Energy Conversion and Storage Laboratory (ECSL)

Professor

이강택

Kang Taek Lee

Assistant Professor

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EDUCATION

Ph. D., Materials Science and Engineering, University of Florida, USA, 2010
(Advisor : Prof. Eric D. Wachsman)

M. S. Materials Science and Engineering/ Nano Science and Technology Program,
Korea Advanced Institute of Science and Technology (KAIST), Korea, 2005
(Advisor : Prof. Soon Hyung Hong)

B. S. Ceramic Engineering, Yonsei University, Korea, 2002
(Early Graduation, Highest Honors Graduate)

PROFESSIONAL EXPERIENCE

2014 - **Assistant Professor**
Department of Energy System Engineering
Daegu Gyeongbuk Institute of Science & Technology (DGIST), Daegu, Korea

2010 - 2013 **Assistant Research Scientist,**
University of Maryland Energy Research Center (UMERC), University of Maryland, College Park, MD, USA

2006 - 2010 **Research Assistant,**
Florida Institute for Sustainable Energy, University of Florida, Gainesville, FL, USA

2005- 2006 **Research Engineer**,

Materials Characterization Group, Device & Materials Lab, LG Electronics Institute of Technology, Seoul, Korea

2003 – 2005 **Research Assistant,**

Composite Materials Laboratory, Korea Advanced Institute of Science and Technology, Daejon, Korea

1998- 2000 **Sergeant,**

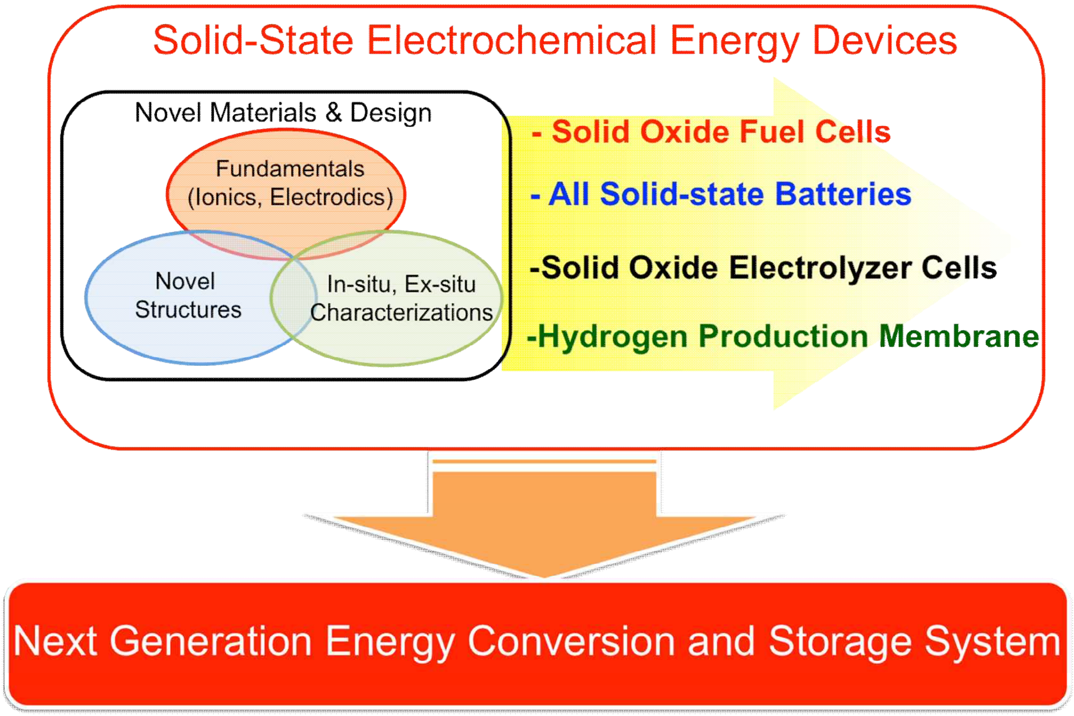
Military Service, Korea Army, Seoul, Korea.

