

LED light in Movies

Unleashes the magic

Bachelor Thesis

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Abstract

Firstly, this research paper gives an overview of lights in movies. Due to this fact, it needs to be considered that it is important to know some definitions about the basics of light and the understanding of light itself. More significant points are the tool, techniques and light sources a director of photography and his team need to know about.

Secondly, after the general understanding of light, the research paper focuses on the LED technology, with all its technical, technological and creative aspects. In addition to that, there are several problems which have to be kept in mind, for example the understanding of the technical aspects and color temperature matching.

Thirdly, the answers to the research paper and all other open questions can be found in the last part. There, interviews with experts from the film industry was conducted.

After carefully weighing up the arguments, it can be said that there should be a technique, aesthetics and creative understanding of the light as a tool. On the one hand, the theoretical understanding of the light, light setting and all the tools is important. And on the other hand, the changing of the work flow, systems and understanding of the LED technology also needs to be considered.

Kurzfassung

Zum einen gibt diese Forschungsarbeit einen Überblick über den Einsatz von Licht in Filmen. Aus diesem Grund muss berücksichtigt werden, dass es wichtig ist, einige Definitionen über die Grundlagen des Lichts und das Verständnis des Lichts zu kennen. Ein weiterer wichtiger Punkt sind die Werkzeuge, Techniken und Lichtquellen, die ein Kameramann und sein Team kennen sollten, um sie zu verwenden.

Zweitens konzentriert sich die Forschungsarbeit, nach dem allgemeinen Verständnis des Lichts, auf die LED-Technologie mit allen technischen, technologischen und kreativen Aspekten. Hierzu kommen einige Probleme, die zu beachten sind, zum Beispiel das Verständnis der technischen Aspekte und die Farbtemperaturabstimmung.

Drittens, die Forschungsfrage und alle offenen Fragen werden im letzten Teil beantwortet. Dort wurden einige Interviews mit Experten aus der Filmbranche geführt.

Nach sorgfältiger Abwägung der Argumente kann gesagt werden, dass es eine Technik, Ästhetik und ein kreatives Verständnis des Lichtes als Werkzeug braucht. Auf der einen Seite sollte das theoretische Verständnis von Licht, Lichteinstellung und allen Werkzeugen im Fokus stehen. Auf der anderen Seite sollte auch die Veränderung der Arbeitsweise, des Systems und des Verständnisses der LED-Technologie berücksichtigt werden.

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1 Introduction

To begin with, to light a scene is not only pushing a button, it is its own science, a passion and a handicraft. Drawing with light is the art of bringing the frame to life and creating the perfect illusion. Making movies is telling stories, it establishes a world and accompanies your audience into that world. Light is a very powerful tool.

Over the last decades, there were several smaller innovations of the working processes and the technology. A few years ago, the LED technique was developed and with this technique, the cinematographers and gaffers have a new possibility to light movies.

The LED technology has many advantages in the film industry. Every system has its breaking point, there are limitations, which will also be explained in this research paper. To understand the newest state-of-the-art technology of the lighting process, it is important have a general knowledge of how to light a scene.

This implies the central research question: Why is it important to use LED lights on movie sets and what changes concerning the handling, technology and technique?

Because of my exchange semester at the Utah Valley University (Orem, UT USA) my research paper has a lot of influence on the American film industry, but I also want to cover the German-speaking world.

During the research process, two related works were found: The first research paper was written by Maximilian Maurer and the title of his diploma thesis is "Wahrnehmung von Licht und Farben im Film" (English translation of the title is "Awareness of light and colors in movies"). This work considers the influence of color and light for the audience.

The second related work is the bachelor thesis of Simon Valderrama and his work has the title "Lichttechnik im Wandel" (English translation of the title is "Lighting technology in transition"). His work considers the transition, with take place because of the LED technology.

2 Method

However, it has to be mentioned that light and in particular in movies, is very important. Because of decades of using light as a story telling tool, there are several books and other media sources about light and LEDs.

The next point, which needs to be considered are Search engines. Google scholar, the library of the St. Pölten University of Applied Science, Fulton Library at the Utah Valley University and the online resources website with links to "IEEE Xplore - Digital Library" and "The ACM Digital Library" were used.

In addition to that, the most significant keywords were the different lighting techniques, the way of using the light and articles about movies, which used LED lights.

