Speaker Abstracts

Session 1: Nanotechnology for Next Generation Electronics and Photonics

Contemporary and Potential Opportunities for 2D Flexible Nanoelectronics and Nanosystems
Deji Akinwande, The University of Texas – Austin, United States

The last 10 years have seen the emergence of two-dimensional (2D) nanomaterials such as graphene, transition metal dichalcogenides (TMDs), and black phosphorus (BP) among the growing portfolio of layered van der Waals thin films. Graphene, the prototypical 2D material has advanced rapidly in device, circuit, and system studies that have resulted in commercial large-area applications. In this work, we present a perspective on the contemporary, emerging and potential translational applications of 2D materials including semiconductors, semimetals, and insulators that comprise the basic material set for diverse nanosystems. Applications include RF transceivers, flexible smart systems, the so-called internet of things, and neurotechnology for healthcare. Global R&D activities and smartphone penetration of nanomaterials will be highlighted.

Challenges for Electronics Design on the Nano-Scale and its Implications on High Performance Computing
Yehea Ismail, Zuwail City and American University of Cairo, Egypt

Semiconductor technologies exhibited explosive growth in complexity and speed over the last two decades. Since the early 1980s, the device sizes have scaled down from few micrometers to tens of Nano-meters and the operating frequencies have increased from a few megahertz to several gigahertz. Also, the spacing between devices and interconnect have dramatically decreased due to the continuous scaling down of the technology feature size. These trends have led to issues and challenges in the design and analysis of high performance integrated circuits that previous generations did not exhibit. Most of these issues are at the device, circuit and interconnect (physical) levels. Also, these issues are expected only to increase in importance in future generations of integrated circuits.

For the reasons above, scaling as we know it is taking a different direction from the last three decades. Chips with tens of billions of transistors and hundreds of cores are expected to be the future of scaling. These chips will achieve performance through parallelism and application specific optimized cores. This trend will use superior technologies to integrate more cores on a chip rather than to push the frequency envelope as in the past. It is expected that every aspect of design and analysis will need to be modified to accommodate this new platform and trend. There is a clear need for new devices and design methodologies that are very different from existing tools in both their focus and scope.

This talk will overview the key challenges for electronics design in the nano-scale and discuss the specific challenges for these many core chips. The talk will also provide an overview into the market and technology factors guiding and driving this trend. Attendees will be provided with insight into both present and future research vectors to support this nascent exponential.

Next Generation of Integrated Circuits: Silicon Photonics for on-Chip Interconnects and Optical Sensing
Marcus Dahlem, Masdar Institute of Science and Technology, United Arab Emirates

Electronic-photonic integrated circuits (EPICs) are a promising technology for overcoming bandwidth and power-consumption bottlenecks of traditional integrated circuits. Silicon is a strong candidate material for building such devices, due to its high-index contrast and low propagation loss at telecom wavelengths. On-chip optical interconnects can be critical in shaping the future of high-performance low-power integrated circuits, playing a role similar to that of optical fibers in current long-distance data communication links. This talk presents recent advances in discrete components that can be used as building blocks for future EPIC systems, fabricated in silicon-on-insulator (SOI) platforms, with a focus on structures based on microring resonators and photonic crystals. These structures can perform functions such as electro-optic modulation, diffractionless propagation, wavelength tunability, wavelength-division multiplexing (WDM), and tunable optical delays. Additional functionalities such as physical, chemical and biological sensing can also be added on-chip. These blocks, when integrated with microfluidics, can enable lab-on-a-chip systems. The work is presented within the context of the Nano-Optics and Optoelectronics Research (NOOR) Laboratory and the Microsystems Engineering program at Masdar Institute, expanding on a collaboration with GlobalFoundries in Singapore.