PROFESSIONAL AFFILIATIONS

2010-present **Member of the Electrochemical Society (ECS)**

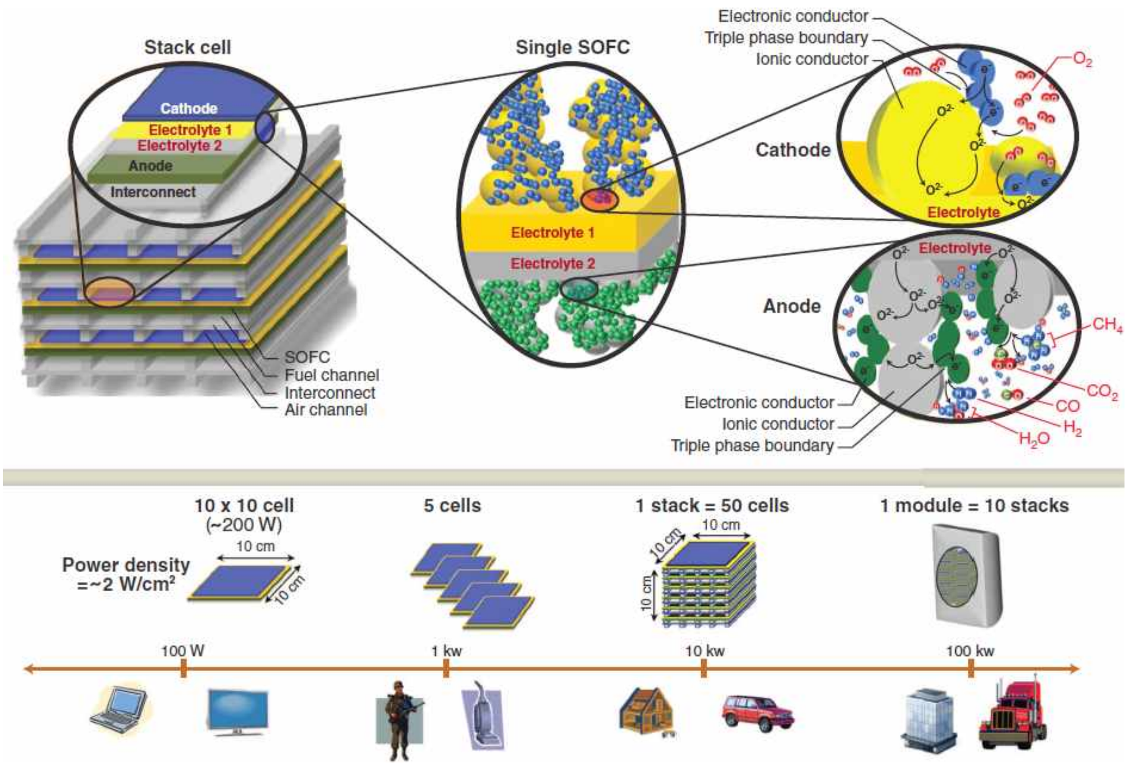
2004 **Member of Korean Powder Metallurgy Institute (KPMI)**

Research



Lee Research Group in the department of Energy System Engineering at DGIST focuses on **fundamental science** and **advanced technologies** of **energy conversion and storage devices** based on **solid state electrochemistry**.

