World Journal of Applied Physics
2016; 1(1): 1-15
http://www.sciencepublishinggroup.com/j/wjap
doi: 10.11648/j.wjap.20160101.11

Unrivaled Incandescent Lamp for Green Energy Project

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To cite this article:
Lyuji Ozawa. Unrivaled Incandescent Lamp for Green Energy Project. *World Journal of Applied Physics.* Vol. 1, No. 1, 2016, pp. 1-15. doi: 10.11648/j.wjap.20160101.11

Received: May 2, 2016; **Accepted**: May 13, 2016; **Published**: May 27, 2016

Abstract: After the study on the confines of the commercial incandescent lamps, we have a conclusion that the both of the W-filament lamps and LED lamps already have the optimized as the power hungry incandescent lamps. Only FL lamps have a capability for the significant improvement in the consumed energy and quantum efficiency. We have studied the FL lamps with the different viewpoints from the established technologies in the past for 80 years. The Ar gas space fills up with the negative electric field. The electric insulating vacuum breaks out by the formation of the volumes of the glow lights at the both ends of the Ar gas space, which act as the cathode and anode of the internal DC electric circuit in Ar gas space. The FL lamp provides the superconductive vacuum for the moving electrons, giving rise to the astronomical quantum efficiency. We have developed the coil-EEFL lamps that brilliantly light up under the external DCdriving circuit with $W_{DC} = 0$ with a longer life. The lighting conditions and the W_{DC}= 0 do not changed with the coil-EEFL lamps in air and in the vacuum-sealed container. The coil-EEFL lamps in the parallel connection in the vacuum-sealed container with $W_{DC} = 0$ can be operated with the combination of asolar cell and a battery.

Keywords: Green Energy, FL Tube, Quantum Efficiency, Power Consumption

1. Introduction

In the last 100 years, daily activity of human being drastically extends to nighttime by the illumination of the rooms in housesand offices in large buildings with the incandescent lamps. The incandescent lamps emit much higher illuminance (lm m^{-2}) as compared with the candescent lamps. The word of candescence comes from theancient Greekthatmeans flame of fire by chemical reaction with oxygen in air. The present lamps on the market do not use flame of fire. The commercial lamps use the invisible electrons and atoms. The lights are generated by the moving electrons in either metals or solids and gases, which atoms are arranged with the different conditions. The commercial lamps are the incandescent lamps.

The commercial incandescent lamps light up with the consumption of the electric power that is supplied by the networks of the electric conductive metal wires from the electricpower generators. The electric power generators releasea large amount of the gases to air atmosphere for generation of the electricity. The released gases are mainly carbon oxides (CO and CO_2), oxidized sulfur (SO_3), carbon particles inthe diameter of 2.5 x 10^{-6} m (PM 2.5), methane (NH_4) and others. Recently, the released gases seriouslyworm up the air atmosphere on the Earth. According to the report of the COP-21 (conference of the particleson 2015), the illumination by the incandescent lamps consumes 31% of the generated electric power on the world. The electric networks also consume the electric power by the Joule Heat (e.g., I^2R), where I is the electric current and R is electric resistance per unit length of the electric lead wire. If the power consumption of the electric network considers, total electric power consumption for the illumination by the incandescent lamps will be higher than 31%. The illumination areas on the Earth are gradually extending to the undevelopedlarge areas. Consequently, total amount of the power consumption of the electric power consumption by the illumination by the incandescent lamps is gradually increasing each year. The reduction of the electric power consumption by the incandescent lamps and by the distribution wires of the electric network on the grand is an urgent subject for theprotection of the worming environment on the Earth.

The typical incandescent lamps our life activity are (1) W-filament lamp, (2) light emitting diode (LED) lamp, and (3) fluorescent (FL) lamp. We may scientifically analyze the confines of the developed incandescent lampsfor the selection which one remarkably saves the electric power consumption, as well as the best performance as the lighting source.

2. Confinesas Lighting Source of Commercial Incandescent Lamps

Here exists a basic error for the evaluation of the performance of the incandescent lamps. The performance of the incandescent lamps has been evaluated by the luminous efficiency (lm W^{-1}) by many scientists and engineers of the incandescent lamps. The luminous efficiency (lm W^{-1}) is for the study on the colorimetry. The W in the luminous efficiency (lm W^{-1}) is the energy of the visible photons, $W_{photons}$. The performance of the incandescent lamps never evaluate with the luminous efficiency (lm W^{-1}).

The incandescent lamps should beevaluated by either (a) luminance (cd, m^{-2}), or (b) illuminance (lm, m^{-2}) and (c) energy conversion efficiency $\{W_{phot}$ x $(W_{input})^{-1}\}$, where W_{phot} is the energy of the visible lights from the incandescent lamp. The W_{phots} is determined by the bolometer that has adjusted to the spectral sensibility to the naked eyes. W_{input} is determined by either (a) the active AC power consumption, W_{act} of the AC driving circuit or (b) the power consumption of the DC driving circuit, W_{DC}. However, the commercial LED lamps and FL tubes have erroneously evaluatedby the luminous efficiency (lm, W^{-1}). This is a great mistake in the study on the incandescent lamps. Beside the W in the luminous efficiency (lm, W^{-1}) is take the power consumption of the electric circuits (W_{elect}) for the evaluation of the incandescent lamps. In this report, we will take the illuminance (lm m^{-2}) collectively.

2.1. Metal-Filament Lamps

The incandescent lamps use invisible electrons and atoms by the naked eyes. The recent science clarifies the followings. The metal filament (e.g., W-filament) lamps use the Joule Heat by the invisible electrons thatmove on in the upper bonding shells (s, or p and d shells) of the atoms in the metals. No vacuum space involves in the moving electrons in the metal-filament lamps. The moving electrons in the metals inevitably have the electric resistance (R) that is caused by the thermal perturbation from the thermally vibrating metal atoms at lattice sites [1]. The illuminance (lm m^{-2}) of the metal-filament lamps is proportionate tothe heated temperatures of the metal filament. The heat source of metal-filament lamps is the Joule Heat that is given by I^2R, where I is electric current. The thin filament in the W-filament lamps has the high electric current by the condensed electric current from the supporting bar electrodes. The tungsten filament (W-filament) has been selected with the stability at the high temperatures. There is no room to reduce remarkably the electric power consumption, W_{DC} or W_{act}, of the W-metal filament lamps. The evaporation of the heated metal filament determines the operation life of the metal filament lamps shorter than 500 hours.

2.2. LED Lamps

In the case of theemerging light emitting diodes (LED) lamp uses the solids that theatoms are formed with covalent bondingof the electrons in the orbital shells of the atoms. The electrons never move on in the bonding orbital shells of the atoms at lattice sites of the solids. Pure solids are electrical insulators. If you measure the absorption spectra of the electrically insulating solids, you surely detect the wide bands. The upper band has been assigned as the electric conduction band. However, the wide bands are caused with the overlapped wave function from the neighbor atoms. The electrons do not move in the bounding orbital shell. The determined wide band is not the conduction band for the moving electrons in the solids. We cannot use the band model for the electric conduction in the solids. The electrons in the solids actually move on in the narrow vacuum between atoms at lattice sites. The pure solids are electric insulator. As the solids contain a small amount of the impurities, the solids have the extra electrons (and deficient of electrons, i.e., holes) in the covalent bindings. The extra electrons in the solids move on in the narrow vacuum (~ 10^{-9} m) between atoms at lattice sites.

The LED lamps use the moving electrons and holes in thenarrow vacuum in the impure solids. The moving electrons in the LED lamps inevitably have R. It has assumed in the past that the elastic collisions of the moving electrons with the atoms at the lattice sites may generate the electric resistance, R. This is a wrong assumption. The moving electrons in the solids never have the elastic collision with the atoms at the lattice sites. The electrons of the operation conditions of the LED lamps move on in the narrow vacuum between atoms with scatteringby the Coulomb's repulsion from the orbital electrons in the atoms at the lattice sites.

The scattering of the moving electrons in the narrow vacuum space of the impure solid can be studied with theconcentration dependence curves of the cathodoluminescent phosphor particles that the luminescence centers uniformly distribute in the solid particles [2, 3]. The luminescence centers do not repulse the approaching electrons by the Coulomb's repulsion. The luminescence centers capture the moving electrons in the atoms. The captured electrons in the atoms only recombine with the holes that are attracted by the electric field by the captured electrons in the luminescence centers. The recombination of the electron and hole generates the light (photon). The luminescence centers, which uniformly distribute in the solids, are the detector of the moving electrons in the phosphor crystals. So we can use the CL lights as the monitor of the moving electrons in the impure solids. The study clearly shows that the electronsmove on one direction in the solidsin the very narrow vacuum space $\{(\sim 10^{-8}\ m)^3\}$ between atoms at lattice sites [2, 3]. Before reaching to the luminescence centers, the moving electrons lose the kinetic energy by the thermal perturbation from the neighbor atoms. The loose of the energy is not by the scattering. The scattering of the moving electrons in the narrow vacuum is made by the Coulomb's repulsion from the atoms at the lattice sites. The disturbance by the scattering of the trails of the moving electrons is negligibly small in the solids of the LED lamps. In the practices, we may consider the one-directionof the moving electronsin the solids under the applied field to the LED lamps.

The LED lamps do not use the Joule Heat for the lighting. The Joule Heat has a negative factor for the operation of the LED lamps. The heated temperatures of the LED lamps by the Joule Heat limit the stability of the impurities (i.e., the luminescence centers) in the crystal of the LED lamps. The temperature for the stability of the luminescent centers in the lighting LED lamps can be determined from the temperature dependence curves of the lighted LED lamps. The luminescence centers in the LED lamps diffuse out from the junction layer at above 70°C. The stable LED lamps should be operated with the temperatures below 70°C.

