faster characterizing of local dielectric property of nanoscale materials, and will further facilitate applications in future nanomaterial based device. Hermes 1, Yi Hou 2, Victor W. Efficient charge extraction within solar cells explicitly depends on the optimization of the internal interfaces. Potential barriers, unbalanced charge extraction or interfacial trap states can prevent cells from reaching high power conversion efficiencies. In the case of perovskite solar cells, slow processes happening on timescales of seconds cause hysteresis in the current-voltage characteristics. Although hysteresis can nowadays be mostly avoided by selection of suitable selective electrode materials[1], its origin is not yet fully understood. Here, we report on local and time-dependent potential measurements with Kelvin probe force microscopy KPFM on cross sections[2] of planar methylammonium lead iodide MAPI perovskite solar cells. Our experiments revealed distinct differences in the charging dynamics at interfaces of the MAPI to adjacent layers[3]. Measurements while switching on and off the illumination attest that more than one process is involved in hysteresis. Furthermore, we used KPFM to investigate perovskite solar cells with different electron transport materials ETM, which exhibited a different hysteretic behavior. Depending on the ETM we observed oppositely oriented electric fields within the perovskite layer, which either aid or counteract the charge carrier extraction from the active layer. Our findings suggest that the introduction of electric fields in the perovskite layer and thus the occurrence of J-V hysteresis could be controlled by the choice of ETM. Box, E, Valencia, Spain. Kelvin probe force microscopy KPFM is long known as a powerful tool for mapping surface potential and topography with nanoscale resolution. The capability to correlate optoelectronic properties with local structure has been crucial to elucidate some fundamental properties responsible for the high performance of perovskite solar cells. This work aims to go beyond previous KPFM studies through the precise quantitative analysis of tip-sample interaction in multi-dimensional spectroscopy. These measurements, combined with advanced data analysis, allow to obtain separately the contact potential difference, the capacitance, and the van der Waals interaction of the tip-sample system as a function of their relative distance. The whole preparation was based on vacuum deposition and resulted in a densely packed mesh of nanocrystals with an average grain size of nm. The first set of measurements, performed in the dark, revealed that the contact potential is determined mostly by the work function of the charge selective contact and remains constant with the tip-sample distance, indicating that there is no net charge at the perovskite surface. When the same experiments were repeated under

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illumination, the contact potential difference varied according to the strength of the photovoltaic effect. Much more acute changes were observed in the second derivative of the capacitance which can be interpreted as photoinduced variation of the dielectric constant of the perovskite. Anfatec Instruments AG, Melanchthonstr. A procedure for the functionalization of BioChips for adherent biomaterials is the modification of the surface by coating or by roughening. SNEF are caused by an asymmetric electric dipole in the semiconductor surface region and detected using Kelvin probe force microscopy measurements [1]. BioChips with a stripe-like pattern have been fabricated. The electrical properties of the implanted silicon wafers have been characterized by Hall and electrical impedance measurements. SNEF allow for a patterned adhesion of electrically polarizable biomaterials [2,3], e. As an outlook it is discussed how the properties of adherent biomaterial, e. Finally, it is discussed how the electrical polarizability of biomaterials on the nanometer and micrometer length scale can be investigated by means of photo-induced force measurements with an AFM platform and tunable lasers. B, , 80, [2] C.

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Chapter 3 : Publications | Laboratory for Energy Storage and Conversion

*Alkali layered compounds interfaces for energy conversion and energy storage final report on NASA cooperative agreement NCC (SuDoc NAS) [Chris A. Papageorgopoulos] on calendrierdelascience.com *FREE* shipping on qualifying offers.*

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Chapter 4 : Strain Engineering to Modify the Electrochemistry of Energy Storage Electrodes

Get this from a library! Alkali layered compounds interfaces for energy conversion and energy storage: final report on NASA cooperative agreement NCC [Chris A Papageorgopoulos; United States.

