



**Professor Hideo HOSONO**  
**Professor, Laboratory for Materials and Structures, Director of**  
**Materials Research Center for**  
**Element Strategy**  
**Tokyo Institute of Technology**  
**Japan**



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Kazuya Masu

President

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January 25, 2019

Re: Nomination of Professor Hosono to the Albert Einstein World Award of Science 2019

Citation "Discovery of Iron-Based High-Tc Superconductors and Frontier Cultivation of Transparent Oxide Semiconductors and Inorganic Electrides"

Dear The Chair of the Selection Committee,

It is my great pleasure to write in support of the nomination of Professor Hideo Hosono to the Albert Einstein World Award of Science 2019. Professor Hideo Hosono of Tokyo Institute of Technology has accomplished three breakthroughs in electronic materials, i.e., discovery of iron-based superconductors, cultivation of transparent oxide semiconductors and inorganic electrides.

The impact of the first, breaking a widely accepted belief of "iron with a large magnetic moment is harmful for emergence of superconductivity", is comparable to the discovery of high Tc-copper oxide superconductors in 1986. Discovery of iron-based superconductor was chosen as the breakthrough of the year 2008 by the Science Magazine, and rekindled extensive superconductivity research globally. As a consequence, several ten thousand of papers on this subject were published in last decade and iron-based superconductor has grown to a new continent of high Tc superconductors comparable to high Tc-copper oxides. The second achievement has opened a new frontier in materials science of semiconductors, transparent oxides, and new application in flat panel display industry. In 2012 industrial production of retina displays for mobile phones and tablet PCs started. Subsequently, large-sized OLED-TVs were put into market in 2014 and are rapidly spreading globally. Each pixel of these displays is driven by amorphous InGaZnOx (IGZO)-TFTs, invented by Hosono. This is a very rare case in which fundamental material research led to the major industrial application which is evidenced by a fact that the patent license fee in 2017 occupies ~30% of that of total Japanese Universities. The last led to opening of materials science of electride in which electrons serve as anions. He realized in 2003 a first RT-stable electride which had been the critical issue since its discovery in 1983, and extended electride's concept to 2D, amorphous materials and intermetallic compounds along with elucidation of their unique properties. Utilization of the intrinsic nature of electride to catalyst for ammonia synthesis at mild conditions is expected to be a revolution of ammonia synthesis which was established in 1913 by Haber and Bosch.

As described above, Dr. Hosono's achievements have large impact on both basic science and applications as evidenced by many prestigious prizes were given to him. He is well known as not only an excellent researcher but an excellent research supervisor for young talented researchers and a leader of material research (president elect of MRS-J). I should like to support unreservedly the nomination of Professor Hideo Hosono to the Albert Einstein World Award of Science 2019.

Sincerely yours,

Kazuya Masu, President  
Tokyo Institute of Technology

**Robert J. Cava**

Russell Wellman Moore Professor of Chemistry

January 22, 2019

World Award of Science Committee  
WCC

Dear members of the Award Committee

I am writing this letter in very strong support of the nomination of Professor Hideo Hosono from the Tokyo Institute Technology for the 2019 WCC World Award of Science. I do not have any professional or personal association with Prof. Hosono, but am a very strong admirer of his inspirational work. Prof. Hosono is a world leader in the discovery and applications of new materials. He has been extremely successful in the discovery of new functional materials with applications ranging from superconductivity to optoelectronics to catalytic chemistry.