The given LED lamps emit the monochrome light that is the line-like lightin the visible spectral wavelengths. The practical LED lamps are operated under the given voltage; e.g., DC 2.8 V. The light intensities from the LED lamps are solely determined by the numbers of the recombined pairs of the injected electrons and holes from the electrodes on the LED lamps. Therefore we can evaluate the efficiency of the generation light in the LED lamps by the quantum efficiency η_q. The η_q is the ratio of the numbers ofthe emitted visible photons from the LED lamp by one pair of the moving electronand hole that are injected from the electrodes of the LED lamps. The numbers of the injected electrons to the n-type solid are the same numbers of the injected holes to the p-type solid. With this reason, we take the numbers of the injected electrons into the n-type solid in the LED lamps for the calculation of the η_q. The LED solids are not the superconductive solids. The moving electrons in the LED solids inevitable lose some amount of the energy by the Joule Heat. Accordingly, the η_q of the LED lamps is below 1.0; e.g., η_q< 1.0. Thepractical LED lamps is usually around $\eta_q \approx$ 0.5.

The required electric current of the LED lamps for the illumination purpose has ever calculated in the published paper. We may calculate the required electric current as the illumination source of 1 m^2 room. With the ideal conditions, the LED lamp emits one visible photon by one injected electron. The required numbers of the visible photons for the illumination purpose of the given room (e.g., 1 m^2) correspond to the daytime scenery with the slightly overcastting sky. The human eyes have adjusted to the daytime sceneries under the slightly overcastting sky for 5 million years. It is not the direct lights from the sun. The comfortable illumination level of the rooms is given by either the luminance (300 cd m^{-2}) or illuminance (300 lm m^{-2}), corresponding to 10^{25} visible photons per m^2 per second [1]. For the illumination purpose, the LED lamp should emit the 10^{25} photons. The electric current of 1 A is given by 1 Coulomb per second. One electron has 1.6 x 10^{-19} Coulomb. The numbers of 1A electric current are 0.6 x 10^{19} electrons {= (1.6 x 10^{-19} Coulomb)$^{-1}$}.

We may calculate the required electric current of the practical LED lamps (η_q = 0.5) for the illumination of the room in 1m^2. The required electric current in the LED lamps is 2 x 10^6 A (= 2 x 10^{25} electronsx 1.6 x 10^{-19} Coulomb per second), independent on the applied voltage to the LED lamps. The practical size of the dais of eachcommercial LED lamp is around 1 x 10^{-3} m that gives the area of 10^{-6} m^2 (= 1 mm^2). If a practical LED lamp isproducedwith the arrangement of 10^6 LED lamps on a givenboard (e.g., 1 m^2) without the space between LED dais, the LED lampon the 1 m^2 board may comfortably illuminate thefurniture in the 1 m^2 room.

We may calculate the electric power consumption W_{LED} of the 10^6 LED lamps on the given board in 1 m^2, using η_q = 0.5. A typical LED lamps operated by the application of the DC 2.8 V. The W_{LED} corresponds to the W_{DC}. The calculated W_{DC} (= VI) is 6 x 10^6 watt (= 2.8 V x 2 x 10^6 A). Since η_q = 0.5, the practical LED lamps in the 1 m^2 board consume 3 x 10^6 watt of the electric energy by the Joule heat (= I^2R). The LED lamps that are operated with the high numbers of the injected electric current inescapably heat up the LED lamps to the high temperatures by the Joule Heat. As already mentioned, the recombination centers (impurities) in the heated LED lamps have the threshold temperature at 70°C for the stability of the operated LED lamps.

The confines of the LED lamps in the practical use are (a) the low $\eta_q \approx$ 0.5 with the Joule Heat, and (b) threshold operation temperature at 70°C by the diffusing-out of the recombination centers from the junction. We may calculate the required injected electron current in an ideal LED lamp as the practical illumination source. The electrons in the ideal LED lamp move on in the superconducting vacuum with η_q = 1, although it is not real LED lamp. The LED lamps for the illumination of the room may operate with W_{DC} = 3 x 10^6 watt.

Unfortunately, we cannot find the superconductive LED lamp. We also cannot find out the illuminance (lm m^{-2}) orluminance (cd m^{-2}) from the LED lamps. Therefore, we cannot quantitatively evaluate the commercial LED lamps scientifically. The commercial LED lamps have been empirically optimized. Consequently, we cannot find the roomsfor (a) the evaluation of the illuminance or luminance of the LED lamps as the incandescent lamps, and (b) the reduction ofthe large $W_{DC}$of the lighting LED lamps by the handling of the intrinsic properties of the LED lamps.

According to the study on the illuminance (lm m^{-2}) of the lighting screens of the screen of the CRT [4], there is a way for the reduction of the W_{LED} of the lighting LED lamps that use the after image effect of the eyes. One may detect the constant images with the modifiedimages of the lighting cycles. If the total LED lamps on the given dais are operated by the field scanof the pulses that have 2.8 V, your eyes may detect the constant light images. As the LED lamps are operated with the field scan of the pulses at 2.8 V, the LED lamps are operated with AC driving circuit. Accordingly, the power consumption of the LED lamps is given by the active AC power consumption, W_{act}, instead of the W_{LED}. In general, the W_{act} is higher than the W_{LED}; $W_{act} > W_{LED}$. We do not know the W_{act} in the reports on the LED lamps. We take the W_{LED} in the following calculations. As the operation of the LED lamps modifies to the field scanof the pulse at 2.8 V by the AC driving circuit, the LED lamp emits the half cycle. The LED lamps do not emit the lights for the subsequent half cycle of the pulse. Considering the conditions described above, we may determine the operation cycles of the pulses. From the experiments of the projected images on the screen of the CRT, the recommended pulse cycles for the illumination of the room are above 100 Hzfor the LED lamps [4]. The actual lighting cycles are 50 Hz. If we take the 100 Hz, the W_{LED} of the illumination of 1 m^2 room may reduce to the 10^{-4} W_{LED} that is 300 watt (= 3 x 10^6 watt x 10^{-4}), excluding the power consumption of the AC pulse driving circuit. The ordinal room size is not 1 m^2. The ordinal room size in the house is usually 30 m^2. The required W_{LED} for the illumination of the 30 m^2 is 9 x 10^3 watt (= 300 m^{-2} x 30 m^2) = 9 k watt. The images with the pulse of 100 Hz may damage the eyes by the flickering illumination of the room by the naked eyes. The practical pulse frequency will be 200 Hz with 18 k watt.

As the consequence of the calculations based on the material scienceand optical science, onemay allow us to say that the production conditions of the LED lampshavealready optimized scientifically. Thelight output from the LED lamps is determined by the numbers of the injected electrons from the anode of the LED lamps. The numbers of the output of the visible photons are regulated with (a) low $\eta_q \approx 0.5$, (b) threshold operation temperature at 70°C, and (c) no superconductive solids of the LED lamp. The production technologies of the commercial LED lamps have already optimized technically. The operation conditions of the LED lamps by the pulse scan has also optimized. We cannot figure out the claimed advantage of the LED lamps as the energy saving incandescent lamps scientifically. The LED lamps are the incandescent lamps as the limited illuminance (lm m^{-2}) with the power hungry with the Joule Heat. The LED lamps have no room for the contribution to the green energy project (COP) on the world as the science, even though someone claims it. For the claimof the energy saving light source of the LED lamps, the claimers should showthe scientific evidence.

2.3. FL Lamps

Other incandescent lampis the FL lamp. The majority of the FL lamps on the current market are the HCFL lamps that hold many technical restrictions in the usages. We may remove the existing technical restrictions scientifically for the evaluation of the inferable FL tubesas the intrinsic quality. After the clarifications based on the science, we have developed theprototype of the coil-EEFL tubes that the electrons move on in the superconductive vacuum with the astronomically high $\eta_q = 10^{13}$ photons (m^{-3}, s^{-1}) and that the electric power consumption of the external DC driving circuit is zero; $W_{DC} = 0$. The light output from the coil-EEFL tubes linearly increase with the numbers of the parallel connection with the $W_{DC} = 0$. The developed coil-EEFL tubes surely contribution to the green energy project (COP). Before the description of the coil-EEFL lamp, we must scientifically analyze the commercialized HCFL lamps for avoidance of the misevaluation of the inherent advantage of the FL lamps.

The commercial FL lamps are called as the HCFL (hot cathode FL) lamps. Figure 1 shows photograph of the lighted HCFL lamps by the removal of the small area of the phosphor screen at the near electrodes for the observation of the visible lights in the Ar gas space. The visible parts of the lighted HCFL lamps are (a) glass tube, (b) opaque phosphor screen on inside wall of glass tube, (c) heated W-filament coils as the electrodes at the both ends, and (d) lighted Ar and Hg atoms in gases. Those visible parts are the essential necessitiesfor the lighting of the HCFL lamps.

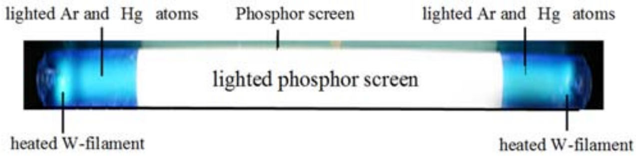

Figure 1. *Photograph of lighted FL tube with visible components by naked eyes.*

At the glance of the uniform lighting of the Ar atoms in the entire area of the lighted FL tubes by the naked eyes, the developers of the HCFL lamps had believed that the moving electrons in the Ar gas space of the lighted HCFL lamps were the similarwith the moving electrons in the solids. However, the individual Ar atoms float in the vacuumwith a wide separation distance (~ 10^{-6} m) in the lighted FL lamp, as compared with the separation distance (~ 10^{-8} m) of the solids. But the separation distance between Ar atoms is beyond the resolution of the naked eyes. The fundamentals of the lighting conditions of the FL tubes should be analyzed from the wide vacuum between Ar atoms. We cannot find a report thatdescribes about the moving electrons in the superconductive vacuum of the Ar gas space of the lighted HCFL lamps. The overlooks of the fundamentals of thevacuum conditions of the gas atoms at the pressures less than700 Pa (≈ 5 Torr) started from the study on the neon sign tubes.