The Art of Falling Apart: Exploiting Nanomaterial Disassembly for Health Sciences
Adah Almutairi, University of California San Diego, United States

This presentation will cover several recent advances in the development of light- and inflammation-responsive polymers as tools for biological research and drug delivery. In the area of light-responsive materials, four exciting strategies will be discussed: chemically amplifying the light signal to accelerate degradation, single-photon absorption of red light, novel upconverting structures enabling efficient conversion of more biologically compatible wavelengths, and application of previously reported polymers to the treatment of various diseases. The chemical amplification strategy relies on phototriggered unmasking of acidic groups that hydrolyze adjacent ketals, which overcomes ketals' requirement of low pH for efficient degradation. Particles composed of the photocaged-acid/ ketal polymer degrade rapidly upon brief irradiation. The red light-degradable polymer incorporates a photocage not previously used in responsive materials, which cleaves in hydrophobic environments (unlike coumarins). Particles composed of this polymer, when subcutaneously injected and irradiated through tissue, release sufficient drug to significantly reduce carrageenan-induced paw inflammation in mice. Our advance in the upconversion field is the application of uniform shell deposition to overcome dopant concentration quenching, allowing unprecedented upconversion efficiencies at 800 nm. Absorption of this wavelength rather than the 980 nm employed by current structures avoids the potential for tissue heating, as water's absorption of 800 nm infrared is much lower. Finally, we have evidence that a UV-degradable polymer (Fomina et al., J Am Chem Soc 2010) may be useful for the delivery of anti-angiogenics in the eye to treat macular degeneration. This strategy would preserve clinician control over dose timing while reducing the frequency of intravitreal injections. UV-degradable particles are stable in the eye for months and release a therapeutically effective dose of a small molecule anti-angiogenic; the irradiation required for release is well-tolerated by the eye.

Inflammation-responsive materials have been recently applied in the lab towards prevention of systemic inflammatory response syndrome (SIRS), treatment of Age Related Macular Degeneration with a single annual injection of a drug depot of VEGF Trap and detection of atherosclerotic plaque likely to disrupt and cause a heart attack or stroke. The first project involves delivering anti-inflammatory drugs in nanoparticles composed of our polythioether ketal (published in 2011). Using this strategy to deliver drugs 12 h prior to the bacterial toxin LPS reduces mortality in mice, suggesting that such nanoparticles could lead to a means of preventing organ failure following systemic infection or trauma. In the second, particles composed of dextran modified to be acid- and H2O2-responsive encapsulate Gd-based nanocrystals with unprecedented relaxivity, such that MRI signal is silenced until encountering inflammation, where particles loosen and nanocrystals can relax surrounding water molecules. This material's ability to detect inflammation in vivo has been demonstrated using fluorescence activation; its applicability to atherosclerosis is currently being tested in ApoE-/- mice fed a high fat diet and implanted with a carotid cuff to reliably induce inflamed plaque.

Session 2: Solar Energy and Water for Sustainable Living

Engineering Flows in Nanostructured Membranes for Water Purification and Separations

Rohit Karnik, Massachusetts Institute of Technology, United States

Understanding and controlling fluid flow in nanostructured materials offers new opportunities in advancing membrane technology for water filtration, desalination, gas and bio/chemical separations, and other applications. In this talk, we present our work on studying fluid flow and developing novel nanostructured membranes for water purification. We first present the development of monolayer nanoporous graphene as an ideal ultrathin membrane material that has potential for high flux, tunable properties, and high chemical resistance. We fabricate single-layer graphene membranes with a high density of sub-nanometer pores and seal defects to quantify the effect of porosity on selective mass transport to realize molecular separations. Next, we present the concept of using nanostructures that trap vapor nanobubbles as a selective medium for water desalination. This approach combines the advantages of thermal desalination and reverse osmosis while providing fundamental insights into the behavior of water at the nanoscale. Finally, we discuss our work on using naturally occurring porous plant xylem – the tissue that conducts sap in plants – as a selective material for low-cost water disinfection. These studies illustrate the interplay between material structure and nanofluidic flows and demonstrate the potential to realize next-generation membranes that may improve efficiency, robustness, cost, and open new avenues in water purification and bio/chemical separations.