Innovative Energy Conversion Device :
Low Temperature Solid Oxide Fuel Cells



Science 334, 935 (2011)

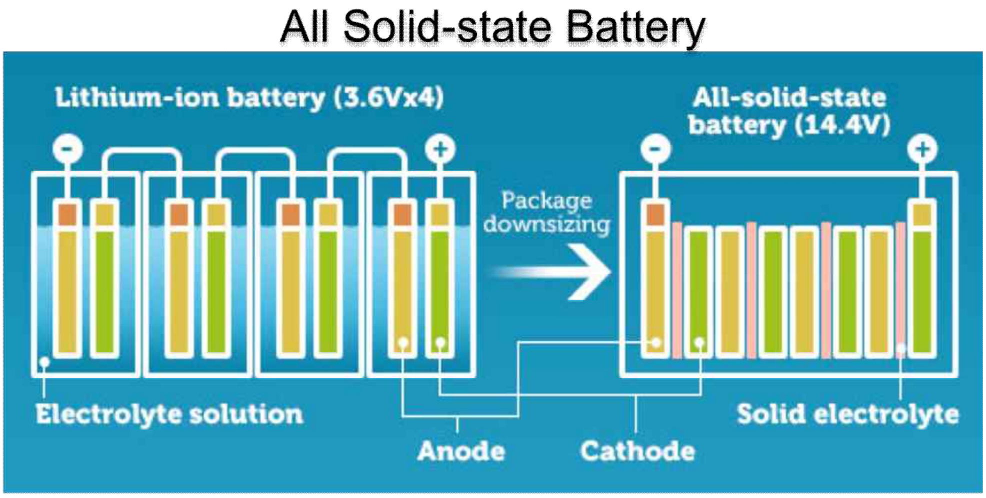
SOFCs offer great promise as a clean and efficient process for directly converting chemical energy to electricity while providing significant environmental benefits. Thus, an SOFC employed vehicle development would be a revolutionary change in transportation technology. Not only could SOFCs transform the automotive sector as a range extender for plug-in hybrid electrical vehicles (PHEVs), but this enabling technology would impact numerous other industries from personal power to large scale power production.

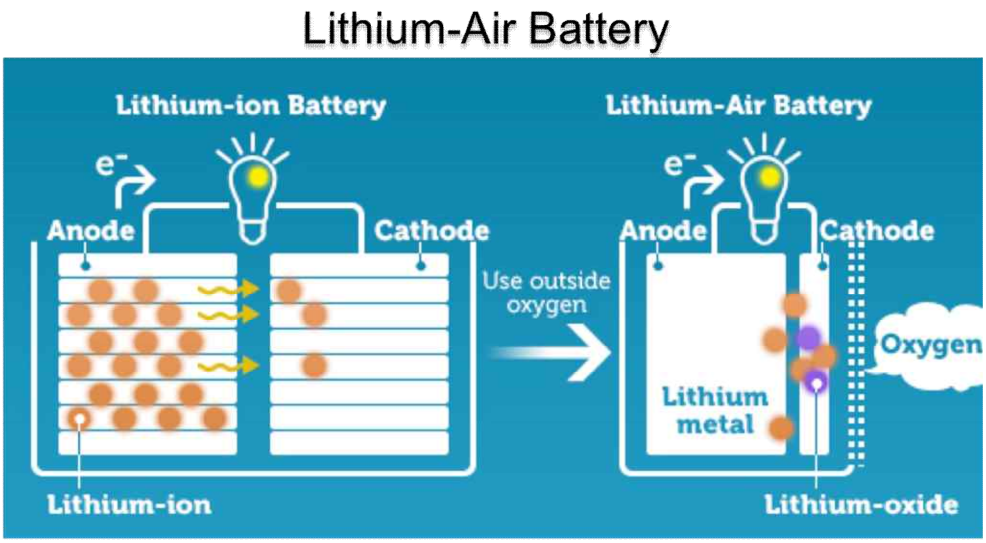
As an auxiliary power unit (APU) this technology could dramatically improve the energy efficiency and emissions of the rest of the transportation sector (trucks, boats, trains, and airplanes), which have to operate large engines in their most inefficient mode (idle) to maintain electric power. SOFCs are modular and can be made in sizes ranging from mW to MW. By driving down the operating temperature, the door opens to a whole host of small personal power applications from battery replacements (mW to W) to battery chargers (~100W) for both civilian and military applications. Operating on natural gas, SOFCs could provide more efficient combined heat (including hot water) and power (CHP) units for residential (~10kW) and commercial (~200kW) use. Thus, development of SOFCs to provide reasonable power output with high efficiency at lower temperatures

(≤ 600 ^{o}C) would make SOFCs both more cost competitive with conventional technology, and significantly reduce start-up times which is critical to transportation and portable power applications.

