

Tuesday Afternoon Poster Sessions, December 4, 2018

Nanomaterials

Room Naupaka Salon 1-3 - Session NM-TuP

Nanomaterials Poster Session I

Moderator: Shintaro Fujii, Tokyo Institute of Technology

NM-TuP-1 alginate based Nanocomposite for Microencapsulation of Probiotic: Effect of Cellulose Nanocrystal (CNC) and Lecithin, *Monique Lacroix*, INRS-Institut Armand-Frappier, Canada

Lactobacillus rhamnosus ATCC 9595 were encapsulated in alginate-CNC-lecithin microbeads for the production of nutraceutical microcapsules. The concentration of CNC and lecithin in alginate microbeads was optimized by monitoring the viability of *L. rhamnosus* after stabilization of the microbeads by freeze-drying. Results showed that alginate microbeads (AC-0) reduced by 0.95 log CFU/g whereas addition of 13 wt% CNC in alginate microbeads (AC-3) reduced ($P > 0.05$) by 0.01 log CFU/g of bacterial viability after freeze drying. Incorporation of 2 wt% lecithin in alginate-CNC microbeads (ACL-1) also revealed a protective effect during free drying same as alginate-CNC microbeads (AC-3). The compression strength of the freeze-dried ACL-1 microbeads improved 40% compared to alginate microbead alone. Swelling studies revealed that addition of CNC and lecithin in alginate microbead decreased (around 47%) the gastric fluid absorption but increased the dissolution time by 20 min compared to alginate microbeads (A-0). During complete transition through the gastric passage, the viability of *L. rhamnosus* in dried ACL-1 microbeads was 52% higher as compared to *L. rhamnosus* encapsulated in A-0 based beads. The viability of *L. rhamnosus* was also evaluated during storage at 25 and 4°C. It was found that at 25 and 4°C storage conditions, the viability of *L. rhamnosus* encapsulated in ACL-1 microbeads decreased by 1.23 and 1.08 log respectively, whereas the encapsulation with A-0 microbeads exhibited a 3.17 and 1.93 log reduction respectively.

NM-TuP-2 In-situ Low Energy Electron Microscopy at Near Ambient Pressures, *Thomas Schulmeyer*, SPECS-TII, Inc.

Low-energy electron microscopy (LEEM) is a spectromicroscopy technique, which allows the study of dynamic processes at surfaces and interfaces, such as thin-film growth, surface reactions, and phase transitions. With the FE-LEEM P90 from SPECS, which is based on the instrument design by Rudolf Tromp from IBM, lateral and energy resolution of below 5 nm and 250 meV, respectively, can be achieved. Depending on the excitation source and the settings on the instrument a variety of different imaging modes are possible: mirror electron microscopy, low energy electron diffraction (LEED), phase contrast imaging, reflectivity contrast, dark field imaging and bright field imaging, as well as photoelectron emission microscopy and spectroscopy. As a new development the technical capabilities of LEEM and PEEM have been extended towards near ambient conditions by developing a special objective lens concept and sample chamber geometry. This enables the analysis of materials and devices under near ambient conditions and even in situ during operation. For this a Laser heater allows for sample temperatures up to 800°C during the measurements. The technical realization will be presented in detail. Furthermore experimental results will be shown on Graphene, Silicon under Nitrogen atmosphere. First results from real surface reactions will be discussed.

NM-TuP-4 High-performance Nanofibrous LaCoO₃ Perovskitecathode for Solid Oxide Fuel Cells Fabricated via Chemically assisted Electrodeposition, *Seung-Bok Lee*, Korea Institute of Energy Research (KIER), South Korea; *S Rehman*, Korea Institute of Energy Research (KIER), South Korea, South Korea; *T Lim, J Hong, R Song*, Korea Institute of Energy Research (KIER), South Korea