As a result of this, it was easy to find books and articles about using lights in movies. Therefore, the manufacture website and some articles in the specialist magazines such as "American Cinematographer" and in "Film & TV Kameraman" were found.

3 There is a light - the theory of light in movies

movies

The main purpose of the first chapter is to give an overview on light in movies in general.

3.1 The fundamental grasp

Landau (2014, p.3) describes that we can not see the light but there are a lot of features which are transported through light, such as giving life, transmitting a mood and setting a shape. Light is energy with surroundings. It has its own way of understanding, which is transmitted beyond its borders and it is important as a storytelling tool. He also states that the light is an emotional transmitter for everybody who can see it.

3.2 Definitions

To begin with this topic, it is important to keep the definitions in mind. In the film industry, the understanding of the meaning and the explanations of the technical literature are important to understand the different parts of light.

3.2.1 What is light?

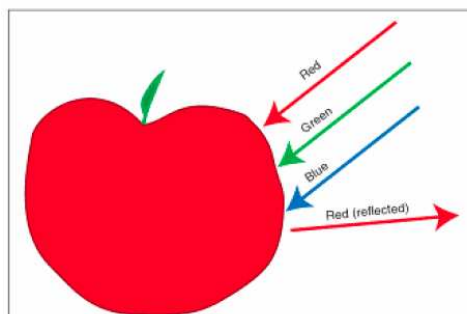


Figure 3.1. The reflection of energy is processed in the brain and results in a color.
(Brown, 2008, p.145)

Brown (2008, p.128f) defines that the components of light are "photons". Color is not part of the light. Light contains many parts of energy and the human eyes can see the color

because the energy is reflected. Figure 3.1 shows how the light falls on an item and how the eye sees the reflected color.

Landau (2014, p.6) describes the combination of all visual lights of the continuous spectrum are used, which is called "white light". There are different ways to lead the light away from its usual beam path, for instance to control the light while using all kinds of ways. These possibilities give the opportunity to transform the light in its physical structure.

3.2.2 Idiosyncrasy of the light

Moreover, it is important to mention that light has four idiosyncrasies, which should be kept in mind while using it. To understand the use of the different tools, it is important to understand the basic functions of the light itself.

Angle

Landau (2014, p.9f) defines the angle of the light as the course the light is positioned. The main focus is on the object, so the light can be put in a cycle around the object. When the light is coming from the side, the profile of the object is in the focus of the viewer. Another possibility to position the light, is in front of the object, as straight as possible. This gives the scene an even, strange look, which reduces the dimension. On a location shot it is really important to control the light. For instance, the available light can be controlled by turning the lights off, cutting of or turning it in into your tool. Every light source produces its own shadow, which is something that has to be controlled. Somehow, the angle of the light source and the position is very important, to position the light source for the object.

Color

Landau (2014, p.11) states that the three colors "red, blue and green" are the main colors and the whole range of the spectrum, for example the rainbow colors consist of them. Other different colors can be made out of these three main colors and therefore, they are also known as the "additive colors". The result of this mixture is the color white. Besides the additive colors, there are the "subtractive" ones, which are "magenta, cyan, and yellow". The combination of all these colors with the same percentage, results in the color black. Colors are an important tool, because of the understanding of the use of different gels. It is important to know which color fits the scene and to understand the different circumstances of the colors and their design variations. The colors of the light source can be changed with the use of gels.



Figure 3.2. Additive Colors (Landau, 2014, p.11)

Look at Figure 3.2, it is showing the additive and the subtractive color space.

Intensity

Landau (2014, p.9) describes the intensity as the measured amount of light that falls onto a scene. This is measured in Lumen¹ and it verifies how effective the light giving object is. The measurement of light with the foot-candle² is a tool to achieve the right f-stops³ and thus, the exposure for the camera. Firstly, the light can be manipulated while changing the distance between the light unit and the object. When this distance is getting bigger the intensity is getting weaker. Secondly, the intensity can be controlled by dimming the light, so the amount of lumen is getting smaller, due to the reduction of the power. Finally, the light can be reduced with a scrim, this tool is reducing the intensity because the light gets blocked.