2.3.1. Early Study on FL Lamps

Before the finding of the FL lamp on 1928 [5], there was the lighting glass tube with the Ne gas using the capped electrodes on and in the Ne sign tubes. The Ne gas tube emits the strong monochrome red lightat 633 nm by the electron transition between $^5s_1$ to $^3p_1$ of the Ne*. We hadprivately obtained the following information from the scientistswho had studied the Ne-sign tubes on 1940s. They detected the very weak lines at the sky-blue wavelengths that had assigned as the lights from the excited Hg atoms. In that time, the most advanced vacuum pump was the combination of the Hg diffusion pump and the rotary oil pump. The produced Ne glass tube was contaminated by a small amount of the Hg vapor from the Hg diffusion pump. The contaminated Hg atoms in the Ne glass tube were excited by the moving electrons. But they had neglected the weak sky-blue lights in their study. They were looking for the strong light from the atoms among the gases in the vacuum sealed glass tube.

Someone had added the Hg droplets in the Ne gas lamp, rather than contamination from the diffusion pump. It was not a difficulty to find the strong UV lights at 365 nm (transition from $^6d_3$ to $^6p_2$ levels), and the 254 nm UV lights (transition from $^6p_1$ to $^3s_0$ grand state) by the spectrometer. As the inner wall of the glass tube was covered with the thin phosphor screen, the phosphor screen transduces the 254 nm UV lights to the visible lights. The lighted colors and light intensities werechanged with the different phosphor screens. The light intensity of the phosphor screen from the Ne glass tube increased with the added Hg droplets on the phosphor screen. But the experimentally optimized light intensity was a weak for the acceptanceas the light source. This is because the ionization of the Ne atoms releases the heat that is not enough for the evaporation of the Hg droplets on the phosphor screen. The studies on the Ne glass tubes have the inherent advantage with Xe gas, instead of the Hg vapor, as the FL lamps, which we may describe in section 7.

2.3.2. Development of HCFL Tubes

It has empirically found that the UV intensity at 254 nm significantly enhanced in theAr gas, rather than the Ne gas. The Ar atoms release the large amount of the heat by the ionization. The UV intensity increased with the high Ar gas pressures. They did not find a reasonof the high intensity of the UV lights in the Ar gas. The practical FL lampswere produced with the combinations of the mixture of the Argas, Hg droplets, and the phosphor screen [5]. The usage of the Hg diffusion pumps shifted to the oil diffusion pump for the mass production of the HCFL lamps. Here arose a problem. TheAr gas in the FL lampsproduced by the used diffusion pump for a long timewas heavily contaminated with the decomposed oil vapor. Ithad empirically found thatthe contaminated oil gases eliminated from the FL lamps by the aging process of the produced HCFL lamps before the forwarding. The large variation came from the selection of the phosphor screens. Then, the capped electrodes shifted to the heated tungsten (W) filament coils with the BaO particles. The new electrodes had called as the hot cathode. The FL tubes with the hot cathode were named as the HCFL tubes. Thelighted HCFL lamps have been empirically optimized with the production conditions, rather than the theoretical analyses of the moving electrons in the vacuum between Ar atoms in the Ar gas for last 80 years. The illuminance of the HCFL lamps gradually decreased with the operation time by the adsorption of the residual gases.

The studies for 80 years are summarized with many papers, books and Handbooks. The typical summaries are the references [6, 7, 8]. So far as you study on the HCFL lamps from the established Handbooks and published papers in the past, you may surely reach the conclusion that the commercial HCFL lamps are produced with the mature technologies. The conclusion undoubtedly indicated no room for the remarkable improvement of the commercial HCFL lamps. According to the conclusion, the systematic studies on the HCFL lamps had terminated on early 1970s in USA and Europe. At present, the commercial HCFL lamps are produced by other countries, mainly Asian countries, with the mature technologies of the established Handbooks. Furthermore, the Japanese Government recently prohibits the production of the HCFL lamps as the Hg poison withtheirintensionof thechange of HCFL lamps by the LED lamps. The details of the Hg disease will describe later in this report

2.3.3. Latent-Potential of Coil-EEFL Tubes

As already mentioned, the FL lamps have the latent potentials that have been concealed by the established mature technologies of the HCFL lamps [1]. We have found a way to remove the invalided technologies from the commercial HCFL lamps. The invalided technologies concealed the advanced potentials of the FL lamps. After the removals of the invalided technologies, we have developed the coil-EEFL lamps that have the following advantages:

(a) Superconductive vacuum for moving electrons in the Ar gas space,

(b) Astronomical high η_q (10^{13} photons per m^3 of Ar gas space per second),

(c) Illuminance higher than (10^4 lm m^{-2}) per FL lamp,

(d) Extremely low power consumption (W_{DC}= 0),

(e) Parallel connection of the coil-EEF lamps with W_{DC}= 0,

(f) Coil-EEFL lamps in the vacuum-sealed container as enhancement ofthe lights,

(g) Wide illumination sourcesby the coil-EEFL tubes with W_{DC} = 0,

(h) Operation with the combination of the solar cell and battery, and

(i) Long operation life (> 10^6 hours).

Those features of the coil-EEFL tubes, which have the superiority over other incandescent lamps, certainly contribute to the green energy project of COP of the United Nation.

3. Revised Mechanisms of Lighted FL Lamps

For the study on the advanced coil-EEFL lamps, first we must wash out the established knowledge of the HCFL and CCFL lamps from the brain. For this purpose, we should study the FL lamps from the basics of the Ar gases at the pressures less than 10^4 Pa (75 Torr).

The vacuum of the Ar gas quietly differ from the vacuum of the solids. The Ar atoms do not have bounding electrons like as the solids. Each Ar atom floats in the vacuum with the wide separation distance. In general, the FL lamps do not light up by the application of the voltages to the electrodes of the FL lamp up to the voltages higher than 1 kV. This is because the vacuum between Ar atoms in the Ar gas spacefills up with the negative electric field of the electrons inthe orbital shells of the Ar atoms. We may detect the negative electric field in the vacuum between floating Ar atoms by the measurements of the optical absorption spectrum of the Ar gas.

The detected absorption spectrum consists with the sharp lines, rather than bands; indicating no overlap of the wave function of the neighboring Ar atoms. However, each inherent energy level of the Ar atoms splits to the sublevelscaused by the Stark Effect. The Stark Effect is the direct evidence that the vacuum fills up with the negative electric field from the electrons in the orbital shells of the neighboring Ar atoms in the vacuum. The electrons from the cathode of the driving circuit cannot step in the vacuum that fills up by the negative electric field. The vacuum of the Ar gas in the unlighted FL tubes is the electric insulator.

For lighting of the FL tubes, the negative electric field should be erased from the vacuum. The insulating vacuum in the gas usually breaks out under a very high electric potential between two electrodes. This is the reason that the thunders between the clouds, and cloud to grand are madeby the arc current accompanying thunder lights. The breaking of the insulator by the arc current had called as the discharge. Then, the established study on the FL lamps names "the discharge FL lamps" [6, 7]. This is a wrong naming of the FL tubes. The FL lamps do not use the arc current in the Ar gas space. The FL lamps use the electron flow in a very low electric current (3×10^{-4}A maximum) in the vacuum in the Ar gas space. The lighted FL lamps are not the FL discharge lamp. It is *"the FL lamp*". The lighting mechanisms by the moving electrons in the FL tubes should be analyzed from the neutralization of the electric field of the vacuum between Ar atoms.

Fortunately, they had empirically found the electron sources for the lighting FL lamps without the arc current. As the heated BaO particles on the tungsten (W) filament coils applied to the electrodes of the FL lamps, the FL lampsbrilliantly light up without the arc current. The FL lamps with the heated BaO particles had named as the hot cathode FL (HCFL) lamps. They believed the vacuum in the Ar gas in the HCFL lamp is similar with the narrow vacuum of the solid. Accordingly, they had believed that the heated BaO particles on the W-filament coil in the HCFL lamps directly injected the thermoelectrons into the Ar gas space. They believed that the amount of the injected thermoelectrons into the Ar gas spacecorresponded to the detected AC current at the electrodes of the AC driving circuit. However, the direct injection of the thermoelectrons into the Ar gas space is a hypothesis, without a scientific proof. The hypothesis of the electron sources led them many mistakes in the analyses of the lighting mechanisms of the HCFL lamps. The electron sources are basics of the study on the lighting mechanisms of the FL tubes. Wemust clarify from the electron sources as the cathode and the electron collection source as anode in the lighted FL lamp.

Their mistakesare supported by the detection of the AC induced current at the electrodes of the HCFL lampsby (a) the ordinal AC current meter and (b) the wave form on the screen of the oscilloscope. They had the mistake of the analysis of the waveform on the screen of the oscilloscope. Under the hypothesis, they believedthat the detected AC current at the electrodes corresponds to the numbers of the injected thermoelectrons from the heated BaO particles into the Ar gas space. Their conclusion totally neglects the existence of the capacitor C_{tube} in the lighted FL lamps. First, we will clarify that the heated BaO particles on the W-filament coils never emit the thermoelectrons in the FL lamps.

They had neglected the results of the study on the thermoelectron emission from the heated BaO particles in the other vacuum devices. The drilled study on the thermoelectron emission from the heated BaO layer on the metal cathode had made in the developments of the cathode ray tubes (CRT) and vacuum (radio) tubes. According to the drilled study, only heated Ba atoms on the BaO layers steadily emit the thermoelectrons into the vacuum at the pressures below 10^{-5} Pa (10^{-7} Torr). The heated BaO particles never emit the thermoelectrons into the vacuum. The heated BaO are the electric insulator. In the vacuum pressures above 10^{-2} Pa (10^{-4} Torr), the heated Ba atoms on the BaO layers change to the BaO particles that do not emit the thermoelectrons into the vacuum.