In this study, a new method is developed for the fabrication of nanofibrous LaCoO₃ (LCO) perovskites as cathodes (oxygen electrodes) for solid oxide fuel cells (SOFCs). The proposed method involves chemically assisted electrodeposition (CAED) of mixed metal hydroxide onto a carbon nanotube (CNT) template, followed by a low-temperature heat-treatment process. The CNT template is first fabricated on porous zirconia-based ion-conducting scaffolds (ICS) by catalytic chemical vapor deposition (CCVD) of C₂H₄. Perovskite-type LCO is then fabricated on the CNT template by CAED process of mixed La-Co hydroxide combined with thermal conversion of hydroxide to perovskite oxide. The method proposed here allows for the fabrication of LCO perovskites with a unique nanofibrous structure at reduced temperatures (900 C), while avoiding the formation of pyrochlore phases (e.g., La₂Zr₂O₇), which are typically observed during conventional

high-temperature sintering processes of LaCoO₃ with zirconia-based electrolytes. The new method also provides the precise control needed to achieve desired oxide loadings without the need for repeated deposition-annealing processes. The anode-supported SOFCs with nanofibrous LCO cathodes on zirconia and ceria scaffolds show high and stable electrochemical performance of 0.95 and 1.27 W cm², respectively, at 800 C. In addition to the absence of insulating pyrochlore phases, the unique nanostructure of the LCO cathode is believed to play a beneficial role in improving the electrochemical properties by providing a large number of active reaction sites and by facilitating mass transport through the porous nanofibrous structure.

NM-TuP-5 Analysis Insitu of Diffusion-nucleation in Multilayer InAs/GaAs Quantum Dots, *Christian Mercado-Ornelas, A Belio-Manzano, L Espinosa-Vega*, Center for the Innovation and Application of Science and Technology, Universidad Autónoma de San Luis Potosí, Mexico; *V Mendez-Garcia*, Center for the Innovation and Application of Science and Technology, Universidad Autónoma de San Luis Potosí, México

In(Ga)As semiconductor quantum dots (QDs) as low dimensional materials have been continuously studied due their interest in their optical and optoelectronic properties, from which have improved significantly the performance in nano-devices.^[1] However, there are still some challenges to be overcome in order to reach the successful implementation of the QDs structures in common devices, that is the case of the vertical alignment in multilayer . In the present work, it is shown samples InAs/GaAs self-assembled QDs samples grown by MBE. The method implemented to synthesize self-assembled QDs is defined as Stransky-Krastanov growth mode, which is well-known that is based on the lattice mismatch between two different materials, recalling for the heterostructure of InAs/GaAs mismatch which is about 7%, this propitiates an increase of strain energy at the interface given as a result the formation of nanoislands. Therefore it is established that this mechanism is completely governed by strain.^[2] A fist set of QDs heterostructures proposed in this work were grown on GaAs (100). Growing firstly a 150 nm thick buffer layer, continuing from three up to five multilayers of InAs QDs capped each layer with 10 nm of GaAs at low temperature. Finally, the structures were ended with 200 nm of GaAs. During each one of the growth stages were monitored by RHEED, taking a main importance in the QDs layers.

The transition curves from a 2D surface to the 3D nanoislands were monitored taking the RHEED 002 diffraction spot intensity during the InAs nucleation. Thus, it was performed a mathematical model to analyze the growth procedure in the multilayers of QDs where it was found that the critical thickness (H_c) decreases as the number of deposited QDs layers increased, such results are explained due to the accumulated strain for successive layers. On the other hand, in the same model proposes an estimation in the adatoms diffusion length, results that remained almost constant, suggesting a similar QDs density in each layer. The vertical alignment of the QDs is a well-known process, associated to the creation of low-strain nucleation centers above each one of the capped dots. Therefore, the similarities in the QDs density in the stacked layers should be expected, which explains the non-variation of adatoms diffusion length.

[1] Yeongho Kim, Keun-Yong Ban, and Christiana B. Honsberg. Appl. Phys. Lett. **106**, 222104 (2015).

[2] E. Eugenio-López, Victor H. Méndez-García, et al, Physica E 95, 22–26 (2018).

NM-TuP-6 Analytical Model Proposal for the 2D-3D Growth Mode Transition in the Synthesis of InAs/GaAs Quantum Dots, *Christian Mercado-Ornelas, L Espinosa-Vega, E Eugenio-Lopez, I Cortes-Mestizo*, Center for the Innovation and Application of Science and Technology, Universidad Autónoma de San Luis Potosí, Mexico; *V Mendez-Garcia*, Center for the Innovation and Application of Science and Technology, Universidad Autónoma de San Luis Potosí, México

The synthesis and properties of low dimensional materials have been studied to improve significantly the performance in nano-devices. This is the case of semiconductor quantum dots (QDs), which have become a topic of interest due to their application in new electronic and optoelectronic devices. Thus, the development of analytical tools that could assist in describing the QDs growth becomes of crucial importance. In the present work, an analytical model to study the diffusion of the adatoms related with the nucleation of the QDs is reported.