Received Apr 6; Accepted May To view a copy of this license, visit <http://www.copyright.com>. Using mechanical strain as an input parameter to modulate electrochemical potentials of metal oxides opens new opportunities intersecting fields of electrochemistry and mechanics. Here we demonstrate that less than 0.1% strain, using the superelastic properties of NiTi to enable strain recovery also recovers the electrochemical potential of the metal oxide, providing mechanistic evidence of strain-modified electrochemistry. These results indicate that mechanical energy can be coupled with electrochemical systems to efficiently design and optimize a new class of strain-modulated energy storage materials. Traditional routes to design materials for electrochemical applications require modification of material chemical composition to control reduction-oxidation energetics when coupled with an electrolyte 1, 2. This causes the search for improved nanomaterials in electrochemical applications to be driven by discovery-focused nanomaterial synthesis and fabrication. Due to the complex cooperative nature of energy storage device performance based on the pairing of electrodes and electrolytes, such routes rarely lead to new materials with characteristics, such as operating voltage, that outperform existing materials. Further, whereas computational guidance has brought about a new paradigm to predict targeted material compounds that can improve advanced energy storage systems 3, 4, experimentalists often remain challenged by the synthesis process of such compounds, many of which are not naturally occurring. This presents a fundamental bottleneck in the conventional approach in which electrochemistry-oriented material research and development occurs that limits the rate of industry innovation in energy storage and conversion systems. Strain engineering, a concept widely implemented in semiconductor electronics 5, 6, opens new opportunities to engineer materials for electrochemical systems. The six-dimensional parameter space of the strain tensor 7 enables a nanostructure with a fixed chemical composition to have electronic and physical properties finely modulated in a manner that is virtually impossible to replicate by varying chemical composition. Unlike bulk materials, many nanostructures exhibit sizes where strain can homogeneously propagate throughout the whole material, instead of only on a surface or an interface 6, 8, 9, 10, 11, 12, 13. In this spirit, recent efforts have demonstrated the capability of strain in nanostructures to modify the energy landscape of catalytic and electro-catalytic surface-bound reactions 15, 16, 17, 18, 19 and modify oxygen ion diffusion in fuel cell technology 20, 21. The direct controlled correlation between mechanical strain as an input parameter and electrochemical processes in nanostructures for energy harvesting applications has only very recently been reported. In the specific case of energy storage electrodes such as pseudocapacitors and batteries 1, 24, Faradaic reactions especially in metal oxides induce a change to the oxidation state of the active material often regulated by the physical characteristics of the lattice structure to enable insertion or alloying of an ion species. Focus of current research efforts so far have been on the adverse effects of strain arising from the changes to the host lattice structures during electrochemical cycling of energy storage electrodes 25, 26. In this regard, mechanical strain imposed onto a nanostructure leading to both physical and electronic changes that can synergistically influence energy storage redox reactions has not yet been reported despite significant advances in the ability to produce, image, and understand strain effects in materials 15, 28, especially those related to semiconductor electronics. Theoretical studies have recently highlighted the prospect of pre-straining materials 29 even though experimental efforts in this direction remain elusive. Under the application of strain to the NiTi and transferred to the surface-bound oxides, we observe consistent shifts in the anodic and cathodic potentials. By recovering this imposed strain, we observe consistent recovery of the electrochemical potentials, clearly demonstrating that strain, as opposed to other effects, is modulating the shifts in electrochemical potentials and can be a viable tool for the design of energy storage materials. EDS maps supporting information obtained from the surface of the wire indicated a mixed

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Ni-Ti-O based surface oxide. Scanning electron microscopy SEM Fig. The strained and unstrained wires with the mixed oxide layers were sonicated in peroxide at room temperature to impart nanotexturing to the oxide. This leads to a material architecture where nanostructured petals of NiO-TiO₂-based metal oxides are conformally coated on the surface of a NiTi wire in a seamless manner Fig. The Ni-Ti-O surface metal oxide was further examined through Transmission electron microscopy TEM supporting information, Figure S5 indicating the crystalline nanostructure of the surface oxide. The presence of the constituent elements of the nanostructured oxide nickel, titanium, and oxygen was further verified using STEM EDS maps. This architecture is ideally suited to correlate strain as an input parameter to the NiTi to assess its effect on the surface-bound redox active Ni-Ti-O material for energy storage applications.

Chapter 5 : USB2 - Liquid metal alloy energy storage device - Google Patents

NASA-C_ / FINAL REPORT ON NASA COOPERATIVE AGREEMENT NCC Alkali Layered Compounds Interfaces for Energy Conversion and Energy storage Start Date.

Chapter 6 : Scanning probe microscopy for energy applications | EMRS

Abstract. During year one a new ultra-high vacuum, an Ar(+) ion sputterer, a low energy electron diffraction (LEED) system, an Auger electron spectrometer (AES), a work function measurement device with a Kelvin probe, and related accessories were used.