His research has cultivated several important new areas of materials science. I remember first noticing his remarkable creativity when I heard about his discovery of the first solid electride, "C12A7e<sup>-</sup>" (i.e. the electron-doped material 12CaO·7Al<sub>2</sub>O<sub>3</sub>, Science **301**, 626, 2003). I am particularly interested in electronically conducting oxides, and also have been interested through my readings in molecular electrides for many years, having known Jim Dye (the discoverer of liquid electrides) personally. It's impossible to overstate how remarkable prof. Hosono's discovery was. People had been working for decades to try to put enough electrons into Zeolites to yield a metallic conductor, without being even close to successful, and yet, through an incredible combination of intuition, persistence, and knowledge in materials science, prof. Hosono found a completely different material in which electrons could be solvated in a solid cage in a high enough concentration to yield a metallic conductor. (There are no transition elements present, and so there is no way, by conventional thinking, that this material should have worked, because there are no atoms present that can accept the electrons, and yet it does!) And then it even superconducts at low temperature! Who could even imagine this!? Superconducting cement! At the same time, he also had the idea that hydrogen in C12A7 would be an H<sup>-</sup> ion (a very rare oxidation state for H, which is usually H<sup>+</sup> of course) and would work as a donor on irradiation with UV light, a concept that would have a strong influence on his later work in superconductivity, described further below. His scientific interests extend to a variety of interdisciplinary areas, and he has also extensively researched chemical applications of C12A7e<sup>-</sup> and related materials. He noticed, for example, the very low work function of C12A7:e<sup>-</sup>, and anticipated that that characteristic might catalyze chemical reactions. As a result, he demonstrated the low-temperature, low-pressure synthesis of ammonia using Ru-loaded C12A7:e<sup>-</sup> (Nature Chem. **4**, 934, 2012). He is also keenly interested in industrial applications of his new materials, and has apparently launched a venture company for ammonia synthesis.

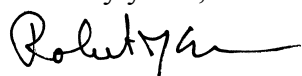
His discovery of a solid electride is truly remarkable, but what he has become very famous for world-wide is his discovery about a decade ago of high-T<sub>c</sub> iron pnictide superconductors. Neither prof. Hosono nor anyone else in materials science could have anticipated such a paradigm-breaking discovery - because iron and other magnetic elements should not be expected

to give rise to superconductivity, but rather magnetism. Prof. Hosono found these superconductors through his research on *p*-type transparent conductors, a program of many years whose publications I followed carefully. I remember being stunned by his early paper on the iron arsenide superconductors, which reported that F<sup>-</sup> doped LaFeOAs exhibited superconductivity at ~26 K (J. Am. Chem. Soc. **130**, 3296, 2008). “What incredible insight could he have had about such materials that no-one else in the world had?” I asked myself. In retrospect I can see that it must have been his work on e<sup>-</sup> and H<sup>-</sup> compounds that led him to this unexpected new kind of material. This discovery invoked a world-wide “fever” about these new very high T<sub>c</sub> superconductors, with many thousands of scientists working on them, and even tens of thousands of papers published based on his discovery. Very few people have ever had such an influence on the course of science as prof. Hosono had with this discovery. He has published many papers on these remarkable materials in the time since his earliest reports, and has had through his discoveries in superconductivity a truly remarkable impact on physics and materials science, for which, in my opinion, he deserves the highest recognition. As previously described, he is highly interested in the industrial applications of fundamental research, and has also contributed to developing practical superconducting wires of his new materials.

Another very influential work was prof. Hosono’s demonstration of amorphous oxide semiconductor thin-film transistors (Nature **432**, 488, 2004). The idea behind this work originated much earlier (J. Non-Cryst. Sol. **203**, 334, 1996) with his realization that the conduction band minimum of some oxides is built mainly from large isotropic s orbitals and is therefore relatively insensitive to disorder. This was unexpected by amorphous semiconductor researchers at that time, because the majority of amorphous semiconductors studied were amorphous chalcogenides and silicon, which have very low mobilities and are largely unsuitable for transistor applications. Hosono realized that because amorphous oxide semiconductors can have high mobilities even if fabricated at room temperature, they might revolutionize electronic systems that currently employ hydrogenated amorphous silicon. His insights into materials science, new materials, and industrial applications has been proven by the wide spread use of amorphous oxide TFTs in commercial applications ranging from high-resolution liquid-crystal displays to large-size organic light-emitting diode displays.

In summary, in my view Professor Hideo Hosono is a world-leading figure in materials science. His exceptional intuition and knowledge have allowed him to make *several* world-leading and very impactful discoveries in new electronic materials. I imagine that these are not the last of his remarkable discoveries – there will be more to come. His contributions are not only in new materials discovery but also extend to industrial applications. Based on his unique, truly remarkable and world-leading contributions, I am very happy to support the nomination of Professor Hideo Hosono to receive the 2019 World Award of Science.