Tuesday Afternoon Poster Sessions, December 4, 2018

As a starting point, it is schemed that along the 2D-3D transition the QDs self-assembling process is controlled with adatoms diffusion mechanisms, and so the surface density r of diffusing species evolves according to $\partial\rho/\partial t = D\nabla^2\rho$, where D is the diffusion coefficient. Considering an in-plane isotropic media the equation can be solved in cylindrical coordinates, and ρ can be expressed as $\rho(r, \phi, t) = \sum X_j(r, \phi) e^{-K_m t}$, where $X_j(r, \phi)$ is the 2D diffusion coordinate and K_m is termed as the rate constant which is proportional to D .

In order to analyze the QDs nucleation, the RHEED 002 diffraction spot was experimentally monitored in order to get for 2D-3D transition curves of the strained system InAs/GaAs. This RHEED spot intensity in particular accounts for the scattered intensity related to the islands nucleation. According to the kinematics theory, the intensity can be written as:

$$I(t) \propto |A(q)|^2 |(1 - e^{-i q d})^{-1} + \sum \theta_j(t) e^{-i q d}|^2$$

Here q is the scattering vector, d is the layer spacing, $q(t)$ is the time-dependent coverage of the n th layer and $A(q)$ is the scattering amplitude. These terms are related to $\rho(r, \phi, t)$. Considering the first order of scattered intensity equation as a solution for the adatoms diffusion, reaching an equilibrium 2D state $I(t)$ can be expressed as $I(t) = |1 - e^{-K_m t}|$. Since the QDs nucleation process takes place not before the critical thickness H_c has been reached, $I(t)$ must be rewritten as follows:

$$I(t) = |1 - e^{-K_m (t - H_c)}|$$

This model was proven during the MBE growth of InAs QDs on GaAs (100) substrates. By fitting $I(t)$ to the RHEED experimental intensity curves it was found that H_c did not present a significant dependence on the buffer layer growth temperature, T_{BL} . However, the K_m parameter decreased from 6.01 to 5.35 as T_{BL} increased. Since K_m is proportional to the surface adatoms diffusion, it means that QDs density increased as T_{BL} increased. Atomic force microscopy (AFM) measurements corroborated such information and consequently validated our theoretical model.

NM-TuP-7 Fano Resonances at Interference of Electron Waves in Geometrically Inhomogeneous Semiconductor 2D Nanostructures, Victor Petrov, Institute of Radio Engineering and Electronics RAS, Russian Federation

Fano resonances (FRs) in a semiconductor 2D nanostructure (NS) geometrically inhomogeneous along the propagation of the electron wave (EW) (the x -axis) are theoretically investigated. As is known, FRs [1] arise from interference of EWs propagating along two channels: one of them in the continuous energy spectrum, and the other - a quasistationary state against the background of this spectrum. The considered symmetric along the z -axis NS consisted of three sequentially arranged rectangular quantum wells (QWs) in which the motion of the particle was limited along the z -axis: QW₁ of width L_1 at $x < -a$, QW₂ of width L_2 at $-a < x < a$ and QW₃ of width L_1 at $x > a$. It was assumed that $L_1 < L_2$. In this case, the potential along the x -axis abruptly changed at the points $x = -a$ and $x = a$, and in each QW a series of quantum-size subbands (QSSs) was formed. Thus the energy QSSs $E_{(1),n}$ in QW₁ and $E_{(3),n}$ in QW₃ was the same for the same width of this QWs. In a wide QW₂ the distance between QSSs $E_{(2),m}$ was less than the distance similar number of QSSs in QW₁ and QW₃ (figures 1,2,3 in round brackets indicate the number of the QW, and n and m - number of QSSs, respectively, in QW₁, QW₃ and QW₂). Therefore, in QW₂ formed longitudinal rectangular QW along the x -axis of width $2a$, due to the different energy position of the QSSs in QW₁, QW₃ and QW₂. These QWs also formed QSSs $E_{(2),t}$ due to the restriction of motion in them along the x -axis. These QSSs were the quasistationary states providing the formation of FRs in the considered NS. We calculated the dependence of the NS transmission coefficient $|T(E_x)|^2$ for the electron wave of the unit amplitude propagating from the QW₁ along the lower QSS $E_{(1),1}$, on its longitudinal energy E_x in the range $E_{(1),1} < E_x < E_{(1),2}$. The widths of the QWs L_1 and L_2 in the symmetric on the z -axis NS were chosen so that in this range of variation of E_x in QW₂ there exist at least two longitudinal QWs of different depths with quasistationary states: QW _{$x,1$} , formed by the QSSs $E_{(1),2}$, $E_{(2),2}$ and $E_{(3),2}$, and lying higher in energy QW _{$x,2$} , formed by the QSSs $E_{(1),2}$, $E_{(3),2}$ and $E_{(3),2}$. In this case, the wave propagation to QW₂ was possible only through this overlying QSS, since the transition from the QSS $E_{(1),1}$ in QW₁ to the $E_{(2),2}$ QSS in QW₂ was forbidden by the symmetry of the NS. At the same time, the wave propagation in the channel in the continuous spectrum and in the quasistationary state with the corresponding energy was possible in QW₂. Further, the interfering waves propagated in QW₃ also along one lower QSS with energy $E_{(3),1} = E_{(1),1}$. Thus, when changing E_x depending on $|T(E_x)|^2$, FRs appeared.