Texture

Landau (2014, p.10) states that the hard light makes it easier to put it more into a direction and brings the object better into focus, for instance the sun. The bigger the distance between the source and the object, the stronger and harder is the texture. On the contrary, the soft lights are harder to focus, control and lighten because light and shadow get more mixed up, so the shadow part also gets light up. This leads to the fact that the separation is not so strict. There is soft light in the dark parts of the scene as well, which makes it more challenging to bounce and reduce the soft light. Another defusing tool are all kinds of filters. Therefore, the light softens up, when there is a diffusing material in front of the source. It is easy to make a soft light out of a hard light source, but it does not work the other way around.

¹Measured the light flux, this the energy of the light measure in time (Schmidt, 2013, p.19).

²The light which is given while lighting one candle (commercial) on one foot distance (Brown, 2016, p.175).

³The amount of light with is getting thought to the sensor, this is the camera aperture (Landau, 2014, p.267).

3.3 Tools and explanations

3.3.1 How to measure light?

Dunker (2014, p.156) defines two ways of measuring light. These possibilities are the incident light metering and the spot meter.

Incident Meter

Dunker (2014, p.156f) says that the incident meter is working with a white spherical cap in front of the photo cell, to measure the light which is arriving directly on the cell. Firstly, the choice of the shutter time is clear and the intensity of the medium will be figured out with the use of the aperture diaphragm in front of the photo cell. Another point is the movement of the actors or camera, the measurement has to follow during the whole motion. During the shot, there can be the possibility to change the f-stop, because of the movement of the camera and the change of the location and the light.

Spot Meter

Dunker (2014, p.156f) describes the workflow of a spot meter. This meter is measuring the light which gets reflected from the camera. The meter is positioned next to the camera, more specifically on the camera axis, so that the photocell of the meter can catch the light. The angle of the measurement is only one degree, so this meter is really handy in combination with an optical system.

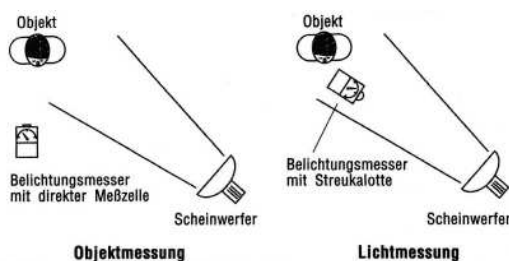


Figure 3.3. A spot meter and a incident meter (Dunker, 2014, p.157).

Look at Figure 3.3, this shows the use of the spot meter and the incident meter. The handling of the two meters is shown, to understand the different work flows.

3.3.2 Color Balance

Dunker (2014, p.58) states that the color balance is defined over an inner black sphere, which is empty. This object is being headed up, until it starts to glow. On the object is a small opening, this light color is measured with Kelvin. In that respect, 0 Kelvin (K) are 273

degree Celsius. This definition results from the ground zero. As an example for daylight, this sphere beams up 5000 Kelvin.

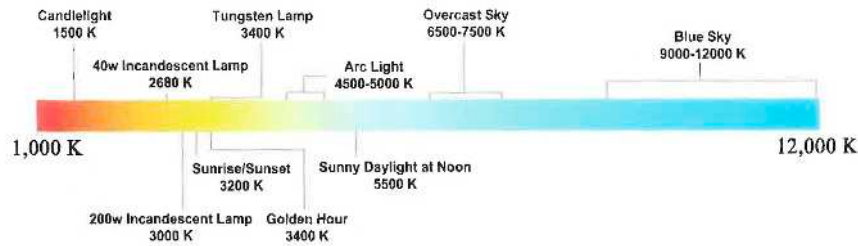


Figure 3.4. Scale of the Color Temperature (Landau, 2014, p.12).

Look at Figure 3.4, this shows the Color Balance. A drawing of the different Kelvins with their different light source.

Daylight and tungsten

Dunker (2014, p.58f) claims that the exact indications, for daylight and tungsten light sources are over the color temperature. Tungsten light has 3200 K and daylight has 5600 K. The tungsten light is more red than the daylight, which has more blue parts.

3.3.3 Intensity of the source

Dunker (2014, p.61) states that the intensity of the light is getting smaller with the increasing quarter of the distance. It is to say that when the source is shining on one meter distance it shines on one square meter, when the distance is two meters, it shines on 4 square meters. This is shown in Figure 3.5. When the distance is getting twice as big as before, the intensity is only a quarter of the basic intensity. For instance, when the actor is moving to the source, it means that he gets more light.