Next Generation Energy Storage Device :

All Solid-State Battery/ Metal-Air Battery





http://www.toyota-global.com/innovation/environmental_technology/next_generation_secondary_batteries.html

World energy use is heavily dependent upon quickly diminishing reserves of hydrocarbon-based energy sources such as oil, coal and natural gas. As easily accessible deposits are exhausted, more difficult and expensive measures are employed to reach them, such as the controversial practices hydraulic fracturing and deep sea drilling. These practices not only introduce massive amounts of pollutants into the environment, but are only short term solutions to the overarching problem of diminishing energy supplies.

An alternative to hydrocarbon-based energy sources lies in renewable sources such as wind and solar power. However, the capricious nature of wind and sunny days increases the difficulty of implementing these solutions. Another obstacle to a move away from fossil fuels is that vehicles must carry their energy with them in a compact, low-weight manner.

The development of high capacity, high power, low cost electrochemical batteries would enable both of these transitions. Inconsistent production of energy could be averaged over several days or weeks with large, inexpensive batteries. Vehicles could run on electric motors powered by energy dense batteries, ultimately drawing their power from the electric grid.

Publications

PUBLICATIONS

Peer Reviewed Publications (SCI) :

20. G. T. Hitz*, **K. T. Lee***, and E. D. Wachsman, "Higher Conductivity NASICON Electrolyte for Room Temperature Solid-State Sodium Ion Batteries", **under review**

19. **K. T. Lee**, B. W. Lee, M. A. Camaratta, and E. D. Wachsman, "Enhanced Oxygen Reduction Reaction with Nano-scale Pyrochlore Bismuth Ruthenate via Cost-effective Wet-chemical Synthesis", ***RSC Advances,*** **3, 19866, (2013)**

18. **K. T. Lee**, N. J. Vito, and E. D. Wachsman, "Comprehensive Quantification of Ni-$Gd_{0.1}Ce_{0.9}O_{1.95}$ Anode Functional Layer Microstructures by Three-Dimensional Reconstruction using a FIB/SEM dual beam system", ***Journal of Power Sources,*** **228, 220 (2013).**

17. **K. T. Lee**, A. A. Lidie, S. Y. Jeon, G. T. Hitz, S. J. Song, and E. D. Wachsman, "Highly Functional Nano-Scale Stabilized Bismuth Oxide via Reverse Strike Co-Precipitation for Solid Oxide Fuel Cells", ***Journal of Materials Chemistry A*****, 1, 6199 (2013).**

16. **K. T. Lee**, D. W. Jung, H. S. Yoon, A. A. Lidie, M. A. Camaratta, and E. D. Wachsman, "Interfacial Modification of $La_{0.80}Sr_{0.20}MnO_{3-\delta}$ –$Er_{0.4}Bi_{1.6}O_3$ Cathodes for High Performance Lower Temperature Solid Oxide Fuel Cells", ***Journal of Power Sources*****, 220, 324 (2012).**

15. M.-B. Choi, **K.-T. Lee**, H.-S. Yoon, S.-Y. Jeon, E. D. Wachsman, and Sun-Ju Song, " Electrochemical Properties of Ceria-Based IT-SOFC Using Microwave Heat-treated $La_{0.1}Sr_{0.9}Co_{0.8}Fe_{0.2}O_{3-\delta}$ as a Cathode", ***Journal of Power Sources*****, 220, 377 (2012).**

14. **K. T. Lee**, C. M. Gore, and E. D. Wachsman, "Feasibility of Low Temperature Solid Oxide Fuel Cells Operating on Reformed Hydrocarbon Fuels", ***Journal of Materials Chemistry,*** **22, 22405 (2012)**.