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NM-TuP-8 Surface Nanostructures Composed of Thiolated Cyclodextrin/Au and Fe Species: Gas- and Liquid-Phase Preparation, S Kotorova, Institute of Nuclear and Physical Engineering, FEI STU, Slovakia; **Monika Jerigova**, Comenius University, Bratislava, Slovakia; **D Lorenc**, International laser center, Bratislava, Slovakia; **M Prochazka**, Polymer Institute, Slovak Academy of Sciences, Bratislava, Slovakia; **D Velic**, Comenius University, Bratislava, Slovakia

Supramolecular surface nanostructures have application potential as functional devices. Studied system consists of a host molecule of monothiolated β -cyclodextrin chemically adsorbed on an Au surface through a S-Au bond (assigned as Au-S-CD) and of Fe species incorporated as the guest. Secondary-ion mass spectrometry (SIMS) is used to study the formation and composition of these surface supramolecular nanostructures.

The Fe species were prepared by pulsed laser ablation in water and thermal effusion in vacuum. Using laser ablation in water, the solution of Fe species was dropped on Au-S-CD. The relevant mass peaks were observed at 1227 m/z, 1243 m/z and 1260 m/z and were assigned to $C_{42}H_{68}O_{34}SNa-Fe^+$, $C_{42}H_{68}O_{34}SKFe^+$, $C_{42}H_{68}O_{34}SNa-FeO^+$ and $C_{42}H_{68}O_{34}SK-FeO^+$, which can be interpreted as supramolecular complexes with Fe as $C_{42}H_{68}O_{34}SNa-Fe$ and $C_{42}H_{68}O_{34}SK-Fe$ or adducts with FeO as $C_{42}H_{68}O_{34}SNa-FeO$ and $C_{42}H_{68}O_{34}SK-FeO$, respectively. The comparison of isotope distributions with the experimental data supported the presence of a supramolecular host-guest complex between Au-S-CD and the Fe species and an adduct between Au-S-CD and FeO. The Fe species were presumably the first product of the ablation, so the formation of a supramolecular CD-Fe complex was preferential. Presumably, the second product of the ablation were the FeO species. Thermal effusion, even with a cooled surface, was negative with respect to the complex observation, no mass peaks corresponding to supramolecular complexes were observed. Nevertheless, a glucopyranose unit of the CD-S molecule and a variety of molecular fragments corresponding to CD-S associated with Fe and FeO were observed. One can assume that supramolecular complex formation is in this case also dependent on the surface diffusion of the Fe species. Since the surface diffusion of the Fe species at this low temperature might be minimized, the probability of complex formation might be close to zero.

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References

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- [2] S. Halaszova, M. Jerigova, D. Lorenc, D. Velic, ChemPhysChem 2015, 10, 2110–2113.