Systematic Design Approaches for Optimal Water-Energy and Desalination Network Synthesis

Patrick Linke, Texas A&M University at Qatar, Qatar

The design of water-energy systems involves the identification of low cost and environmentally benign configurations from amongst the vast number of possible alternatives. It is possible to capture all design alternatives in superstructure network representations. Optimization techniques can then be deployed to identify the best designs embedded in the superstructure with respect to selected objectives such as minimum cost or maximum resource efficiency. This lecture will present recent developments of superstructure optimization approaches for sustainable water and energy utilization in eco-industrial parks and for membrane desalination systems. Approaches for industrial parks will focus on inter-plant integration across the water-energy nexus. Particular emphasis will be placed on the representation of integration options to capture design constraints often faced in practice. The approaches are demonstrated for an industrial city of a configuration similar to an industrial city in Qatar. Approaches for desalination process design will focus on recent synthesis approaches for optimal seawater reverse osmosis (SWRO) designs as well as novel approaches for hybrid membrane networks for integrated production of desalinated water and salt monetization. Case studies will be presented to illustrate the capabilities of the presented approaches and their potential to quickly identify high performance designs from the vast number of alternatives.

Overview of Water Treatment and Desalination Options for Unconventional Oil and Gas Wastewater in North America

Prakash Govindan, Gradiant Corporation, United States

The cost and complexity of handling produced and flowback water and the associated environmental concern are among the greatest challenges associated with unconventional oil and gas. In 2014, the industry spent over $2B on disposal of produced/flowback water in the US alone. This water is highly saline with total dissolved solids (TDS) content of up to 260,000 ppm. Affordable treatment of produced water at the wellhead (or at a centralized location within a few miles of the source of produced water) and recovering of a high percentage as fresh water is an ideal solution which would reduce the cost and liability associated with transporting produced water.

In this seminar, the various water treatment and desalination options that are commercially available (and those that are under development) for this application will be described in detail. These options include Chemical precipitation, electrocoagulation, membrane based techniques (including MF, UF, RO) Mechanical Vapor Compression (MVR), Forward Osmosis (FO), Membrane Distillation (MD), Shared wall humidification-dehumidification and Carrier gas extraction (CGE). The fundamental operating principles and relative advantages/disadvantages of all these options will be presented. Zero liquid discharge (ZLD) techniques including conventional crystallizers and CGE crystallizers will also be discussed.

Use of Nanotechnology in Photovoltaics

Ammar Nayfeh, Masdar Institute, United Arab Emirates

Thin-film solar cells have garnered a plethora of interest to the reduction in material cost and quality needed. However, they suffer from low absorption of the incoming spectrum because of very thin active layer. As such effective light management mechanisms are important for the improved performance of thin film solar cells. Novel techniques such as surface texturing, photonic crystals, plasmonics, spectrum modifications, hot carriers, intermediate-band cells, multiple carrier excitation etc. are being explored for that purpose. Recently metal and semiconductor nanoparticles in particular are being studied extensively to improve thin film solar cells. Metal nanoparticles are capable of scattering the incoming light from the solar cell surface and trap them within the solar cell. This increases the effective path length that they photon can travel within the cell and increases the photo current. On the other hand, semiconductor nanoparticles can contribute to the down-shifting of UV light. They absorb UV light with high-energy photons and emit visible light with lower energy photons which,allows the solar cell to receive more light from the visible spectrum and thereby increase the overall photo-generation. We have been studying gold (Au), silver (Ag), silicon (Si), and indium-nitride (InN) nanoparticles for their application in solar cells. In addition, recently, we used ALD to deposit ZnO nanoislands. J-V and quantum efficiency measurements are carried out and the results show an increase in short-circuit current density (J_{sc}) and external quantum efficiency (EQE) with the incorporation of the various nanoparticles. Finally, plasmonic metal nanoparticles and photoluminescent semiconductor nanoparticles highlight a promising and simple enhancement for future thin film solar cells using nanotechnology.