13. **K. T. Lee**, H. S. Yoon, and E. D. Wachsman, "The Evolution of Low Temperature Solid Oxide Fuel Cells", ***Journal of Materials Research*****, 27, 2063 (2012). –** ***Invited Featured Paper (Cover Featured Article***)

12. **K. T. Lee**, H. S. Yoon, J. S. Ahn, and E. D. Wachsman, "Bimodally-Integrated Anode Functional Layer for Low Temperature Solid Oxide Fuel Cells", ***Journal of Materials Chemistry*****, 22, 17113 (2012).**

11. **K. T. Lee**, N. J. Vito, H. S. Yoon, and E. D. Wachsman, "Effect of Ni-$Gd_{0.1}Ce_{0.9}O_{1.95}$ Anode Functional Layer Composition on Performance of Lower Temperature SOFCs", ***Journal of The Electrochemical Society*****, 159, F187 (2012).**

10. **K. T. Lee**, D. W. Jung, M. A. Camaratta, H. S. Yoon, J. S. Ahn, and E. D. Wachsman, "$Gd_{0.1}Ce_{0.9}O_{1.95}$/$Er_{0.4}Bi_{1.6}O_3$ Bilayered Electrolytes Fabricated by a Simple Colloidal Route using Nano-sized $Er_{0.4}Bi_{1.6}O_3$ Powders for High Performance Low Temperature Solid Oxide Fuel Cells", ***Journal of Power Sources*****, 205, 122 (2012).**

9. E. D. Wachsman, C. A. Malowe, and **K. T. Lee,** "Role of Solid Oxide Fuel Cells in a Balanced Energy Strategy", ***Energy and Environmental Science*, 5, 5498 (2012). *News report in *Ceramic Tech Today, American Ceramic Society Bulletin, etc.***

8. E. D. Wachsman, and **K. T. Lee,** "Lowering the Temperature of Solid Oxide Fuel Cells", ***SCIENCE*, 334, 935 (2011). (Cited > 110 times) *News report in *Scientific American, Ceramic Tech Today, MSNBC, Technology Review, American Ceramic Society Bulletin, PRNEWS WIRE, physorg, etnews(Korea), etc.***

7. D.-K. Lim, M.-B. Choi, **K.-T. Lee**, H.-S. Yoon, E. D. Wachsman, and S.-J. Song, "Non-Monotonic Conductivity Relaxation of Proton-Conducting BaCe0.85Y0.15O3-δ upon Hydration and Dehydration," ***International Journal of Hydrogen Energy***, **36**, **9367 (2011).**

6. D.-K. Lim, M.-B. Choi, **K.-T. Lee**, H.-S. Yoon, E. D. Wachsman, and S.-J. Song, "Conductivity Relaxation of Proton-Conducting $BaCe_{0.85}Y_{0.15}O_{3-\delta}$ upon Oxidation and Reduction," ***Journal of the Electrochemical Society*, 158, B852 (2011).**

5. K. L. Duncan, **K. T. Lee**, and E. D. Wachsman, "Dependence of Open-circuit Potential and Power Density on Electrolyte Thickness in Solid Oxide Fuel Cells with Mixed Conducting Electrolytes", ***Journal of Power Sources***, **196, 2445 (2011).**

4. D.W. Jung, K. Duncan, M. A. Camarratta, **K. T. Lee**, J. Nino and E. Wachsman "Effect of Annealing Temperature and Dopant Concentration on Conductivity Behavior in $(DyO_{1.5})_{x}$-$(WO_3)_{y}$-$(BiO_{1.5})$", ***Journal of The American Ceramic Society***, **93**, **1384 (2010).**

3. J.S. Ahn, M. Camaratta, D. Pergolesi, **K.T. Lee**, H. Yoon, B.W Lee, D.W. Jung, E. Traversa and E. D. Wachsman, "Development of High Performance Ceria/Bismuth Oxide Bilayered Electrolyte IT-SOFCs", ***Journal of The Electrochemical Society***, **157**, **B376 (2010).**