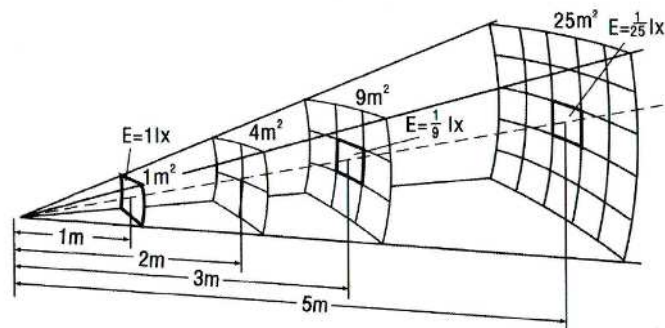


Figure 3.5. Relation between the distance and the intensity of the light (Dunker, 2014, p.61).

3.4 Different light setting techniques

3.4.1 Common lighting definitions

This subsection gives an impression on the understanding of the terminology of light. To understand the language of the industry, it is really important to understand the process of light setting. Understanding how to push effects on the picture is crucial to be able to paint with the light.

Three-Point Light

Landau (2014, p.41) defines the three point light as light which is created as a basic light setting. This light setting is coming from the theater, 45 degree position of the lights was used because of the stage. For film this technique has the camera as a base. This setting has a key light, fill light and a back light (all three items are described below). The key light is position at a 45 degree angle from the camera on the one side, the fill light is mirrored and the back light is positioned on the opposite side of the camera.

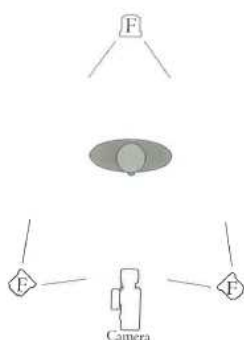


Figure 3.6. Three-Point Light (Landau, 2014, p.42)

Look at Figure 3.6, this is a standard light setting with the name three-point light. This setting includes three different other settings, such as key light, fill light and back light.

Key light

Brown (2016, p.264) defines the key light as the main light source. It is the central light on the actors or objects.

Fill light

Brown (2016, p.264) states that the fill light is used to light the part of the object, which the key light is not. It is mostly used to brighten up the shadows. There are some definitions for the relationship between the key and fill light, for instance the "key/fill ratio" or "contrast ratio".

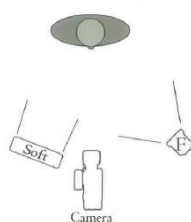


Figure 3.7. A key and fill light (Landau, 2014, p.47).

Figure 3.7, shows the light setting for a key and a fill light. The description of the image is showing the correct positions of the lights.

Back light

Brown (2016, p.264) describes that the back light light shines "from behind and above" on the substance. It is used to distance the substance from the background, such as the face or to highlight a side.

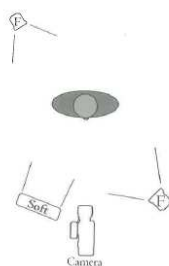


Figure 3.8. Three point light (Landau, 2014, p.48)

Figure 3.8, shows a standard three point light, with a back light.



Figure 3.9. Lighting definition (Brown, 2016, p.270)

Figure 3.9, shows a set up of a close up lighting, with the common lighting terminologies.⁴

⁴Brown (2016, p.264) states that the kicker is on the fill light side in the background, it is highlighting the face of the substance.

Hard light

Brown (2016, p.266f) describes the hard light as a light with a clearly visible shadow. Because the rays are parallel, a small light source is the key for a hard light. "The smaller the source, the harder the light will be." Nevertheless, the size itself is as important, as the relationship between the source size and the same distance to the object. For instance, if the sun is the source, it is a far away pointed light, which is acting as a hard light. Due to the fact that the distance between the source and the objects is changing, also the source has to come closer to the object, when the camera is moving from a wide to a close up.



Figure 3.10. Hard and Soft lighting (Holshevnikoff, 2016, p.7).

Figure 3.10, shows the impact of the hard and soft light source, all the advantages and disadvantages of these two light sources are clearly visible.

Soft light

Brown (2016, p.266f) states that the soft light is only producing a blurry shadow or none at all. Therefore, a very big light source is used. For instance, on a cloudy day the light is soft and there are no shadows, this is based on the sky as the source and not the sun. There are two ways to produce soft light. Firstly, a big white surface to bounce the light off is used, such as "foamcore", "cotton muslin" or "Ultrabounce", a "white wall", "umbrella" or "a piece of white styrofoam." These materials can also be used for bigger set ups. Secondly, the diffusion of the light is also a way to produce soft light. Therefore, the diffusion material is placed in front of the source.