Session 3: Exploring the Brain

Biomolecular Engineering for Non-Invasive Imaging and Control of Biological Function

Mikhail G. Shapiro, California Institute of Technology, United States

Many important biological processes – ranging from simple metabolism to complex cognition – take place deep inside living organisms, yet our ability to study them in this context is very limited. Technologies such as fluorescent proteins and optogenetics enable exquisitely precise imaging and control of cellular function in small, translucent specimens using visible light, but are limited by the poor penetration of such light into larger tissues. In contrast, most non-invasive technologies such as magnetic resonance imaging (MRI) and ultrasound – while based on energy forms that penetrate tissue effectively – lack the needed molecular precision. Our work attempts to bridge this gap by engineering new molecular technologies that connect penetrant energy to specific aspects of cellular function in vivo. In this talk, I will describe molecular reporters for non-invasive imaging using MRI and ultrasound developed by adapting and engineering naturally occurring proteins. These proteins have physical properties, such as paramagnetism or self-assembly into hollow nanostructures, that allow them to be sensitively detected with MRI and ultrasound. By engineering them at the genetic level, we have adapted these natural constructs into non-invasive molecular reporters of biological processes ranging from gene expression to chemical neurotransmission and metabolism.

Ultrastructural Analysis of Cellular and Subcellular Brain Structure: An Old Fashion Method Revised using Virtual Reality to Investigate Brain Metabolism

Corrado Cali, King Abdullah University of Science and Technology, Saudi Arabia

Understanding the mammalian brain's computational efficiency represents, to date, an ambitious challenge. Growing evidence suggests that the key to unveil such mystery relies in its complex energy management system. In the early 90s, the discovery that lactate, an intermediate product of the glucose metabolic pathway, plays a central role in neuronal energy supply, was formalized as the "astrocyte-neuron lactate shuttle" (ANLS). This theory brought a paradigm shift, from glucose to lactate, into the field of neuroenergetics, and shed new light on the importance of astrocytes into brain physiology and pathology. Recently, astrocytic, glycogen-derived lactate has been shown to be pivotal for brain plasticity, learning and memory; also, benefits of lactate have been shown in a number of pathological conditions, including stroke and epilepsy. In order to unveil how astrocytic lactate is sustaining the brain machinery, we decided to investigate the complex morphological pattern through which astrocytes are tightly connected to neurites and its vasculature (the so called neuro-glia-vasculature unit, or NGV), by means of 3D reconstructions from electron microscopy. Information on astrocytic coverage, of synapses, the extent of ER and mitochondria and their presence in lamelliform processes, and their proximity to spines, boutons, and PSDs, as well as intracellular distribution of glycogen granules provides a structural basis to understand not only ANLS, but also many other phenomena involving astrocyte-neuron crosstalk. Because the morphology of astrocytes in particular is extremely complex to visualize and analyze, we developed custom algorithms the allow to perform these tasks directly in 3D, provided a high-resolution reconstruction; also, we take advantage of virtual reality facilities like CAVE, a virtual reality (VR) room, or the portable oculus rift system, that allow users to interactively "dive" into brain models and navigate it. This approach is similar to what early observers like Golgi and Ramon y Cayal used to do, by hypothesizing the functional role of brain components by their morphology, but revised using much higher resolution imaging techniques and VR visualization.

Biology of Individual Variation: The Interface of Genes and Experience in Shaping Behavior and Mental Health

Zoe Donaldson, University of Colorado, Boulder, United States

As humans, we are complex creatures shaped by a combination of our genes and by individual experiences acquired over a lifetime. These two sources of variation do not exert their effects in a vacuum, but rather combine in non-additive ways to impact our physiology and create unique individuals. My talk will focus on our current understanding of how genetic and environmental variation together shape who we become, and why some people are more likely to develop mental illness based on combination of genes and environment.

Many complex traits and disorders, including depression and other forms of mental illness, are heritable. However, the majority of disease-associated "genes" that are reported in the literature are actually genomic regions that are over-represented in a particular disorder. This correlative work requires subsequent biological experiments to identify the specific sequence differences that directly contribute to disease risk, as well as how those sequences change our biology. My lab and others have used genome editing to identify the direct contribution of specific genetic variants. We have shown that DNA sequences outside of genes can impact their expression and contribute to behavior. This work has provided important examples of how common genetic differences can impact gene expression and behavior and has highlighted that many genetic differences cannot be easily predicted outside of the appropriate biological system.