The FL lamps are produced with the pure Ar gas at the pressures above 10^{2} Pa (1 Torr). The Ar gas in the produced FL lamps is not the pure Ar gas. The Ar gas in the commercial HCFL lamps is heavily contaminated with the residual gases (e.g., air, water, CO_2, CH_4, and others) at the total pressures around10 Pa. The contamination come from the improper production process, especially degassingconditions and vacuum sealing process of the FL lamps from the pumping facilities [1]. It is said again that the heated BaO particles on the W-filament coils in the HCFL lamps do not emit the thermoelectrons into the Ar gas space of the FL lamps.

The HCFL tubes utilize the 4G electron source that is the volume of the corona light of the heated Ar atoms at the high temperatures. The heated spot of the small bear metal spot in the W-filament coils heats up the nearby Ar atoms to the high temperatures [9]. The Ar atoms in the heated volume at the high temperatures (at around 60°C) are ionized by the low electric field. The ionized heated volume contains the Ar^{1+}, free electrons, and excited Ar*. Only excited Ar* emits the sky blue lights and others are invisible by the naked eyes. The heated and ionized volume is the 4G electron source of the lighted FL lamps. The 4G electron source works asthe cathode of the internal DC electric power generator that forms in the Ar gas space without the electron flow from the electrodes of the external AC driving circuit [9]. The detected AC current at the electrodes of the lighted FL tubes is not by the electron flow from the electrode into the Ar gas space. In fact, the electrodes pick up the induced AC current from the capacitor, C_{tube}. The induced AC current at the electrodes is not caused by the electron flow.

The lighted HCFL lamps utilize the 4G electron sources that can be operated by the DC riving circuit. The initial

HCFL lamps were indeed operated with the DC electric circuit with W_{DC}= 0. But the operation life was too short, less than 100 hours, due to the cut-off of the W-filament coil by the continuous evaporationof the W-metal from the heated bear metal spot in the W-filament coil. As the HCFL lamps are operated with the AC voltage with 50 Hz, the heated spot of the W-filament coils discontinuously heat up by the electron beam from the 4G electron source for each half cycle, as the W-filament coil has the positive potential. The W-filament coil is not heated with the subsequent half cycle as the W-filament coil has the negative potential. The heated BaO particles at the nearby the heated bear metal spot hold the temperature for the 4G electron source. The heated BaO particles that have the large heat capacitor hold the required temperature during the cooling of the W-filament coil for the subsequent half cycle [9]. Consequently, the operation life of the HCFL lamps extendsto 2000 hours with the periodical heating for each half-cycle ofthe 50 Hz. The recent HCFL lamps are operated with the 30 kHz to 50 kHz for the prolonging of the operation life longer than 10^4 hours.

By the operation of the HCFL lamps with the AC driving circuit, the electrodes of the HCFL lamps certainly detect the AC current. The HCFL lamps brilliantly light up under the low applied voltages, less than 1 kV. Thedetected AC current at the electrodes is 0.3 A to 0.7 A, depending on the Ar gas pressures and volumes of the HCFL lamps. They believe the lights from the HCFL lampsare generated by the moving electrons in 0.3 A to 0.7 A [6, 7]. Their beliefs are the hypothesescaused bythe observed results by the naked eyes. The maximum moving electrons in the vacuum in the Ar gas space is very low at 3 x 10^{-3} A that is the reality [9]. The detected AC current at the electrodes of the HCFL tubes are induced AC current from the capacitor C_{tube}, which is formed in the lighted Ar gas space. The capacitance of the C_{tube} synchronously changes with the AC electric field from the electrodes. It does not correspond to the flowing electrons in the vacuum in the Ar gas space. Here arises a question why the scientists who are studying on the HCFL lamps make the basic mistake. The answer is a very simple that the electrons are invisible by the naked eyes.

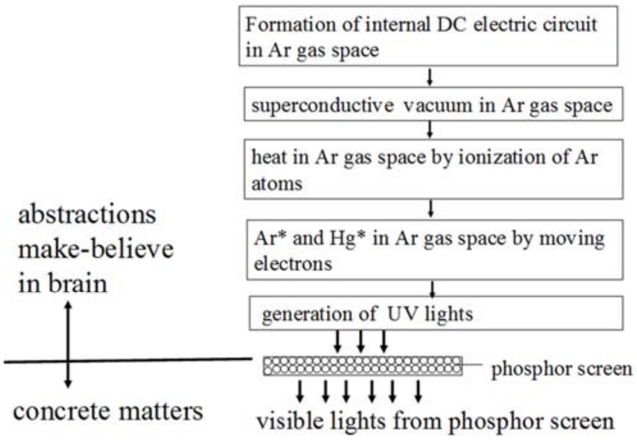

Figure 2. *Schematic explanation of concrete mattersby eye and abstractions that make believe in brain, which involve in generation of lights in Ar gas space in lighted FL lamp.*

Figure 2 illustrates the visible and invisible items involved in the lighting mechanisms of the HCFL lamps. The assemble parts are visibleby the naked eyes so that the assemble parts are the concrete matters. The technologies of the abstraction in Figure 2 are invisible by the naked eyes. Recently, we have studied the abstractions in Figure 2 with the science of the gases [1].

The Ar atoms distribute in vacuum with the Maxwell-Boltzmann distribution. We may calculate the average separation distance between Ar atoms in the FL lamp. The separation distance between Ar atoms is 1 x 10^{-6} m that is the very wide vacuum space as compared with the vacuum space (10^{-8} m) in the LED lamps. Furthermore, the vacuum between Ar atoms fills up with the negative electric field from orbital electrons in the Ar atoms, as already described. The vacuum in the unlighted FL lamp is the electricinsulator. We have found a wonderful phenomenon that happens in the study on the lighting mechanisms of the FL lamps [1].

As the electric voltage above 1 kV to the needle electrode, the Ar atoms in a small volume {(3 x 10^{-3} m)^3}at the nearby the needle electrode are ionized. Theionized small volume contains the positive charges of the Ar^{1+}, free electrons, and excited Ar atoms (Ar*). Only the excited Ar* emit the sky blue lights that are visible by the eyes. The majorities of the Ar^{1+} and free electrons in the ionized small volume are invisible by the eyes. We may use the visible sky blue light as the monitor of the presence of the ionized small volume of the Ar atoms. The ionized volume is called as the volume of the glow light or corona light. The volume of the glow light forms on the polarized phosphor particles in the screen [10]. The volume of the corona light forms by the Ar atoms by the heated W-filament coils with the BaO particles, as the 4G electron source [9].

The presence of the Ar^{1+}in the volume of the glow light electrically neutralizes the negative electric field in the vacuum. We take the glow light in the following description. The weight of the Ar^{1+} is 1.7 x 10^{-24} kg and the weight of the electron is 9.1 x 10^{-28} kg. Under the given electric field, the moving speed of the electrons in the volume of the glow light is 10^3 time faster thanthe movingspeed of the Ar^{1+}. We may consider the dominant moving particles in the volume of the glow light are the free electrons. The Ar^{1+} stay at the floating positions for a half cycle of the 50 Hz.

The volume of the glow lightis formed by the electric field from the sharp points of the polarized phosphor particles under the external electrode [10]. The thickness of the 3G electron source on the phosphor screen is ~ 3 x 10^{-3} m, and the volume of the 4G electron source is larger than (3 x 10^{-2} m)^3 in the commercial HCFL lamps.

The negative electric field of the inside of the volume of the glow light is electrically neutralized by the presence of the Ar^{1+}. The neutralized vacuum in the glow lights changes to the superconductive vacuum for the free electrons. The free electrons in the volume of the glow light are accelerated by the electric field between the cathode and anode, F_{DC}, of the internal DC electric power generator. The accelerated electrons in the volume of the glow light may step out from the volume of the glow light to the Ar gas space at nearby the glow light. The stepped out electrons ionize the Ar atoms in the nearby the volume of the glow light. The neutralization of the negative electric field by the Ar^{1+} extends to the entire Ar gas space of the FL lamp with the moving speed of 10^5 m per second of the electrons in the Ar gas [10]. As the unlighted FL lamp, the Ar^{1+} instantly recombines with the free electrons and return to Ar atoms, resulting in the electric insulator. The formation and disappearance of the glow lightare repeated in the operation of the AC driving circuit of the lighted FL lamps.

Now we will describe the supreme property of the FL lamps over other incandescent lamps. The wide vacuum space (1 x 10^{-6} m) in the lighted FL lamps provide the superconductive vacuum for the moving electrons in the diameter of 5.6 x 10^{-15} m. Naturally, the moving electrons in the lighted FL lamp from the cathode to the anode do not have R caused by the thermal perturbation by the neighboring Ar atoms. The moving electrons from the cathode to the anode never lose the energy by the Joule Heat. The significant advantage over the LED lamps is the generation of the lights. The given electron moves on in the superconductive vacuum with the multiple excitations of the Hg atoms before the collection by the anode. The numbers of the Hg* by one moving electron give the quantum efficiency η_q of the moving electron in the lighted FL lamp.

We may quantitatively calculate the η_q of the lighted FL tube. The numbers of the Hg atoms are 10^{-4} times of the Ar atoms at 40°C. Each moving electron in the superconductive vacuum has the astronomical high $\eta_q = 10^{13}$ photons $(m^3, s)^{-1}$bythe excitation of the Hg atoms. The total numbers of the emitted photons from the FL lamps is given by the multiple of the numbers of the moving electrons in the lighted FL lamp.