NM-TuP-9 Controlled Pore Arrangement of Silicon Nanoparticles Having Mesoporous Structure, Taisuke Kuga, K Sato, Tokyo Denki University, Japan

In recent years, semiconductor nanoparticles (NPs) having mesopores have been applied in a wide range of environment, energy and medicine fields, such as sensors, rechargeable batteries and drug delivery systems. The NPs can produce inexpensively by using electrochemical etching. However, they are confronting some serious problems, such as complicated preparation techniques and low production yield of mesopores. Therefore, it is necessary to develop new synthesis approaches for realization of facile preparation of the NPs with mesopore structures and large-scale production of the mesopores. We have prepared silicon nanoparticles (SiNPs) with mesopore structures using an inexpensive chemical route with good productivity. In this presentation, we propose a new way to fabricate SiNPs with mesopore structures by simplified procedures based on a chemical approach, and investigate the size distribution, depth and density of the mesopores by scanning electron microscopy (SEM). The features of our synthesis technologies are to adopt the simplified synthesis system in which only commercially available SiNPs with mean diameter of approximately 100 nm and redox agent were used. The size, depth and density of the mesopores on the SiNP surfaces strongly depends on the redox reaction time. When the redox reaction time was 1 min, the shallow mesopores with mean size of approximately 24 nm were formed on the SiNP surfaces. As the redox reaction time increased from 1 min to 5 min, the depth of the mesopores deepened without change of mean size. SEM images of SiNPs with mesopores obtained by redox reaction time for 10 min were shown in Figure 1. The mesopores with mean size of approximately 29 nm were densely formed on the SiNP surfaces, and also their depths became increasingly deeper. Therefore, our suggested synthesis technologies can provide a new chemical route for high production yield of mesopores.

Tuesday Afternoon Poster Sessions, December 4, 2018

NM-TuP-10 Nanobiosensor Comprising Conductive Polymer Enclosed with Polymer Vesicles for Selective Detection of Influenza A Virus, Geunseon Park, Yonsei University, Republic of Korea; *H Kim*, Korea University, Republic of Korea; *J Lim*, *C Park*, *S Haam*, Yonsei University, Republic of Korea

Nanobiosensor has been selected as a method for detecting wide range of pathogens to prevent pandemic emergence. As one of promising platform, conductive polymer based nanobiosensor has a distinct advantage in the way that its ability to sensitive and rapid detection. In this study, we designed a detection system which is conductive poly aniline based on polymersome conjugated with peptide for specific recognition of influenza A virus. We synthesized poly aniline polymerized within a polymersome consisting of methoxy polyethylene glycol-block- polyphenylalanin copolymer (mPEG-b-pPhe). Then we conjugated the polymersome with peptide binding to hemagglutinin located on the surface of influenza virus. In the presence of Influenza virus, the nanoparticle aggregated with the virus, exposing absorption wave length change. These results indicate that this nanobiosensor could be a potential candidate in terms of detecting influenza virus.

NM-TuP-11 Efficient Antiviral Delivery Polymersomes by Optimization of Surface Density of Cell-targeting Groups for Virus Treatment, Chaewon Park, *H Chun*, Yonsei University, Republic of Korea; *M Yeom*, *H Kim*, Korea University, Republic of Korea; *J Lim*, Yonsei University, Republic of Korea; *W Na*, Korea University, Republic of Korea; *G Park*, Yonsei University, Republic of Korea; *A Kang*, Korea University, Republic of Korea; *D Yun*, Yonsei University, Republic of Korea; *J Kim*, Yonsei University, Republic of Korea; *D Song*, Korea University, Republic of Korea; *S Haam*, Yonsei University, Republic of Korea, Republic of Korea

Influenza A virus (IAV), which causes one of the most contagious diseases is a global health concern, and is responsible for seasonal epidemics and pandemics. Despite laudable advances in antiviral agents and drugs, the vast majority of them have shown limited efficacy due to non-specificity and low viability in physiological or endosomal environment, especially in the case of intracellular drug. A nano platform, consisting of phenylboronic acid (PBA) pendant group polymer which has sialic acid-targeting property, gained greater access to the intracellular space transporting antivirals within the host cell. Amphiphilic copolymers made of pPhe-b-mPEG-PBA formed polymersomes which encapsulated hydrophilic antiviral agents in the core and hydrophobic drugs in the exterior layer. Combination of antiviral drug delivery using amphiphilic nanocarrier and cell-targeting functional group gives a better chance to improve transfection and intracellular distribution efficiency of therapeutic substances.