Sincerely yours,



Robert J. Cava  
rcava@Princeton.edu

(The letter writer is a past recipient of the Materials Research Society’s MRS Medal, two national awards from the American Chemical Society (Materials Chemistry and Inorganic Chemistry) and one from the American Physical Society (The McGroddy Prize for new materials), a President’s International Fellowship for Distinguished Scientists, Chinese Academy of Sciences, a Doctor Honoris Causa from the Technical University of Gdansk, and is a member of the US National Academy of Sciences and a Foreign Member of the Royal Society of London.)



On the scientific achievement of Dr. Hideo Hosono

2019.1.25.

Dr. Hosono has achieved several, not a single, very important contribution in material science with his ability to create new functional materials as a chemist with his penetrating understanding of electronic states as a physicist. Up to now I have not encountered a case like Dr. Hosono, who has both abilities in a single human being. To my view three discoveries of his are truly outstanding.

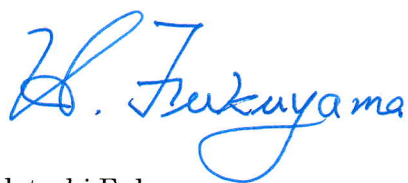
The first is the discovery of iron-based high temperature superconductivity, which was totally unexpected since iron is the symbolic element of magnetism known to be antagonistic to superconductivity. It has now been clarified that the superconductivity here results from many bands at the Fermi energy leading to inter-band coupling of electrons. This is in sharp contrast to the case of high temperature superconductivity copper oxide where a single band is playing roles. Hence Hosono's discovery of iron-based high temperature superconductivity is not only important by itself but also has opened a new paradigm by revealing a fact that existence of many bands at and near the Fermi energy can lead to new functionality. Since each band is associated with a particular orbital of Fe atom, this finding indicates importance of multi-orbital effects. It is to be noted that iron based superconductors are more tractable in actual use than copper oxides because of metallic characteristics compared with brittle ceramics.

The second is exploration of new possibility of transparent oxide semiconductors. In particular, realization of thin-film transistors based on transparent amorphous oxides semiconductors, which are already in the market to drive pixels of flat panel displays. Physically, control of Fermi-level in wide gap oxides is difficult unlike narrow gap materials such as Si and GaAs. This is particularly true for realization of p-type conduction because of highly localized nature at valence band maximum, and for the field effect to work due to high density of tail states arising from structural randomness including defects. Dr. Hosono has overcome these difficulties by proper choice of metals coupled to oxygens through deep understanding on the roles of local atomic orbitals constituting the valence band maximum and conduction band minimum, which can be taken as a kind of "orbital engineering". The strong social impact of these research

results can be identified by the high citation in patents.

The third is discovery of chemically stable inorganic electrides, where electrons are serving as anions, a new state of matter with very low work function. Dr. Hosono has not only discovered several novel type electrides and interesting physical properties including superconductivity but also developed their application. In particular, catalysts based on electride materials opened a way of on-site  $\text{NH}_3$  synthesis for which the Haber-Bosch process cannot be applied. This will be truly innovative once in action.

All these research records prove unique features of research activity of Dr. Hosono exploring frontier of basic science in view of contributing to society.



Hidetoshi Fukuyama

Adviser to the Chair and the President, Tokyo University of Science

Professor Emeritus, The University of Tokyo

Honorary Member, Physical Society of Japan

Fellow, American Physical Society

Vice President, International Union of Pure and Applied Physics (IUPAP) (2002-2005)

## Resume of Dr.Hideo Hosono's Achievements in Research

### “Discovery of Iron-Based High-Tc Superconductors and Frontier Cultivation of Transparent Oxide Semiconductors and Inorganic Electrides”

Dr. Hideo Hosono has cultivated electronic functions in inorganic materials over the past 2 decades and created several innovative materials, some of which have opened novel and large academic fields and/or led to large industrial applications. His approach is to combine physical measurements with unique material choices based on his chemical intuition. He has published ~1,000 original papers (h-index 127), 5 books in English, ~90 registered international patents on these subjects, and has received many scientific prizes including the Imperial Prize and Japan Academy Prize, the highest academic honors in Japan (each year a single Imperial Prize is awarded in the natural science sector to the researcher with greatest research achievement) and several highest prizes from the academic societies such as Materials Research Society (MRS), Society for Information Display (SID) and American Physical Society. In 2016, the Japan Prize, the highest international prize endorsed by the Japanese Government, was awarded to him. The impact of his research not only developed new areas in materials science but led to large industrial application such as displays. The highlights of his research achievements are summarized as follows:

#### 1. Discovery of High-Tc Iron-Based Superconductors

Magnetic elements with large magnetic moments, such as iron, were widely believed to be harmful for the emergence of superconductivity because static magnetic ordering competes with the dynamic formation of electron pairs (so called Cooper pairs). It was thus transformative when Dr. Hosono discovered the iron-based superconductors (IBSCs) LaFeOP (T<sub>c</sub>=4K, JACS 2006) and LaFeAsO<sub>1-x</sub>F<sub>x</sub> (T<sub>c</sub>=26K, JACS, 2008), in the course of his exploration of magnetic analogues of the p-type transparent semiconductors LaCuOCh (Ch=S, Se) with similar crystal structures. This discovery fired extensive research globally, leading to the publication of more than ~Several ten thousands of papers in the last decade. His JACS 2008 paper became the most cited paper published in 2008 in all disciplines, and the discovery of IBSCs was selected as breakthrough of the year by the *Science Magazine*. Nature magazine's feature “High Temperature Superconductivity (Vol.475, pp.280) highlighted ten achievements in the field, two of which were the discovery of new superconductors: the high T<sub>c</sub> copper oxides in 1986 by Bednorz and Muller and high T<sub>c</sub> iron-based superconductors in 2008 by Hosono et al.

#### 2. Creation of Transparent Oxide Semiconductors and Their Display Application

Most of transparent oxides, such as glass and alumina, are insulators. The few exceptions to this rule are known as transparent conducting oxides (TCOs). The representative examples are In<sub>2</sub>O<sub>3</sub> doped with Sn<sup>4+</sup> and ZnO doped with Al. Although TCOs are widely used as transparent electrodes, their application as transparent semiconductors was impossible because tuning the Fermi level with a biasing voltage is difficult in these materials. In addition, no p-type transparent oxide material was reported when Hosono entered the field. Hosono created new materials that led to the solution of the above issues. First was the creation of transparent amorphous oxide semiconductors (TAOS) with large electron mobility comparable to that of polycrystalline analogues. He designed TAOS based on a simple consideration of the orbital constitution for the conduction band minimum (CBM) in the post-transition metal cations. Since the overlap between the s-orbitals of adjacent metal cations (through intervening oxygen atoms) is large and insensitive to the

structural randomness, he deduced that amorphous versions of these post-transition metal oxides could retain large electron mobility. This idea was proposed in 1996 along with several concrete materials (J.Non-Cryst.Sol. 1996, 2006) and was later demonstrated in the lab using various spectroscopic techniques combined with cluster calculations (Phys. Rev. B,2002). In 2003-4, he fabricated thin film transistors (TFTs) using InGaZnOx (IGZO), which can be prepared as a TAOS, and reported that IGZO-TFTs have large electron mobilities that are an order of magnitude higher than that of amorphous Si:H. These publications on crystalline (Science,2003) and amorphous IGZO-TFTs (Nature,2004) strongly stimulated the display and amorphous semiconductor communities. As a result, these two papers became the most cited publications (2200 for Science, 6000 for Nature) regarding oxide semiconductors. The citation count of a series of his patents has risen to ~30,000 (Google Scholar), the largest number in this field. IGZO-TFTs are now practically used as the backplane to drive high-resolution and energy-saving LCD panels, and OLED-TVs. The most visible product with IGZO-backplane is large-sized (55&65") OLED-TVs by LG display, which are now rapidly growing in market. Recently, he described a brief story of IGZO-TFT invention in Nature Electronics upon request (Nature Electro. 2018).

Hosono's second major contribution to this field is the realization of p-type oxide semiconductors. In 1997, the first transparent p-type oxide semiconductors  $\text{CuAlO}_2$  was reported along with a chemical design concept (Nature,1997). Subsequently, a series of new transparent p-type semiconductors using  $\text{Cu}^+$ -bearing layered oxides, such as  $\text{SrCu}_2\text{O}_2$  and  $\text{LaCuOS}$ , and pn-junction devices were fabricated employing these materials. He also succeeded in finding bipolar oxide semiconductors similar to Si using  $\text{CuInO}_2$ .