2. J.S. Ahn, H. Yoon, **K. T. Lee**, and E.D. Wachsman, " Performance of IT-SOFC with $Ce_{0.9}Gd_{0.1}O_{1.95}$ Functional Layer at the Interface of $Ce_{0.9}Gd_{0.1}O_{1.95}$ Electrolyte and Ni-$Ce_{0.9}Gd_{0.1}O_{1.95}$ Anode", ***Fuel Cells*, 9, 643 (2009).**

1. J. S. Ahn, D. Pergolesi, M. Camaratta, H. Yoon, B. W. Lee, **K. T. Lee**, D.W. Jung. E. Traversa and E. D. Wachsman, "High Performance Bilayered Electrolyte Intermediate Temperature Solid Oxide Fuel Cells", ***Electrochemistry Communications***, **11, 1504 (2009).**

Dissertations :

2. **K. T. Lee**, "Comprehensive Development of High Performance Solid Oxide Fuel Cells For Intermediate and low Temperature Applications", Ph.D Dissertation, *University of Florida*, (2010).

1. **K.T. Lee**, "Microstructure and Mechanical Properties of In-situ Fabricated Alumina by Spark Plasma Sintering Process", MS Thesis, *Korea Advanced Institute of Science and Technology*, (2005).

Patents :

2 . Eric. D Wachsman, Hee Sung Yoon, **Kang Taek Lee**, Matthew Camaratta, Jin Soo Ahn, "Advanced materials and design for low temperature SOFCs", Filed October 14, 2008, U.S. Patent Application Serial No. 61/105,294.

1. K. T. Kim, S. I. Cha, C. B. Mo, **K. T. Lee** , K. H. Lee, Y. J. Jeong and S. H. Hong, "Fabrication method of nanocomposite powders consisted of carbon nanotubes with metal", Application number: 10-2005-18722 (2005), Korea.

CONFERENCE PRESENTATIONS

16. **K. Lee**, and E. Wachsman "Efficient High Power Density SOFCs with Zirconia/Bismuth Oxide Bilayered Electrolytes", 222th ECS Meeting, Hawaii, USA (2012).

15. G. Hitz, **K. Lee**, and E. Wachsman "Synthesis and Characterization of $Na_{3+x}M_xZr_{2-x}Si_2PO_{12}$ for Solid State Na-Ion Battery Applications", 222th ECS Meeting, Hawaii, USA (2012).

14. C. Gore, **K. Lee**, H. Yoon, and E. Wachsman "Anode Materials and Design for Lower Temperature, Hydrocarbon-Fueled Solid Oxide Fuel Cells", 222th ECS Meeting, Hawaii, USA (2012).

13. A. Lidie, **K. Lee**, and E. Wachsman "Fabrication and Characterization of Nanosized $(DyO_{1.5})_x(WO_3)_y(BiO_{1.5})_{1-x-y}$ for Lower Temperature SOFC Application", 222th ECS Meeting, Hawaii, USA (2012).

12. H. Yoon, C. Gore, A. Lidie, **K. Lee**, and E. Wachsman "Process Integration for Scale-Up of $Ce_{0.9}Gd_{0.1}O_{1.95}$ Electrolyte-Based LT-SOFCs", 222th ECS Meeting, Hawaii, USA (2012).

11. **K. T. Lee**, A. A. Lidie, H. S. Yoon, and E. D. Wachsman "Development of High Performance LSM-ESB Cathode for Lower Temperature Solid Oxide Fuel Cells", 220th ECS Meeting, Boston, USA (2011).

10. **K. T. Lee**, C. M. Gore, H. S. Yoon, and E. D. Wachsman "Performance of Lower Temperature Solid Oxide Fuel Cells Operating on Reformated Hydrocarbon Fuels", 220th ECS Meeting, Boston, USA (2011).