NM-TuP-12 Photovoltaic Performance of Inorganic/Organic Hybrid Solar Cells using Boron-doped Silicon Nanoparticles, Kuniaki Furuya, K Sato, Tokyo Denki University, Japan

Solar cells using silicon nanoparticles (SiNPs) have attracted attention as one of highly-efficient cells because they not only widen the absorption bands of solar light but also enable the light harvesting via excitonic energy transfer [1]. In order to enhance the transfer efficiency of photogenerated charge carriers between the SiNPs region, we have fabricated boron (B)-doped p-type SiNPs of single nanometer in size by combining thermal diffusion at high temperature with redox reaction of the surface regions of the Si powders (100 nm in size) in etchant containing hydrofluoric acid/nitric acid. Additionally, we have also prepared the inorganic/organic hybrid solar cells consisting of the B-doped p-type SiNPs and poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) so as to reduce the production cost. In such hybrid solar cells, the arrangement of the B-doped p-type SiNPs and PEDOT:PSS in the active layer is critical to improve the power conversion efficiency (PCE). In this presentation, we focus on the position of the B-doped p-type SiNPs, such as the stacking structures consisting of n-type Si substrate/blend layer of B-doped p-type SiNPs and PEDOT:PSS and the stacking structures consisting of n-type Si substrate/B-doped p-type SiNPs/PEDOT:PSS, and discuss the photovoltaic performance of these inorganic/organic hybrid solar cells. The *J-V* characteristics of the hybrid solar cells consisting of n-type Si substrate/blend layer of B-doped p-type SiNPs/PEDOT:PSS (cell 1) and n-type Si substrate/B-doped p-type SiNPs/PEDOT:PSS (cell 2) were shown in Figure 1. The photovoltaic performance of these hybrid solar cells strongly depends on the arrangement of the stacking structures. The cell 1 constructed from the blend layer of B-doped p-type SiNPs/PEDOT:PSS obtained PCE of 3.85% with open circuit voltage (V_{oc}) of 0.36 V, short circuit current density (J_{sc}) of 26.5 mA/cm² and fill factor (FF) of 0.40. The value of the PCE increased to 5.27% for the cell 2 stacked individually the B-doped p-type SiNPs and the PEDOT:PSS, showing the V_{oc} of 0.34 V, J_{sc} of 29.6

mA/cm² and FF of 0.52. This result demonstrates that the control of arrangement of B-doped p-type SiNPs is beneficial for obtaining the higher PCE because of the efficient transport of the charge carriers between the NPs region.

Reference

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Author Index

Bold page numbers indicate presenter

— B —

Belio-Manzano, A: NM-TuP-5, 1

— C —

Chun, H: NM-TuP-11, 3

Cortes-Mestizo, I: NM-TuP-6, 1

— E —

Espinosa-Vega, L: NM-TuP-5, 1; NM-TuP-6, 1

Eugenio-Lopez, E: NM-TuP-6, 1

— F —

Furuya, K: NM-TuP-12, **3**

— H —

Haam, S: NM-TuP-10, 3; NM-TuP-11, 3

Hong, J: NM-TuP-4, 1

— J —

Jerigova, M: NM-TuP-8, **2**

— K —

Kang, A: NM-TuP-11, 3

Kim, H: NM-TuP-10, 3; NM-TuP-11, 3

Kim, J: NM-TuP-11, 3

Kotorova, S: NM-TuP-8, 2

Kuga, T: NM-TuP-9, **2**

— L —

Lacroix, M: NM-TuP-1, **1**

Lee, S: NM-TuP-4, **1**

Lim, J: NM-TuP-10, 3; NM-TuP-11, 3

Lim, T: NM-TuP-4, 1

Lorenc, D: NM-TuP-8, 2

— M —

Mendez-Garcia, V: NM-TuP-5, 1; NM-TuP-6, 1

Mercado-Ornelas, C: NM-TuP-5, **1**; NM-TuP-6, **1**

— N —

Na, W: NM-TuP-11, 3

— P —

Park, C: NM-TuP-10, 3; NM-TuP-11, **3**

Park, G: NM-TuP-10, **3**; NM-TuP-11, 3

Petrov, V: NM-TuP-7, **2**

Prochazka, M: NM-TuP-8, 2

— R —

Rehman, S: NM-TuP-4, 1

— S —

Sato, K: NM-TuP-12, 3; NM-TuP-9, 2

Schulmeyer, T: NM-TuP-2, **1**

Song, D: NM-TuP-11, 3

Song, R: NM-TuP-4, 1

— V —

Velic, D: NM-TuP-8, 2

— Y —

Yeom, M: NM-TuP-11, 3

Yun, D: NM-TuP-11, 3