The maximum DC electric current in the Ar gas space in the lighted FL lamp is 3 x 10^{-4} A. Above 3 x 10^{-4} A, the moving electrons becomethe arc current via streamer electron beam. The electron currentat 3 x 10^{-4} A contains 2 x10^{15} electronsper second{= 3 x 10^{-4} A x (1.6 x 10^{-19} Coulomb)$^{-1}$}. The phosphor screen transduces the UV lights to the visible lights by the $\eta_q \approx 1.0$. The calculated numbers of the emitted visible photons from the phosphor screen of the lighted FL lamp are 2 x 10^{28} photons $(m^3, s)^{-1}$ {= 10^{13} x 2 x 10^{15} $(m^3, s)^{-1}$}. The inner volume of the commercial 40W-HCFL lamp (T-10) in 1.0 m long is 2 x 10^{-4} m^3. The commercial 40W-HCFLlamp may emit 4 x 10^{24} photons per second (2 x 10^{28}photons x 2 x 10^{-4}). The 1 m^2 room may be comfortably illuminated with the one commercial 40W-HCFL lamp with the daytime scenery under the slightly overcastting sky. The calculation of the illuminance (300 lm m^{-2}) of the commercial HCFL lamps by the η_q accords with the practice.

It should point out the importance of the charges of the phosphor particles in the screen. The localized electric field from the electric charges of the phosphor particles, F_{phos}, determines the diameter of the volume of themoving electrons in the Ar gas space of the lighted FL lamps. The F_{phos} is the vertical electric field against the F_{vect} of the cathode and anode.

Each moving electron has the electric charge of 1.6 x 10^{-19} Coulomb. The moving electrons in the Ar gas space are sensitively influenced by the localized F_{phos} on the phosphor screen. The localized F_{phos} ever discussed in the established technologies of the HCFL lamps. They took the care of the pinholes and clumped particles in the phosphor screen of the HCFL lamps. Their consideration is minor item in the FL lamps. The commercial HCFL lamps are produced with the phosphor powders that have the surface treatments by the electric insulators. Consequently, the phosphor screens have the strong F_{phos} [11]. As the moving electrons approach to the phosphor screen, the approaching electrons push back to the center volume (positive column) of the Ar gas space by the F_{phos} [3, 4]. Naturally, the lighted commercial HCFL lamps inevitably have the deep gap between positive column and phosphor screen. The moving electrons never step in the gap and never get in the phosphor particles in the screen. The depth of the gap of the commercial HCFL lamps is deeper than 4 x 10^{-3} m. The deep gaps of the commercial FL lamps ever discussed in the past because one cannot observe the depth of the gap by the naked eyes. The gap belongs to the abstraction in Figure 2. The Ar gases in the gap have two negative roles in the lighted FL tubes. One is the thermal insulation between the positive column and phosphor screen, and other is the absorption of the UV lights from the positive column.

We take first the thermal insulation between the positive column and phosphor screen. The Hg droplets in the unlighted FL tubes are on the surface of the phosphor screen. The Hg droplets should heat up for the evaporation of the Hg atoms into the Ar gas space. The ionization of the Ar atoms in the positive column is only heat source in the lighted FL tubes by the change in the entropy. The vacuum in the gap works as the good thermal insulatorfor the positive column. There is no thermal convection in the gap. The Hg droplets on the phosphor screen should be heated by the thermal radiation from the positive column. Consequently, the lighting FL lamps always have the slow build up curve of the illuminance (lm m^{-2}), corresponding to the heating speed of the Hg droplets on the phosphor screen. The building up of the light intensity is slow with the deep gap. Furthermore, there is always the temperature difference between positive column and phosphor screen in the lighted FL lamps in the room. The outer glass tube is cooled by the air convection in the room. If there is no temperature difference between the positive column and the phosphor screen, the Hg vapor in the positive column will increase to more than 20%. The elimination of the temperature difference between positive column and phosphor screen will describe with the development of the coil-EEFL lamps in late.

Other negative actionof the gap is the optical absorption of the UV light from the positive column. The gap contains many unexcited Hg atoms that efficiently absorb the 254 nm UV lights before reaching to the phosphor screen. The deep gap of 4 x 10^{-3} m determines the compromised outer diameter of the commercial HCFL lampsas 3.2 x 10^{-2} m (T-10) with the ratio of the volume of the positive column and volume of the gap. The developed coil-EEFL lamps should have the shallow depth of the gap; hopefully shallower than 3 x 10^{-4} m [11]. The shallow depth of the gap is made by the arrangement of the low voltage CL phosphor particles and the PL phosphor particles side by side on the top layer of the phosphor screen [11]. The phosphor screens of the commercial HCFL lampsdo not arrange the low voltage CL phosphor particles on the top layer. As the consequence, the commercial HCFL lamp has the deep gap, 4 x 10^{-3} m.

The next important item of the lighted FL lamps is the electric power consumption of the lighted FL lamps. We have found that the electric AC power consumption, W_{act}, of the commercial 40W-HCFL lamps has deliberately and incorrectly determined by the W_{tube}. The real W_{act} is 88 watt that is more than double of the 40 watt. The 40W of the 40W-HCFL lamps are the nominal power consumption. This is a kind of the social fraud by the producers of the HCFL lamps.

Then we have carefully studied the power consumption of the lighted FL lamps. It has found that the lighted FL lamps are operated with the coexistence of the disparity of the electric circuits: (a) external AC electric circuit and (b) internal DC electric circuit. There is no electron flow between disparate circuits. The AC driving circuit is active with only induced AC current from the capacitor C_{tube} that is only formed in the lighted FL lamps. The internal DC electric circuit forms between the cathode and anode of the internal DC power generator in the Ar gas space. Figure 3 illustrates the disparity of the external AC driving circuit (A) and the internal DC electric circuit (B). It is clear from Figure 3 that the active power consumption W_{act} of the external AC driving circuit does not involve in the generation of the lights in the FL lamps. The traditionally determined electric power consumption, like as 40W, is not related with the generation energy of the lights from the HCFL lamps.

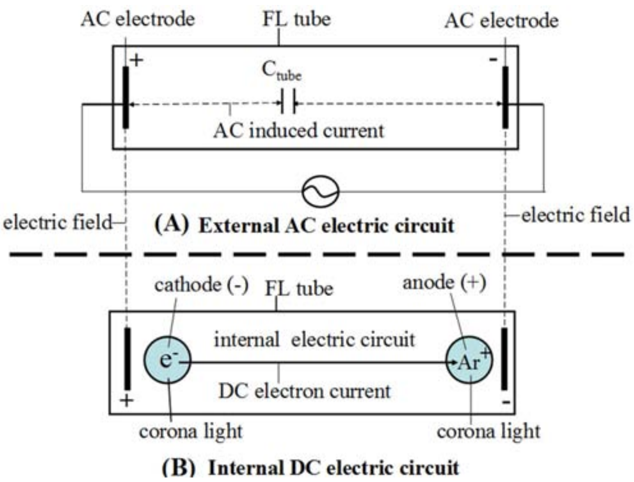

Figure 3. *Schematic explanation of coexistence of disparities of (A) external AC electric circuit and (B) internal DC electric circuit by volume of corona lights at both ends of HCFL lamp.*

You may experimentally confirm the above statement by use the commercial capped CCFL lamp with the Ar gas pressure at 7 x10^3 Pa (50 Torr). We obtained the capped CCFL lamps from a commercial store. We have determined the depth of the gap as 3 x 10^{-4} m of the capped CCFL lamp from the build-up curves of the illuminance. Figure 4 illustrates capped CCFL lamp (above) and cylinder EEFL lamp (below). The cylinder EEFL lamp was made with the cut-off of the bottom of the capped electrode. The CCFL lamps are the outer diameter 1 x 10^{-2} m (T-3) with 0.4 m long. The both capped CCFL and cylinder EEFL lamps are operated with the same AC driving circuit at above 3 kV with 50 kHz. The both FL lamps have the same illuminance (~10^3 lm m^{-2}), indicating that the same electron sources involved in the both FL lamps. The difference is the AC active power consumption. The W_{act} of the capped CCFL lamp is 18 watt. The W_{act} of the cylinder FL lamp is only 5 watt that is 0.3 W_{act} of the 18 watt. The difference comes from the picking up of the induced AC electric current from the capacitor C_{tube} and C_{phos}. The bottom of the capped electrodes picks up the AC induced current from the C_{tube}, so that the W_{act} is linearly increased with the Ar gas pressures. On the other hand, the electrodes of the cylinder FL lamp only pick up the C_{phos} caused by the periodical polarization of the phosphor particles under the AC voltage at the cylinder electrodes. The electrodes of the cylinder FL lamp never pick up the AC current from the C_{tube}. Therefore, the W_{act} of the cylinder FL lamps do not change with the Ar gas pressures. The internal DC electric power source of the both FL lamps is formed with the same volume of the glow lights on the polarized phosphor screen under the cylinder electrodes, resulting in the same illuminance (~10^3lm m^{-2}).

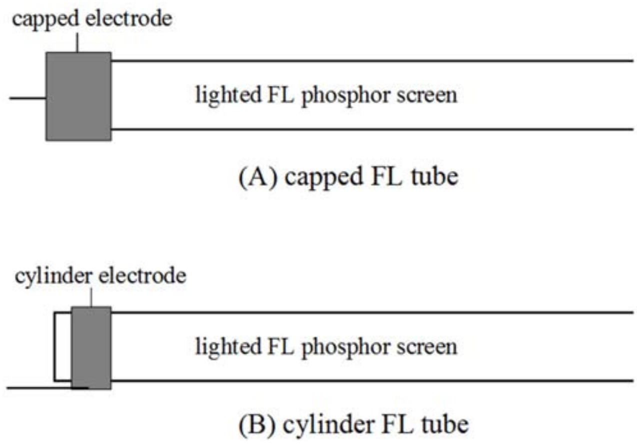

Figure 4. *Schematic explanation of (A) capped electrode and (B) cylinder electrode on FL tube.*

Then, we have changed the external AC driving circuit to the external DC driving circuit of 4 kV output. The electrodes of the both FL lamps never pick up the induced current under the DC voltage at the electrodes. The power consumption of the DC driving circuit, W_{DC}, is zero without sacrifice of the illuminance (10^3 lm m^{-2}). This is a moment that we havefoundthe FL lamps as anultimate incandescent lamp. The cylinder-EEFL lamps light up with the high illuminance (> 10^3 lm m^{-2}) with the W_{DC} = 0 of the external DC driving circuit. The internal DC electric power generator is formed in the Ar gas space in lighted FL lamp under the assistance of the electric field from the electrodes of the external DC circuit. There is no electron flow from the external DC driving circuit to the internal DC electric power generator. The light of the cylinder-EEFL lamps are generated by the moving electrons from the cathode to the anode of the internal DC electric power generator. The cylinder-EEFL lamps are lighted with no power consumption of the external DC driving circuit. The electrodes just help the formation of the internal DC electric power generator in the Ar gas space with the electric field. This is the ultimate incandescent lamps for the illumination of (a) the rooms of the house, (b) offices in the large buildings, and (c) outside active grand areas. The weak point of the cylinder electrodes is the vacuum breakduring the operation by the tiny through hole under the electrodes on the FL glass tube. The cylinder electrode has a tiny air gap less than 10^{-3} m between glass tube and cylinder electrode, the air in the tiny gap may have the arc current in the operation. The arc current heats up thetiny spot of the glass tube to the softening temperature. The softened spot of the glass tube pushes down under the air pressure at one atmosphere, resulting in the tiny through hole in the glass tube. The vacuum of the lighted FL tube breaks down by the air.