However, this work has also highlighted what decades of genomic studies have also shown - namely that most of the common genetic differences that have been linked to complex traits and diseases are not deterministic. Having a specific genetic variant may influence behavior and disease risk, but it does not guarantee that one will develop a mental illness. This observation has led to new challenges and a new conceptualization of genetic risk factors for disease – specifically by incorporating a more nuanced understanding of how genes work in a larger context.

The larger contexts that influence such genetic effects are multifaceted. For instance, experience-dependent factors, such as exposure to trauma or loss of a loved one, represent non-genetic risk factors for mental illness. Some people are more sensitive to these experiences, and my lab is studying how certain genetic variants may act as risk factors for mental illness only in certain, traumatic environments. These so-called gene-environment interactions represent a new frontier on our understanding of the mechanisms underlying disease risk and individual differences more generally and may help guide future preventive and therapeutic strategies for mental illness.

The Cognitive Mechanism of Action of SSRI Antidepressants in Responder and Non-Responder Patients with Major Depressive Disorder

Mohammad M. Herzallah, Al-Quds University, Palestine

According to recent clinical trials, only 30% of patients with major depressive disorder (MDD) respond to pharmacological treatment with antidepressants such as selective serotonin reuptake inhibitors (SSRIs). Furthermore, a significant barrier to understanding cognitive function in MDD has been the inadequate dissociation of cognitive changes due to MDD from the side effects of antidepressants such as SSRIs in both responders and non-responders. The two most implicated brain regions in the pathophysiology of MDD are the basal ganglia (BG) and the hippocampus, which are also key areas for cognitive function. Here, we utilize cognitive assessments that selectively and sensitively evaluate BG and hippocampal function to tease apart the cognitive effects of MDD from those of SSRIs in responders and non-responders. Moreover, we explore individual differences in cognitive function resulting from naturally occurring genetic variations in dopamine and serotonin genes. We investigate two cognitive functions that have well-characterized neural bases informed by animal studies, patient work and neuro-computational models: (1) Learning stimulus-response rules from positive and negative feedback, known to depend on the BG; and (2) Generalization of past stimulus-response learning to novel task demands and contexts, known to depend on the hippocampus. Our findings define the cognitive profile of MDD and delineate the cognitive mechanism of action of SSRIs. Further, we present statistically reliable cognitive markers that can a priori differentiate SSRI responders and non-responders and highlight the effects of naturally occurring genetic variations. This research can lead to clinically significant transformations to inform innovative individualized treatment and diagnosis protocols for MDD, guiding physician choices among treatment modalities according to a patient's individual cognitive and genetic profile upon initial diagnosis.

Neural Circuits Regulating Mood Disorders

Dipesh Chaudhury, New York University Abu Dhabi, United Arab Emirates

Major depressive disorder (MDD) is a common psychiatric disorder effecting approximately 121 million people worldwide and recent reports suggest that it will be the leading contributor to the global burden of diseases according to the World Health Organization. Furthermore, the global rise in depression has been reported to cause approximately 1 Trillion dollars a year in lost productivity. At present, the most commonly used treatment is still based on classical strategies developed 60 years ago, where approximately only 50% of depressed patients exhibit full remission. The limited understanding of the neural circuitry of the brain involved in depression is one of the key reasons for the lack of more effective treatments. One brain region that may be a potential target for novel, faster acting therapeutics is the brain reward center. In normal situations neural activity in the brain reward center typically encodes for pleasurable or rewarding stimuli for things such as chocolates or a delicious meal. Recent findings, however, has shown that neural activity in the brain reward center can also encode for stressful stimuli that can ultimately lead to depression. For example, animal experiments using a social stress paradigm, where animals undergo severe stress exposure leading to the development of depression-like behaviors, has been shown to affect the brain reward center. Specifically, neural activity in this region was found to exhibit the same kind of neural activity typically seen when animal receives a reward such as sugar water. Our lab is currently using an animal model of depression to investigate the effects of social stress on neural connections between the brain reward center and other regions of the brain. In order to understand the underlying mechanisms effecting neural circuit activity in animals that exhibit depression-like behaviors, we are using a combination of behavioural analysis together with