9. **K. T. Lee**, D. W. Jung, H. S. Yoon, M. A. Camaratta, N. A. Sexson and E. D. Wachsman "High performance LSM-based cathode boosted by stabilized bismuth oxide for low to intermediate temperature solid oxide fuel cells", 219th ECS Meeting, Montreal, Canada (2011).

8. **K. Lee**, N. Vito, M. Camaratta, H. Yoon and E. D. Wachsman "Effect of AFL Composition on IT-SOFC Electrochemical performance and Quantitative Microstructural Analysis Using FIB/SEM", 217th ECS Meeting, Vancouver, Canada (2010).

7. **K. T. Lee**, H. Yoon, J.S. Ahn, M.A. Camaratta, N. A. Sexson, E. D. Klump and E. D. Wachsman "Novel Anode Functional Layer for High Performance Solid Oxide Fuel Cells Operating below 600^{o}C", 34th International Conference & Exposition on Advanced Ceramics & Composites (ICACC), Daytona, Florida, USA (2010).

6. **K. Lee**, H. Yoon, J. Ahn, M. A. Camaratta, D. Jung, N. A. Sexson, E. D. Klump and E. D. Wachsman "High Performance IT-SOFCs with Functionally Graded Anode Functional Layer Using Nanoscale Ni- $Ce_{0.9}Gd_{0.1}O_{1.95}$ Precursor", 2009 Fuel Cell Seminar & Exposition, Palm Springs, CA, USA (2009).

5. **K. T. Lee**, M.A. Camaratta, D.W. Jung, J.S. Ahn, H.S. Yoon, B.W. Lee and E.D. Wachsman "Fabrication and Characterization of High Performance IT-SOFC with Ceria/Bismuth Oxide Bilayered Electrolyte", 33rd international conference and exposition on advanced ceramic and composites, Daytona, Florida, USA (2009).

4. J. S. Ahn, D. Pergolesi, **K. T. Lee**, M. Camaratta, H. Yoon, B. W. Lee, E. Traversa and Eric. D. Wachsman, "High Performance Ceria/Bismuth Oxide Bilayered Electrolyte IT-SOFC", 214th ECS Meeting, Honolulu, Hawaii (2008).

3. J. Ahn, H. Yoon, **K. Lee**, B. Lee and E. D. Wachsman, " Performance of IT-SOFC with anode functional layer at the interface of gadolinia doped ceria electrolyte and nickel-ceramic composite anode", 32nd international conference and exposition on advanced ceramic and composites, Daytona, Florida, USA, p28 (2008).

2. T. Oh, **K. Lee**, B. Lee and E. D. Wachsman, " Proton conducting solid oxide fuel cell based on the thin $Ba_{0.9}Ce_{0.1}YO_{3-\delta}$ electrolyte film on $Sr_{1-x}Ce_xEuO_{3-\delta}$ -NiO anode substrate", 32nd international conference and exposition on advanced ceramic and composites, Daytona, Florida, USA, p129 (2008).

1. **K. T. Lee**, S. I. Cha, K. T. Kim, S. H. Hong, " Fabrication process, microstructures, and mechanical properties of alumina fabricated from amorphous powders by spark plasma sintering(SPS) process", 2004 International Symposium on Powder Materials and Processing, Yongpyung, Korea, p86 (2004).

INVITED SEMINARS

3. **Kang Taek Lee** "Innovative Energy Conversion Device : Low Temperature Solid Oxide Fuel Cells", Korea Institute of Science and Technology (KIST), Seoul, Korea (Feb. 22. 2013).

2. **Kang Taek Lee** "Innovative Oxide Materials for Electrochemical Energy Conversion", University of Maryland, College Park, USA (Sept. 11. 2012).

1. **Kang Taek Lee** "Advanced Materials and Design for Low Temperature SOFCs", Samsung Heavy Industry, Daejeon, Korea (Jan. 16. 2012).