4. Development Coil-EEFL Lamps in Parallel Connection with $W_{DC} = 0$

Then, we have developed the coil-EEFL lamp for the protection of the vacuum-break in the operation. The coil-EEFL lamps have made with the winding of the electric lead wire in the diameter of 1 x 10^{-3} m. The lead wire is covered with the plastic layer in the thickness of 1 x 10^{-3} m. The winded lead wire on the coil-EEFL lamp tightly pushes down to the surface of the glass tube by the application of the thermally shrinking plastic tube. The lighting conditions of the coil-EEFL lamps are the same with the cylinder CCFL lamp, except for the operation life. No consumed element involves in the operation of the coil-EEFL lamps. Consequently, the coil-EEFL lamps will have the prolonged operation life longer than 10^6 hours under the DC driving device with voltages higher than 2 kV. If the coil-EEFL tubes lights up for 24 hours per day, the life of 10^6 hours corresponds to the light up for more than 100 year. Here is a condition that the coil-EEFL lamps should contain the residual gases less than 10^{-3} Pa (10^{-5}Torr).

It should be note that if the coil-EEFL lamps are produced with the established production facilities and technologies, the vacuum sealed FL lamps severely contaminated with the residual gases. In the operation of the coil-EEFL lamps, the residual gases form the CH_4 and then polymerize it to the high number of n of CH_n. The surface of the phosphor particles in the screen adsorbs the polymerized CH_n. The adsorbed CH_n layer on the phosphor particles absorbs the UV lights from the positive column. The coil-EEFL tubes should be produced with the advanced vacuum facilities and vacuum sealing technologies [1].

The coil-EEFL lamps light up with the high illuminance (lm m^{-2}) with the external DC driving circuit, even though the coil electrodes do not inject the electrons into the Ar gas space and do not collect the electrons from the Ar gas space. This is a kind of the mystery to the persons who have the knowledge of the electric circuits. We must solve the mysterious phenomena in the coil-EEFL lamps. Figure 5 show photograph of the lighted coil-EEFL lamp (above), showing thatthe coil-EEFL lamp surely light up with the external DC driving circuit. The electrodes are on the outer glass tube that is the electric insulator. The electrode and Ar gas space is electrically insulated by the glass tube. However, the coil-EEFL lamp lights up as the DC driving circuit supply the DC voltage to the coil electrodes at above 2 k V. The mystery of the lighting mechanisms of the coil-EEFL lamp, that is the abstraction, is below.

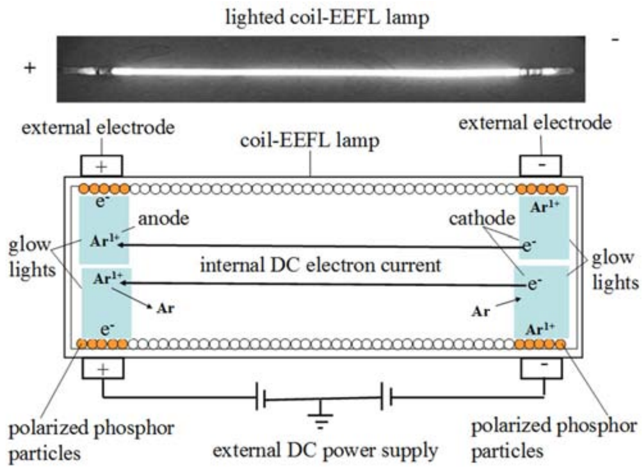

Figure 5. *Schematic explanation of internal DC electron current from cathode to anode of internal DC electric power generator in Ar gas space. Cathode and anode are formed on polarized phosphor particles under external electrodes.*

The mystery is solved by the formation of the volume of the glow light on the polarized phosphor particles in the screen. As the coil electrode, hear after EE, has the DC potential, the electric field from the EE penetrates through the glass tube. Only phosphor particles in a few layers, the orange color in Figure 5, on the inner glass wall under the EE are polarized by the electric field that has penetrated through the glass wall from the EE. The phosphor particles are the polycrystals that contain many growing axes that generate the sharp edges and sharp pints in the particles with the growing conditions [4]. The sharp edges and sharp pints in the polarized particles generate the high electric field to the Ar atoms at the nearby of the polarized phosphor particles. It should note that the particles of the commercial phosphor powders do not have the sharp points and sharp edges. The high electric field from the many sharp edges and points of the polarized phosphor particles ionizes and excites the Ar atoms at nearby on the polarized phosphor particles. The extension range of the electric field from the polarized phosphor particles is changed with the applied voltages to the EEs.

The generated Ar^{1+} and free electrons (e^-) respectively have the positive electric charges and negative charges. The distribution of the electric charges in the volumes of the glow lights differs by the polarity of the EEs on the glass wall. The electric field of the polarized phosphor particles (orange color in Figure 5) under the positive EE (+) attracts the free electrons on the surface on the polarized phosphor particles and repulse the Ar^{1+} to the other side of the volume of the glow light. The accumulated Ar^{1+} in the volume of the glow light (Σ Ar^{1+}) acts as the anode of the internal DC electric power generator. The electric field of the polarized phosphor particlesunder the negative EE (-) attract the Ar^{1+} on the surface of the polarized phosphor particles and repulse the free electrons. The accumulated electrons (Σ e^-) in the volume of the glow light acts as the cathode of the internal DC electric power generator. Consequently, the internal DC electric circuit is formed by the Σe^- (cathode) and ΣAr^{1+} (anode) in the Ar gas space. Theelectrons move from the cathode to the anode of the internal DC electric circuit in the Ar gas space. The moving electrons generate the light from the coil-EEFL lamps without the electron flow from the EEs on the outer glass wall. This is the reason that the coil-EEFL lamps are independently operated with the W_{DC}= 0 of the external driving circuit. The DC power consumption of the internal DC circuit is 1.2 watt (3 x 10^{-4} A x 4 x 10^3 V). However, we cannot detect the 1.2 watt from the outside of the FL lamp.

Figure 6. *Two lighted coil-EEFL lamps in parallel connection under DC voltage at 4 kV.*

The coil-EEFL lamps have another advantage to increase luminance (lm m^{-2}) of the coil-EEFL lamps with the operation of the parallel connection of the coil-EEFL lamps, with no change in the W_{DC} = 0 of the external DC electric circuit. The illuminance (lm m^{-2}) of the coil-EEFL lamps is linearly increased with the numbers of the parallel connection of the coil-EEFL lamps, without the change in the W_{DC} of the external DC driving circuit. Figure 6 shows, as an example, photograph of the experimental 2 coil-EEFL lamps in the diameter in 1x 10^{-2} (T-3) with 0.4 m length. The coil-EEFL lamps in Figure 6 are operated with the DC voltage at 4 kV. The W_{DC} of two coil-EEFL lamps is zero. By the consideration of the polarities of the volume of the glow lights on the polarized phosphor particles under the EEs at both ends, the preferable DC driving circuit is composed with the series connection of two (2) external DC driving circuits with the grand at the center of the series connection, as illustrated in Figure 5.

The single coil-EEFL lamp has the intrinsic advantage. The advantage is the increase in the illuminance (lm m^{-2}) of the coil-EEFL lamp by the high Ar gas pressures. The η_q increases with the amount of the evaporated Hg atoms from the droplets on the phosphor screen. As already mentioned, the heat source in the FL tubes is only ionization of the Ar atoms by the change of the entropy. The temperatures of the positive column linearly increase with the Ar gas pressures. However, the outer glass wall of the coil-EEFL lamp is always cooled by the air convection of the room temperature. The evaporation of the Hg droplets on the phosphor screen is determined by the temperatures of the glass tube of the FL lamps, which are lower than the temperature of the positive column. The temperature difference between positive column and phosphor screen is enhanced by the high Ar gas pressures.

Consequently, there is the large temperature gradient between positive column and phosphor screen of the coil-EEFL lamps that have the Ar gas pressures higher than 4 x 10^3 Pa (30 Torr). The temperature gradient in the gap can be minimized if the lighted coil-EEFL lamps in the parallel connection set in a vacuum-sealed glass tube or in the vacuum-sealed flat container. The vacuum in 10^2 Pa is the good thermal insulator. As the lighted coil-EEFL lamps in the parallel connection set in a vacuum-sealed glass tube or in the wide flat container, the cooling of the phosphor screen by the air convection is perfectly prevented, resulting in the equivalent temperature of the heated Hg droplets with the temperature of the positive column. The rapid heating of the Hg droplets on the phosphor screen give rise to (a) the rapid build-up curve of the illuminance and (b) a high saturation level of the illuminance (lm m^{-2}) from the given coil-EEFL lamps.