invasive brain recording techniques. Findings from these studies will help us unravel the effects of stress on brain activity between different regions of the brain. Furthermore, as we begin to understand the underlying mechanisms regulating brain activity during stress exposure, and the consequent development of depression, we hope to develop more effective novel therapeutic strategies that will help alleviate the global rise in the incidence of depression.

Session 4: Advances in Petroleum Geosciences, Oil and Gas Exploration

Nanotechnology for Oil and Gas Industry: Are We There Yet?

Simone Musso, Schlumberger, United States

For several industries nanoscale technology has moved from science fiction into reality. Is this the case for upstream (exploration and production) gas and oil industry? I will show the possible solutions that only nanotechnology can offer to solve several technical challenges in petroleum industry. From structural nanomaterials, to smart fluids and advanced sensors. From a more efficient oil and gas production to a greener and safer technology. I will also discuss the important role that the Advanced Energy Consortium has played to enable the development and application of new nanoscale technology into the upstream petroleum industry.

Nano-Additives as Drilling Fluids Performance Modification and Heavy Oil Viscosity Reduction

Majid Al-Ruqeishi, Sultan Qaboos University, Oman

Crude oil is the most attractive source of energy. It is formed at high temperatures and pressures deep down in the earth. Extraction of this energy resource, involves expensive drilling and extraction processes. The composition and physical characteristics of the oil depends on the source of the organic material, the temperature, and heat. The greater the viscosity of the oil the more difficult it is to extract. Heavy oil, is the name given to oil with API gravity between 10 and 20, and high viscosity <10,000 cP. It is technologically challenging and expensive to extract. Many solutions have been explored owing to the high financial returns in this business. In this study, we propose new smart solutions, utilizing unique properties of nanoparticles of different shapes and sizes to reduce the viscosity of heavy oil to make it easier to extract. Nanoparticles are 1- 100nm in size, have high surface to volume ratio, high heat capacity, excellent heat conductivity, low thermal expansion, and high melting temperatures. A combination of some of these properties was utilized to explore solutions for drilling and heavy oil viscosity problems. In drilling, problems like pipe sticking, lost fluid circulation, formation damage, erosion of the borehole, thermal instability of drilling fluids and their insufficient gel properties, lies in controlling and optimizing the rheology of the drilling fluid. Therefore, to advance the performance of water based drilling fluids in such a harsh reservoir conditions, a simple treatment based on nanotechnology was utilized by synthesizing in-house nano-addtives. 1-3 wt% of nano-additives increases fluid density by~ 5% and dynamic viscosity by~ 20% and reduces fluid loss by 50%. In addition to this, it forms a thin smooth Mud Cake with the surroundings of the formation. At ambient temperatures, crude oil and bitumen are resistant to flow through reservoir rock because of their high viscosities. Consequently, the energy expended to produce and upgrade a barrel of oil can be as high as 40% of the total energy available from the crude oil resource. Thermal enhanced oil recovery techniques such as steam assisted recovery and also in situ combustion are employed to upgrade and save the physicochemical properties of the oil. All these recovery techniques are expensive, complicated and need periodic maintenance; therefore, direct and cheap solutions are the main targets for high in situ upgrading. Our study provides alternative method that can help in production and upgrading of such heavy oil by cracking it. For the heavy oil cracking process, iron oxide Nano-Rods (IONRs) were synthesized by an environmentally friendly method. These rods were embedded and well mixed with 1 L of heavy oil (12 API) and subjected to direct microwave radiation. The radiation causes a reduction in dynamic viscosity of crude oil due to the presence of dipole water molecules. This reduction increased up to 50% when controlled amount of IONRs additives were added at the same temperature.