### 3. Materials Science and Application of Inorganic Electrides

An electride is a crystal in which electrons serve as anions. Electrides prepared (restricted to organic materials) were so chemically and thermally unstable that almost no physical properties had been measured. Hosono succeeded in synthesizing the first RT stable electride (Science, 2003), employing  $12\text{CaO} \cdot 7\text{Al}_2\text{O}_3$ , a cement mineral. He focused on the unique crystal structure of  $\text{C}_{12}\text{A}_7$ , i.e., positively charged sub-nm-sized cages are connected through shared oxide monolayers to form a 3D-structure, and  $\text{O}^{2-}$  ions are loosely bound as counter anions to maintain electro-neutrality. He was able to exchange these loosely bound  $\text{O}^{2-}$  ions with electrons. The resulting material may be regarded as an electride ( $\text{C}_{12}\text{A}_7\cdot\text{e}$ ) and exhibits a metal-insulator transition (Nano Letters, 2007). Furthermore, when metallic  $\text{C}_{12}\text{A}_7\cdot\text{e}$  is cooled down, it was found to display superconductivity! (JACS,2007). Such a discovery demonstrated the hidden potential of abundant elements and led to the establishment of a Japan Science& Technology Policy "Element Strategy Initiative".

After considering the unique properties of  $\text{C}_{12}\text{A}_7\cdot\text{e}$ —its very low work function(2.4eV) but strong chemical & thermal stability—Hosono discovered that Ru-loaded  $\text{C}_{12}\text{A}_7\cdot\text{e}$  showed high catalytic activity for ammonia synthesis at ambient pressure (Nat. Chem., 2012, Nat.Com. 2015). Furthermore he extended the concept of electride to intermetallics and found a series of new electride materials and their high catalytic activity for  $\text{NH}_3$  synthesis (Nature Catal. 2018). As a result, a company aiming at industrial application of his invention to on-site  $\text{NH}_3$  synthesis was established in 2017 by sponsorship of a Governmental fund, UMI, and Ajinomoto, the largest food company in Japan.

In addition, he extended the electride concept to 2D-materials in which anionic electrons occupy spaces between cationic slab layers and found  $\text{Ca}_2\text{N}$  to be one such 2D electride material, formulated as  $(\text{Ca}^{2+})_2(\text{N}^{3-})(\text{e}^-)$ , in 2013 (Nature, 2013). Two D electride materials may be viewed as bulk analogues to the 2D-electron gases which occur at clean hetero-interfaces between semiconductors such as GaAs/AlGaAs.

## Curriculum Vitae

Jan.20, 2019

**Name:** Hideo Hosono

**Birth:** Sep.7, 1953

Kawagoe, Saitama Pref. Japan

**Family:** wife (Emiko), daughter (Nao)

**Home Address:**

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TEL: +81-46-277-8961

**Current Position:**

Professor, Laboratory for Materials and Structures,  
Director of Materials Research Center for Element Strategy,  
Tokyo Institute of Technology

**Business address:**

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4259 Nagatsuta-cho, Midori-ku, Yokohama 226-8503, Japan

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**Education:**

March 1977 B.E.

Applied Chemistry, Tokyo Metropolitan University

March 1979 M.E.

Applied Chemistry, Tokyo Metropolitan University

March 1982 Ph.D

Applied Chemistry, Tokyo Metropolitan University

Thesis: ESR Characterization of Oxide Glasses

(Supervisor: Takafumi Kanazawa, Hiroshi Kawazoe)

**Employment:**

April 1982 Assistant Professor, Department of Inorganic Materials,  
Nagoya Institute of Technology, Japan

Feb. 1990 Associate Professor, Department of Materials Science and Engineering  
Nagoya Institute of Technology, Japan

July 1993 Associate Professor, Materials and Structures Laboratory,  
Tokyo Institute of Technology

Oct 1999 Professor, Materials and Structures Laboratory  
Tokyo Institute of Technology

Oct. 2004 Professor, Frontier Research Center & Materials and Structures Laboratory