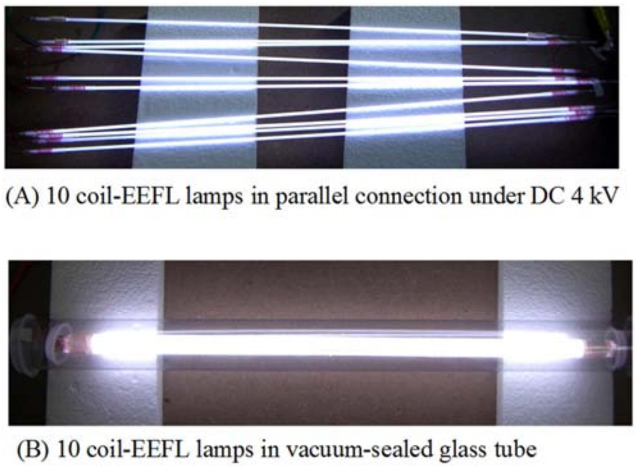

Figure 7. *Individuals of lighted 10 coil-EEFL lamps in parallel connection under DC voltage at 4 kV (A) and lighted 10 coil-EEFL lamps set in vacuum-sealed glass tube.*

We have preliminarily studied the prevention of the cooling of the phosphor screen of the lighted coil-EEFL lamps by the convection of the room air. We take the 10 coil-

EEFL lamps in the diameter of 3 x 10^{-3} m (T-1) with 0.4 m long, which are modified from the commercial CCFL lamps. The determined depth of the gap is 3 x 10^{-4} m. Figure 7 shows photograph of the lighted 10 coil-EEFL lamps in parallel connection under the DC 4 kV voltage in air (above). Figure 7 (below) shows photograph of the 10 coil-EEFL lamps in the vacuum sealed glass tube in the diameter 2 x 10^{-2} m. Figure 8 shows the illuminance (lm m^{-2}) of (a) the individual lamps, (b) the 10 coil-EEFL lamps in the parallel connection in air, and (c) the 10 coil-EEFL lamps in the vacuum-sealed glass tube. By a glanceof the results in Figure 8, only coil-EEFL lamps in the vacuum-sealed glass tube linearly increase the illuminance (lm m^{-2}) with the numbers of the coil-EEFL lamps in parallel connection with the W_{DC} = 0. The results indicate the temperatures of the phosphor screen in the coil-EEFL tubes are the equaltemperatures with the temperature of the positive column. The illuminance (lm m^{-2}) of the coil-EEFL lamps linearly increase with the numbers of the parallel connection. Although the lighted coil-EEFL lamps have the temperatures higher than 70°C, the temperature of the outer wall of the vacuum-sealed glass tube has the near temperature of the room. This is a great advantage of the application of the coil-EEFL lamps as the illumination source in the room in houses and offices in the buildings as the safety incandescent lamp. Recently, we have experience of the fire of the next neighbor with the LED lampsat the midnight.

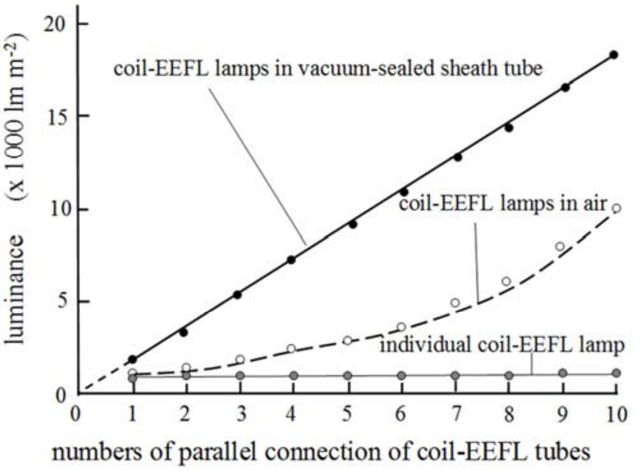

Figure 8. *Illuminance (lm m^{-2}) curves of individual coil-EEFL lamps, coil-EEFL lamps with parallel connection in air, and coil-EEFL tubes setting in vacuum-sealed glass tube.*

The results in Figure 8 suggest us the followings. As the coil-EEFL lamps contain the Ar gas pressures higher than 10^4 Pa (80 Torr), the coil-EEFL lamps may have a high illuminance (lm m^{-2}), but the coil-EEFL tubes have the large temperature gradient between positive column and glass wall. If the plural coil-EEFL lamps in the outer diameters of 1 x 10^{-2} m with any lengths set in the vacuum-sealed glass tube, the vacuum-sealed glass tubes may emit the high illuminance higher than 10^6 lm per m^2 with the W_{DC} = 0. The temperature of the outside of the vacuum-sealed tube is the room temperature. The vacuum-sealed coil-EEFL lamps are safety lighting source. The coil-EEFL lamps in the vacuum-sealed glass lamp area suitable light sourcefor the outdoor illumination lamps; and the illumination sources along the roads, without the distribution wire from the electric power generators. The coil-EEFL lamps in the vacuum-sealed glass tube lights up with own power supply from the combination of a solar cell and a battery.

Furthermore, the illuminance (higher than 10^4 lm m^{-2}) of the vacuum-sealed flat panel with the W_{DC} = 0 also uses for the light source of the LCD TV panels. For the applications of the coil-EEFL lamps in the vacuum-sealed container, we must know more about the characteristic properties of the coil-EEFL lamps for the optimization as the illumination sources.

5. Flat Lighting Panel by Coil-EEFL Lamps in Parallel Connection

The human eyes adjusted the daytime scenery under the slightly overcastting sky for more than 5 millions. The comfortable daytime scenery is made with the scattered lights from the thin white clouds that give the scenery with the less shadow. Therefore, the ideal light source for the rooms of house and working offices in the buildings should beilluminated with the lights from the wide lighting sources as possible. Furthermore, the ideal lamps should be operated with the DC operation, rather than the AC operation or pulse operation, for the felling tire of the brains. The eyes may not detect the flicker of the lights higher than 70 Hz. But the brain continuously detects the flickering lights. The steady flat lighting sources that aremade by the DC operation have the advantage as the illumination source of the room in the houses and offices in the large building over the LED lamps. The results in Figure 7 (B) and Figure 8 inform us that the coil-EEFL lamps in the vacuum-sealed panels providethe great advantage as the ideal illumination source over other incandescent lamps.

generation	electron source	volume of electron source	images
1 G	heated metal filament	line	—
2 G	sharp point	point in μm	↑
3 G	glow lights on polarized phosphor particles	thin volume in front of phosphor screen on inner glass tube	3G
4G	high temperature Ar corona space (HTACS)	whole diameter to inner glass wall	4G

Figure 9. *Schematic illustration of electron source of incandescent lamps.*

Figure 9 illustrates the sizes of the electron source of the incandescent lamps. The coil-EEFL lamps use the 3G electron source with the volume of the glow light in the thickness of 3 x 10^{-3} m on the polarized phosphor particles in the screen. Therefore, the optimal inner diameter of the coil-EEFL lamps are the around 6 x 10^{-3} m. We take the coil-EEFLlampsthat are converted from the commercial CCFL lamps in the outer diameter of 9.5 x 10^{-3} m (T-3) with 0.4 m long for the preliminary experiments of the flat lighting source. The phosphor screen of the coil-EEFL lamps should be made with the arrangement of the low voltage cathodoluminescence phosphor particles with the threshold at 110 V and the PL phosphor particles. The both phosphor particles are arranged with the side by side at top layer [12]. There is no limitation of thenumbers of the parallel connection and the lengths of the coil-EEFL lamps. You can take any sizes of the coil-EEFL lamps and any numbers of the coil-EEFL tubes. We take the 4 coil-EEFL lamps in the parallel connection as the example. The 4 coil-EEFL tubes set in the opaque glass panel container that has vacuum pressure at 133 Pa (1 Torr). The size of the container is 0.6 x 0.8 m^2 = 0.5 m^2. The inner glass walls of the glass panel in the container are coated with the thin layer (3 layers) of the $CaSO_4$ particles as the light scatter. The coil-EEFL lamps are operated with the DC voltage at 4 kV. The panel emits the uniform light intensity. Figure 10 shows photograph of the prototype of the flat lighting source by 4 coil-EEFL tubes. The determined illuminance of the panelwas 10^4 lm per m^2 with the W_{DC} = 0. The examined panel by the coil-EEFL tubes can illuminate the room of 30 m^2 with the illuminance (330 lm m^{-2}) with W_{DC} = 0. The optimization of the lighting panel by the coil-EEFL lamps remains for a future study.

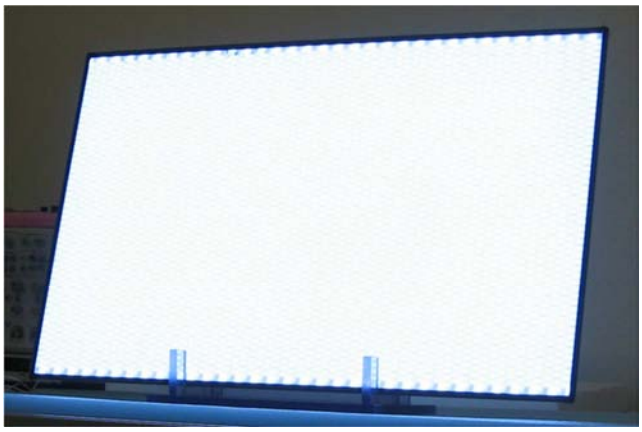

Figure 10. *Lighted flat panel that contains 4 coil-EEFL lamps in the vacuum-sealed panel container.*

Since the coil-EEFL lamps in the parallel connection are operated with the W_{DC} = 0, the coil-EEFL lamps in the parallel connection in the light panel may light up with the DC power supply from a pair of the solar panel and electric battery. We have a conclusion thatthe developed coil-EEFL lamps surely contributes to the anti-pollution of the air and grand by the electric power generators by burning of the coals, and fuel gases, and atomic power generators. It should note that this report is aiming to the fundamental mechanisms of the coil-EEFL lamps. The studies on the advanced research and the engineering works at the production remain for a future study.