Controlling Fluid Flow from Pore- to Field-Scales through Nanotechnology
Jacinta Conrad, University of Houston, United States

Producing oil and natural gas involves fluid flow through channels whose characteristic length scales vary across twelve orders of magnitude. Traditional methods produce oil from fields that can span kilometers through meter- to centimeter-wide bores. Recently-developed methods to stimulate production, such as hydraulic fracturing, generate networks of fractures whose diameters are of the order of centimeters and smaller. Finally, the rocks found in oil and gas fields feature a continuum of pore throat sizes that range from submillimeter for conventional reservoir rocks to submicrometer for tight sandstones down to nanometers for shales. Nanotechnology-based methods for enhancing oil recovery modify fluid flow or wettability through additives, such as nanoparticles, surfactants, foams, or emulsions that are structured on the nano- and microscale. Hence a central challenge for nanotechnology-based oil recovery is to understand how transport and interfacial processes at very small (pore) length scales affect the production of oil at large (field) scales. Here, I will describe recent advances in understanding the transport properties of complex fluids at the nano- and microscale. To generate controlled micromodels for transport studies, we use microfabrication methods to create periodic arrays of nanoposts of various spacings and arrangements; we also create packed beds within microcapillaries using silica particles of various sizes. Using a combination of imaging and image processing, we characterize the flow of submicron particles, suspended in water or in polymer solutions used to enhance oil recovery, through the micromodels and calculate diffusion and dispersion coefficients. These measurements allow us to relate the geometric properties of the porous medium and the rheological properties of the suspending fluid to the ease at which nanoscale particles transport and spread. I will discuss the implications of these studies for enhancing oil and gas production

A Novel Hybrid EOR Using Electrokinetic Driven Nano/Surfactant in Developing SMART EOR in Abu Dhabi Carbonate Conventional and Tight Reservoirs
Mohammed Haroun, Petroleum Institute, United Arab Emirates

Among the emerging hybrid EOR technologies in carbonate reservoirs are Nano-EOR and surfactant-EOR in conjunction with the application of Electrokinetic Enhanced Oil Recovery (EK EOR) (Haroun et al., 2012, 2013, 2014, 2015, 2016). This is gaining increased attention due to a number of reservoir-related advantages such as reduction in fluid viscosity, water-cut and increased reservoir permeability.
The concept of SMART EOR (Simultaneous Modified Assisted Recovery Techniques) takes advantage of the high transport phenomena of EK coupled with chemical flooding to enhance depth of penetration by as much as 400%. The main objective of this research is to target unswept oil efficiently while reducing HSE concerns of handling and transporting the nano particles and surfactant. The procedure proposed in this study aims to develop an understanding of the SMARTTM EOR physical processes on lab-scale tests. The main objective of this research is to target unswept oil efficiently while reducing HSE concerns of handling and transporting the nano/surfactant. Experiments were conducted on 1.5-inch. carbonate reservoir core-plugs from Abu Dhabi producing oilfields with porosity and permeability ranging from 0.01 to 21% and 0.007 to 24.4 mD, respectively. Several nano particles including AlO, CuO and NiO of 50nm size range were tested and compared for ultimate recovery factors against the injection of a non-ionic alkyl polyglucoside (APG) with C10/12 chain structure, a blend of nonionic-anionic APG surfactant and a cationic fatty amine based betaine surfactant were evaluated for this study. These surfactants were selected based on the fact that they are synthesized from renewable resources such as starch and coco derivatives, easily bio-degradable and have very low ecotoxicity.

The experimental results at reservoir conditions representative of Abu Dhabi reservoirs show that the application of SMART EOR was very successful in stimulating the tight formations while increasing the permeability by over 50% without the use of hydraulic fracturing or acid fracturing. The extent of the stimulation was also imaged precisely using dual energy CT Scan validating the process while tracking the depth of penetration. Overall, SMART EOR achieved the following results: average of 94% displacement efficiency, stimulation of tight formations, while sustaining a 50% reduced water footprint compared to other IOR/EOR techniques. Furthermore, this process can be engineered to be a sustainable approach as the water requirement can be reduced drastically on application of electrokinetics, while power consumption can be optimized at $4/Bbl, thus improving environomics.