## Tokyo Institute of Technology

- Aug.2011~ The founding director, Materials Research Center for Element Strategy
- April 2015~ Professor, Laboratory for Frontier Materials, Institute for Innovative Research
- 1988-1989 Visiting Associate Professor, Department of Materials Science and Engineering,  
Vanderbilt University (Host: Robert A. Weeks)
- 2005-2007 Associate Professor, National Institute for Molecular Science, Okazaki, Japan
- 2000 Guest Professor, Institute for Chemical Research, Kyoto University
- 2004-2009 Guest Professor, SAINT, Sungkyunkwan University, Korea
- 2012- Special Invited Professor, Nagoya Institute of Technology, Japan
- 2014-2015 Guest Professor, Research Laboratory for Electronic Science,  
Hokkaido Univ. Japan
- 2019 Honorary Professor (Huazhong University of Science and Technology), China

## Honor: Award

- 1986 Award for Young Ceramist (The Ceramic Society of Japan)
- 1990 1st Otto-Schott Research Prize (Ernst Abbe Foundation, Germany)
- 1995 W.H.Zachariasen Award (J.Non-Crystalline Sol.)
- 1999 Academic Prize (Ceramic Society of Japan)
- 2002 Academic Prize (Chemical Society of Japan)
- 2004 Japan MEXT Minister Prize
- 2009 Bernd T. Matthias Prize for Superconductivity,  
Medal with purple ribbon (The prime minister of Japan),  
Special Recognition Award (Society for Information Displays)
- 2011 Asahi Prize (The Asahi Shin-bun)  
Jan Raychman Prize (Society for Information displays, US)  
Research Achievement Prize (Japan Applied Physics Society)
- 2012 The Japan Chemical Society Prize  
The Nishina Memorial Prize for Physics (The Nishina Foundation)
- 2013 Mott Lecture Award (International conference on amorphous semiconductors)  
Daiwa-Adrian Prize (UK)  
Thomson Reuter Citation Laureate in Physics
- 2014 Highly Cited Researchers (Thomson Reuter)
- 2015 James McGroddy Prize for New Materials (American Physical Society)  
The Imperial Prize (Japan Emperor, the highest honor in Japan Academia)  
The Japan Academy Prize (Japan Academy)
- 2016 The Japan Prize (The Japan Prize Foundation, highest international prize endorsed by  
the Japanese Government)  
The Ceramics Grand Prize (The Ceramic Society of Japan)

2018 Highly Cited Researchers (Clarivate Analytics)  
Von Hippel Prize (Materials Research Society)

### **Best Paper Award**

J.Ceram.Soc.Jpn (1993, 1997, 2014), Jpn.J.Appl.Phys.(2008,2014)  
J.Phys.Soc.Jpn.(2010), Int.Display WS.(2012,2016), Suf.Soc.Jpn(2013)  
J.Inform.Displays (2007)

”

### **Honorary Member**

Chemical Society of Japan, Materials Research Society

### **Academic Fellow**

American Ceramic Society, Applied Physics Society of Japan,  
World Academy of Ceramics, Society for Information Displays  
Foreign Member of the Royal Society (London)

### **Members, Board of directors**

The member of Science Council of Japan (2006-)  
The Materials Research Society (2015- 2016)  
The Ceramic Society of Japan (2010-2016 )  
The vice president (presient-elect) of MRS-J (2017-2019)

### **Publication Citation Statistics Data**

< from Web of Science >

Sum of the Times Cited ~56,000

h-index 99

< from Google Scholar >

Sum of the Times Cited ~126,000

h-index 127

### **Patents**

Registered (international) 90

Pending (International) 46

Registered (domestic) 90

Patant Citation ~30,000

## The List of the most important 10 papers

By Hideo Hosono

### *High Tc Iron-based superconductors*

- (1) Y. Kamihara, T. Watanabe, M. Hirano, and **H. Hosono**: Iron-Based Layered Superconductor  $\text{La}[\text{O}_{1-x}\text{F}_x]\text{FeAs}$  ( $x = 0.05\text{--}0.12$ ) with  $T_c = 26$  K, *J. Am. Chem. Soc.*, **130**, 3296-3297(2008). The first report of high  $T_c$  Iron-based superconductor  
The most cited paper published in 2008, Total Citation=8,100
- (2) H.Takahashi, K.Igawa, K.Arii, Y.Kamihara, M.Hirano, and **H.Hosono**, Superconductivity at 43 K in an iron-based layered compound  $\text{LaO}_{1-x}\text{F}_x\text{FeAs}$ ; *Nature*, **453**, 376-379 (2008). Paper reporting the highest  $T_c$  except cuprates, Total Citation = 1,328
- (3) S.Imura, S.Matuishi, H. Sato, T.Hanna, Y.Muraba, S-W. Kim, J-E.Kim, M.Takata, and **H.Hosono**, Two-dome structure in electron-doped iron arsenide superconductors, *Nat. Commun.*, **3**, 943-1-6 (2012). Discovery of two  $T_c$  dome structure by heavy e-doping using substitution of  $\text{O}^{2-}$  site by  $\text{H}^-$ , Total Citation= 151
- (4) **Hideo Hosono** and Kazuhiko Kuroki: Iron-based superconductors: Current status of materials and pairing mechanism; *Physica C*, **514**, 399-422 (2015).  
Invited Review, Total Citation= 190