As the conclusion of the study on the FL lamps, we have developed the prototype ofthe most promising incandescent light source with the coil-EEFL lamps to the green energy project. That is the coil-EEFL lamps in the parallel connection in the vacuum-sealed flat and optically opaque container.

6. Safety of Hg Atoms with FL Lamps

Here is an action against the production of the FL tubes on the world with the use of the Minamata disease. The Japanese Government had ordered the termination of the production of the FL lamps in Japan on 2014 with the antipollution of the Hg by using the Minamata disease. Their action lacks the basics of the biological science. The living matters on the Earthdo not directly take the metallic atom (e.g. Hg droplets) in the body. The necessary metallic atoms for the disease should be in the organic compounds. The Minamata disease is caused by the uncontrolled drain of the organic compound of the methane mercury (CH_4Hg) solution from the chemical factory to the sea water in Minamata Bay. If the Japanese Government hadcontrolled the drain of the organic CH_4Hg solutionto the sea water from the starting of the chemical factory, the Minamata disease never happened in the fishing villages at Minamata. But the Japanese Government did not it. There is no report from the industrialized countries in USA and Europe about the disease of the organic CH_4Hg solution from the similar and more largerchemical factories that use the CH_4Hg catalysis. This is because the Governments in the USA and Europe well control the drain of the organic CH_4Hg solution to the rivers. Only Japanese Government has the responsibility on the Minamata disease with the no control of the drain of the organic CH_4Hg solution to the Minamata Bay. It is clear that the Minamata disease responded on the Japanese Government by the out control of the drain of the organic CH_4Hg solution from the factory.

The Hg metal has the melting temperature at -39°C. The surface tension of melted Hg atoms at room temperature is 4.6 x 10^6 dyne per m that is very high surface tension. The small amount of the Hg metal at the room temper forms the droplet. The evaporation of the Hg droplets at the room temperature is 0.1 Pa (10^{-3}Torr). The Hg droplets has the density of 1.3 kg per m^3 (= 13g per cm^3). The human society has used the Hg droplets as the useful material for more than 2000 years. But there was no report of the Hg disease like as the Minesota disease.

We have found the followings. The Minamata disease was limited in the fishing villages, and was not the residents in the Minamata City. Why the Minamata disease was limited in the fishing villages? The disease by the catalytic CH_4Hg solution in the fishing village occurs with the organic cycles in the living body on the Earth. As a large amount of the organic CH_4Hg solution dischargesto the seawater in the Bay, the organic CH_4Hg float in the sea water. The bacteria in the sea water first takes the floating organic CH_4Hg compounds in to the cell of the bacteria. The bacterianever directly take the Hg atoms from the sea water. As the small fishes in the sea eat the contaminated bacteria, the organic Hg selectively concentrates in the brain and innards of the small fish. The meats of the small fish are not contaminated with the organic Hg. When the mother in the fishing villages eats the small fishes without removal of the head and innards of the fishes, her body is contaminated, but the mother does not have the serious trouble in the daily activity. When the mother is pregnant, thefetus in early stage selectively receives the contaminated organic Hg from the mother. The brain of the fetus is seriously damaged by the received organic Hg, like as case of Ziga Virus. The Minamata disease is limited as the new born babies. The residents in Minamata city, who eat the meets of the large fishes with the removal of the head and innards, never have the Minamata disease. If the Japanese Government controls the drain of the organic CH_4Hg solution from the factory at early stage, the Minamata disease never happened in the fishing villages.

The FL lamps had invented more than 80 years ago. Each FL tubes use the small amount of inorganic Hg droplets (mg order) inthemass production of the FL lamps. The FL tubes never use the organic Hg compounds. Since then, the annual production volume wasmore than multimillions each year. There is no report of the disease by the Hg droplets on the world, because the FL lamps use the melted Hg metal droplets in mg each. The melted Hg metal and Hg ingots (amalgam) had used in the human society for more than thousand years. There is no report like as the Minamata disease.

Now it is clear that the Japanese Government has the responsibility to the Minamata disease. According to the biological science, the Japanese Government cannot claim the unsafe of the Hg droplets in the FL tubes as the poison of the human body, using the Minamata disease. The organic bacteria are not involved in the production of the FL lamps. The Hg droplets in the FL lamps quite differ from the catalytic CH_4Hg solution. The regulation of the FL lamps by the Japanese Government using the Minamata disease is unacceptable as the biological science. The coil-EEFL lamps are the necessary illumination source for the green energy project of COP with the electric power consumption $W_{DC} = 0$.

7. Coil-EEFL Lamps with Combination of Ne and Xe Gases

In early study on the FL lamps, the neon tubes had studied as the lighting lamp. Because the Ne atoms release a small amount of the heat bythe ionization energy, the FL tube with Ne gas did not absorb the attention as the lamp. We have found that the small volume of the Ne atoms on the polarized phosphor particles also ionized with the electric field from the EEs on the outer glass tube. We may have the cathode and anode of the internal DC electric power generator in the Ne gas space without the heat of the Ne atoms. We also know the Xe atoms in gas phase also emit the UV light at 172 nm and 142 nm. The phosphor screen may convert the UV lights from the Xe* to the visible lights. With this reason, the coil-EEFL lamps can be produced with the combination of Ne gas and Xe gas, instead of the combination of the Ar and vaporized Hg atoms. In this case, the origin of the lights is the UV lights from the excited Xe atoms (Xe*) without the heated FL glass tube. The concentrations of the Xe atoms in the Ne gas can be simply controlled by the pressures of the Xe gas.

The melting temperature of Xe is -112°C, and boiling temperature is -107°C. Xe at room temperature is always gas phase. In this case, the lighted FL lamps are unnecessary heat up for the Xe atoms. The FL lamps can be produced with the mixture of the gases of the Ne and Xe. The emitted UV lights from the excited Xe* by the moving electrons is the wavelength at 173 nm in the vacuum UV range. The preferable phosphor screens for the FL lamps by the mixture of Ne and Xe gases are produced with (a) $BaMgAl_{10}O_{17}$: Euas the blue light, (b) Zn_2SiO_4: Mn as the green light, and Y_2O_2S: Eu as the red light. The plasma display panel (PDP) uses (Y, Ga)BO_3: Eu phosphor as the red lights. However, the control of the sizes and surface conditions is a very hard with the (Y, Ga)BO_3: Eu phosphor particles. We recommend the use of the Y_2O_2S: Eu red phosphor powder that each phosphor particles have the sharp points and sharp edges. The study of the coil-EEFL lamps by the combination of Ne and Xe gases is underway.

8. Conclusion

Our life activity is supported by the illumination of the incandescent lamps that use the lights generated by the electrons and atoms in the vacuum and solids. However, we encounter a great difficulty which incandescent lamp may hold a high potential as the illumination source. No one shows it. With this reason, wehave analyzed the confines of the developed incandescent lamps. We have found the W-filament lamps, LED lamps and commercial HCFL lamps have already optimized technically with the mature technologies, and there is no room for the improvement of the properties.

The W-filament lamps use the Joule Heat that is given by I^2R where I is electric current and R is the electric resistance. The confines of the W-filament lamp are the evaporation of the W-metal that determines the operation life less than 500 hours.

The lights (photons) from the LED lamps are generated by the recombinations of the pairs of the electrons and holes at the luminescence centers in the solids. The electrons and holes must move on in the narrow vacuum between atoms at the lattice cites toward to the luminescence centers in the solid LED lamps. The vacuum space between atoms of the LED lamps is not the superconductive vacuum. Naturally the moving electrons and holes have R caused by the thermal perturbation from the thermally vibrating atoms at lattice sites. Injected electrons and holes from the electrodes lose the kinetic energy by the Joule Heat before reaching to the luminescent centers. Therefore, the quantum efficiency η_q per single moving electron in the LED lamps is less than 1.0. The stability of the luminescence centers in the lighted LED lampsrestricts in the operation temperature at below 70°C. The numbers of the required electrons, that are the electric current from the electrodes of the lighted LED, are determined from the required illuminance (330 lm, m^{-2}) of the room. The required electric current is 10^6 Ain the LED lamps for the illumination of 1 m^2 room. The commercial LED lamps essentially have the confines described above. The commercial LED lamps are not the energy saving incandescent lamps, even though it has claimed in the public media from the producers.

The technologies of the commercialized HCFL lamps have been established by the studies for the last 80 years as the mature technology. We have found the commercial HCFL tubes are produced by the premature technologies. The established FL technology had concealed the advanced features with many invalided technologies. We have clean up the invalided technologies in the past. Then, we have studied the FL lamps from the fundamentals as the advanced science. The coil-EEFL lamps are the results of the studies.

The electrons in the coil-EEFL tubes move on in the superconductive vacuum between Ar atoms, resulting in the astronomical high quantum efficiency $\eta_q = 10^{13}$ photons (m^3, $s)^{-1}$. The moving electrons in the Ar gas in the FL tubes is 3 x 10^{-4} A maximum, corresponding to the numbers of 2 x 10^{15} electrons per second. The numbers of the visible photons from the phosphor screen of the FL tubes are calculated as 2 x 10^{28} photons (m^3, $s)^{-1}$.

Then we have found the coil-EEFL tubes can operated with the external DC driving circuit with the $W_{DC} = 0$, without the sacrifice of the η_q. The numbers of the coil-EEFL lamps in the parallel connection can be operated with the single external DC electric circuit with the $W_{DC} = 0$. The parallel connection of the coil-EEFL lamps in the vacuum-sealed container may operate with the solar cell and battery, eliminating the distribution network of the supplement of the electricity from the electric power generators. The coil-EEFL lamps are also produced with the combination of the Ne and Xe gases, instead of the Hg vapors. The developed coil-EEFL tubes in the vacuum-sealed container may contribute to the green energy project of COP by the United Nation.

It should be noted that this report has described the fundamental research for giving a direction of the future study by the applied research, and then engineering works at the FL productions.

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