3.4.2 Basic light setting techniques

This subsection gives an overview on the different techniques, this is only a small amount. Every situation, scene and location (daylight, tungsten, inside, outside, camera movement, different shots, is there light available...) needs another light setting and therefore, it is important to know the basic settings and to combine the knowledge and the expectations of the director of photography.

General Knowledge

Brown (2016, p.271f) defines some points for the light. Firstly, try to shine the light from the side or back, and not from the front. Secondly, try to avoid the light next to the camera, this gives only a flat image. Another significant point is the separation between foreground and background, for instance, while using all kinds of lights. Also the shadow can be used to create and transport different emotions and meanings of the scene. Therefore, as much light as possible should be used for a good balance, for all the tones of the range. Another tool can be all kinds of textures and thus, making filters in front of the light.

Cross keys lighting

Landau (2014, p.72f) describes the lighting for a face-to-face situation for two actors. This cross key lighting creates a three-point lighting for every person but only with three lamps. Moreover, it is avoiding too much lighting and shadows, which could happen while using a three-point light for every person. Figure 3.11, shows this standard light setting. This lighting can also be combined with the use of already available light, such as a windows, lamps and other things. Therefore, it is important to match the color temperatures of the single sources with gels. The tricky part of this light setting is the staging of the actors. Due to this cross lighting, they have to hide their markers, otherwise an actor can get not enough light and this lighting is visual. Another issue is the hard light, which ensues the shadow. Because of the texture this light source is producing, it is not really pretty on a face. Therefore, the use of diffusion is helpful. Not only hard light sources can be used for the cross key lighting, also soft sources. Unfortunately, these are harder to control. Sometimes the look of the source is helpful in the scene and for the look of the scene.

Chicken Coop Lighting

Landau (2014, p.76f) states that there is a soft light source adjusted above the actor, normally it is a big rectangular source, which can be adjusted to every situation. The light source is placed over the head of the actor, facing straight down. To avoid spill light, all kinds of black material can be used. Because of the light source, this has a soft and washed out look. The back light can be used as a separation from the foreground and the background. To isolate the character in the scene, this is the best lighting setting. It can also be used for all kinds of table scenes, which is an ideal way to light more than two people. For this settings there is also the possibility to put some light on a close distance with them, so that the eyes also get a soft light. This technique is also working with China balls, which can be combined with normal bulbs to make a smooth light. This setup is used for scenes in hallways or other narrow spaces, which would be too big for normal lighting gear.

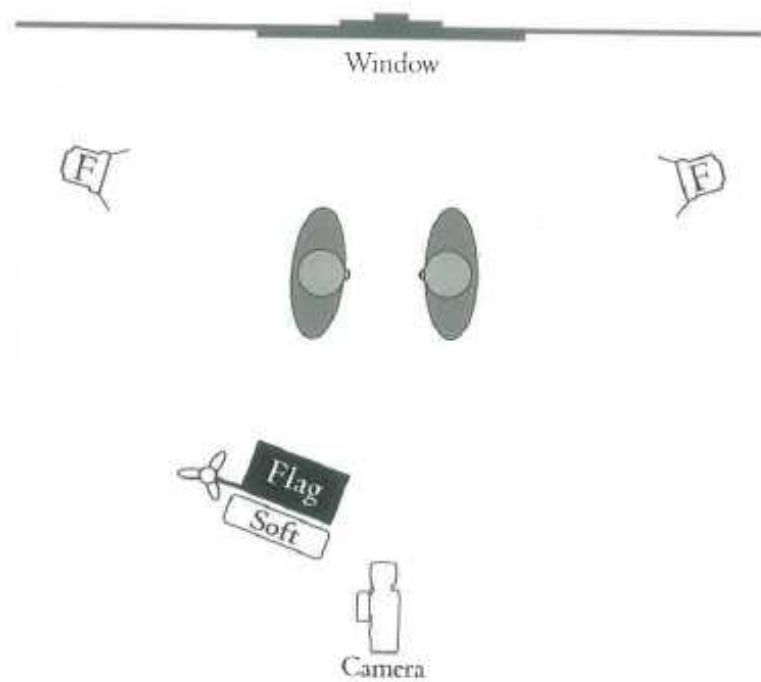


Figure 3.11. Cross Key lighting (Landau, 2014, p.72)



Figure 3.12. Chicken Coop Lighting (Brown, 2016, p.241)

Figure 3.12, shows a standard light setting for a cross key lighting. Because there are many different basic light setting techniques, this subsection only gives two examples. There are several other ways to set the light, for different scenes, locations and situations. All in all, it can be said that the choice of the right setting should work hand-in-hand with the vision of the film makers.