### *Oxide Semiconductors and TFTs*

- (5) H.Kawazoe, M.Yasukawa, Y.Yanagi, **H. Hosono**, P-type electrical conduction in transparent thin films of  $\text{CuAlO}_2$ , *Nature*, **389**, 939~942 (1997).  
The first paper reporting transparent p-type oxides along with the design concept,  
Total Citation = 1,800
- (6) K.Nomura, H.Ohta, K.Ueda, T.Kamiya, M.Hirano, and **H.Hosono**, Thin-film transistor fabricated in single-crystalline transparent oxide semiconductor, *Science* **300**, 1269-1272 (2003). The paper reporting the highest mobility in oxide TFT comparable to poly-Si-TFT. Total Citation=2,447
- (7) K.Nomura, H.Ohta, A.Takagi, T.Kamiya, M.Hirano, and **H.Hosono**, Room-Temperature Fabrication of Transparent Flexible Thin Film Transistors Using Amorphous Oxide Semiconductors,” *Nature* **432**, 488-492 (2004).  
The first paper reporting high mobility TFTs using amorphous oxide semiconductor, IGZO. Total Citation = 6,026

### ***Electrides***

- (8) S.Matsuishi, Y.Toda, M.Miyakawa, K.Hayashi, T.Kamiya, M.Hirano, I.Tanaka, and **H.Hosono**, High-density electron anions in a nano-porous single crystal:  $[\text{Ca}_{24}\text{Al}_{28}\text{O}_{64}]^{4+}(4\text{e}^-)$ , *Science*, 626-6295 (2003).

Paper reporting first RT-stable electride materials, Total Citation= 503

- (9) K.Lee, S-W.Kim, Y.Toda, S.Matsuishi, and **H.Hosono**, Dicalcium nitride as a two-dimensional electride with an anionic electron layer, *Nature*, **494**, 336-340 (2013).

The First paper reporting 2D-electride material, Total Citation= 157

- (10) M. Kitano, Y.Inoue, Y. Yamazaki, F.Hayashi, S.Kanbara, S.Matsuishi, T.Yokoyama, S-W. Kim, M.Hara, and **H.Hosono**, Ammonia synthesis using a stable electride as an electron donor and reversible hydrogen store, *Nat. Chem.*, **4**, 934-940(2012). Paper reporting efficient catalytic activity of electride for catalyst for ammonia synthesis at mild condition, Total Citation= 321

## List of Publication (December, 2018)

**Hideo HOSONO**

### 1. Citation Statistics Data

<from Web of Science>

Sum of the Times Cited ~56,000

h-index 99

<from Google Scholar> (including patents)

Sum of the Times Cited ~126,000

h-index 127

### 2. Journal Statistics

The total number of SCI Journal Papers ~1,000

#### Journal Statistics

|                         |     |
|-------------------------|-----|
| Nature                  | 5   |
| Nature Sister Journals  | 18  |
| Science                 | 3   |
| Proc.Nat.Acad.Sci.USA   | 6   |
| JACS                    | 30  |
| Physical Review Letters | 19  |
| Physical Review B       | 117 |
| Applied Phys.Lett       | 98  |
| J.Appl.Phys.            | 60  |
| Advanced Materials      | 13  |

### 3. Original Papers (Refereed Journal papers)

★ most significant

1978

1. H.Kawazoe, H.Hosono, and T.Kanazawa, Electronic Structure and Properties of Oxide Glasses, (I)  $\Pi^-$  Electron distribution on alkali borate glass networks; *J.Non-Cryst.Sol.*, 29, 159-171(1978).
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## 5. Patents

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