Session 5: New Spacecraft Technologies for Earth and Space Exploration

The 'Hope Probe' Emirates Mars Mission

Fatima Al Aydaroos, UAE Space Agency, United Arab Emirates

In July 2014 the UAE President, His Highness Sheikh Khalifa bin Zayed Al Nahyan, announced the establishment of the UAE Space Agency (UAE SA). The UAE SA was setup to develop the UAE Space sector; create Space policy and regulation; and direct national Space programs that will benefit the UAE's economy. The Mohammed Bin Rashid Space Centre is the Prime contractor to the UAE SA for the 'Hope Probe' Mars mission. This paper will explain the rationale behind the EMM science objectives and what makes it a unique mission. EMM is intended to fill the gap in scientific observations of Mars as identified by the Mars Exploration Program Analysis Group (MEPAG) and aims to complement and add to the science data being collected by other Mars missions including MAVEN. The Hope probe is expected to contribute significantly to the understanding of the Martian atmosphere through observations that will allow complete temporal and spatial coverage of its variations over a whole Martian year. The presentation will also cover the Hope probe planned mission profile, an overview of the spacecraft, and its payloads.

Small Explorations of a Big Solar System

Andrew Klesh, Jet Propulsion Laboratory, United States

The increasing capability of small explorers, including interplanetary spacecraft the size of shoe boxes, is based upon the continuing miniaturization of commercial electronics. These explorers are now headed to the Moon, Mars, asteroids, and soon, the outer solar system. While not equivalent to larger vehicles, they can fill a unique niche for focused, and potentially risky, exploration. Imagine surveying a hundred asteroids near the earth, or diving beneath the ice-covered oceans of Europa - it is cost prohibitive for large vehicles to make these journeys. In this talk we'll discuss the current state of small explorers, and imagine the future of where we might go next!

Going to Space to Discover Earth

Haithem Altwaijry, King Abdulaziz City of Science and Technology, Saudi Arabia

In this talk, we will present a path that led from exo-solar planets to rediscovering our planet Earth. We will start by looking at the development of interferometric methods for exo-solar planetary imaging, realizing that the application of these methods for Near Earth Objects (NEOs) research may allow for better understanding, tracking and characterization schemes for NEOs. Furthermore, how such technologies can be deployed onboard CubeSats. Finally, we continue to rediscover Earth through past, current and future research as well as space missions related to Earth exploration and observation with focus on joint research activities.

Risk Reduction Ground-Based Technology to Emulate Exploring Missions

Ahmad Bani Younes, Khalifa University, United Arab Emirates

In conceiving and planning space exploration missions, ground-based experiments are required that combine theory with experimental hardware to reduce mission risks. These experiments replicate expected on-orbit behavior, and provide a virtual "wind-tunnel-like" environment for gaining insights into the complicated behaviors that characterize interactions between multiple critical subsystems. Such Risk Reduction Ground-Based Experiments provide anomaly resolution experiments in an operationally relevant environment. At Khalifa University, we have recently developed a suitable approach to ground-based mobile platform technology that simultaneously permits large general motions and highly precise inertial and relative navigation and control, by building the Spacecraft Platform for Astronautic and Celestial Emulation (SPACE) laboratory. The key contribution of such ground robotics-based experimentation is a low-risk method to validate dynamic models, control laws and space technology and to demonstrate aerospace missions.

Frontiers for Automation and Semi-Autonomous Operations in Robotic and Human Exploration

Jessica Marquez, National Aeronautics and Space Administration, United States

NASA future exploration missions will go farther and for longer periods of time than ever before. Dr. Marquez will describe current mission operations for International Space Station, and then discuss how mission operations will have to change for future exploration missions. Key to mission success will be to appropriately integrate operators, be it astronauts or ground operators, and new automation-robotic systems, enabling safe, effective, and efficient exploration.