3.5 The use of light as a visual storytelling tool - Awareness of using light

As it was mentioned before, light has a really technical aspect, but to make good movies it is also important to comprehend the creative and visual aspects of this tool. To understand light and the process of lighting, it is also important to understand the awareness of using light.

Brown (2016, p.261) pictures the aim of a well lighted scene as part of the light setting process, which is important for storytelling. Thus, light is a tool to carry the pattern and the story forward. In that respect, light and all its tools are important for the cinematographer. These tools help to tell the story, for instance open up the emotions and shades of colors.

3.5.1 Atmosphere

Brown (2016, p.261f) makes it clear that the cinematographer and gaffer can create mood with the light. To influence the mood and tone, there are several creating aspects, which can be used. These aspects can be "color, framing, use of the lens, frame rate, handheld or mounted camera". To impact the movie and in particular the audience, the camera crew can use every kind of tool on the camera's side and on the lighting part to create the perfect illusion.

3.5.2 Character

Brown (2016, p.262) defines that the shape is a way to light. When the light source is positioned on the side or back, it brings shape in a particular way. This way of using light makes the character more interesting, helps to tell the story and brings more depth into the scene. To use this technique to paint with the light, makes the scene more realistic, tangible and rememberable. The author states that the direction of light is really important for the texture in the scene. The light is coming from the lenses pivot, but if the shot looks flat, the texture does too. If this happens, shadow is needed, because when the light source is too close at the camera, there are no shades. Another signification point is that the light can also be in the character of this form.

3.5.3 Color

Brown (2016, p.262) states that many decades ago, the color balance was really limited. Only tungsten or daylight sources were used and it was later fixed in postproduction. Nowadays, there are more possibilities due to the improvement of the cameras. Now there are

options to control the intensity of the different colors. This results in ways to improve the color control, which is an important part of the visual shaping of the shots.

3.5.4 Isolation

Brown (2016, p.262) describes the separation as an eye catcher, due to the different visual distances to the background. To achieve a good separation, the light source comes either from the back or as a hard light source is set behind the actors. The goal of this lighting is to make the shot with as much depth as possible, by creating three layers, in order to make a clear split-up of the several parts of the picture. To create the perfect illusion of the reality, the deep, form and angle are important tools and therefore, the light is helping. To create the perfect three-dimensional entertainment and to get close to the nature view, the use of depth is really important to make the difference between a professional and an amateur.

3.5.5 Tones

Brown (2016, p.261f) makes it clear that the filmmaker wants a range from black to white, which implies a full range. The ground color of this tool is the color gray, which means all the gray steps between black and white. If the image looks realistic, it is easy to catch the eye and it has more influence on the audience. This is called an image with the use of the whole amount. Another aspect, which can also influence the range is the visual aspect of the scene. The amount of light and the specialties of this light make the contrast, which brings us back to the range of tones.

3.6 All kind of sources - different light fixtures

Due to the understanding of light, the definitions and the tools how to set your light, this following section is describing the different types of light fixtures. The next point to be considered is the fact that this section gives an overview of the common types, their field of use and an understanding.

Brown (2016, p.238) states that there are different fabricates of the fixture. Normally the only difference between daylight and tungsten light features is the source itself. To handle the different color temperatures, there are different ways to vary between these differences. This works in most cases while using different light bulbs.

3.6.1 Color-correcting fluorescents

Brown (2016, p.250f) states that the advantage of these tubes are a light, flexible and less power using light source. Before inventing this light source, a big light, much place and white material to create a soft light were needed. This kind of light source is basically a "high-frequency" fluorescents ballast, to minimize the flicking problem, which are very common for these light sources. Because of the construction of this source, it can be easily used as a light from the back side. Another advantage of this light source is the fact that they are producing less heat.

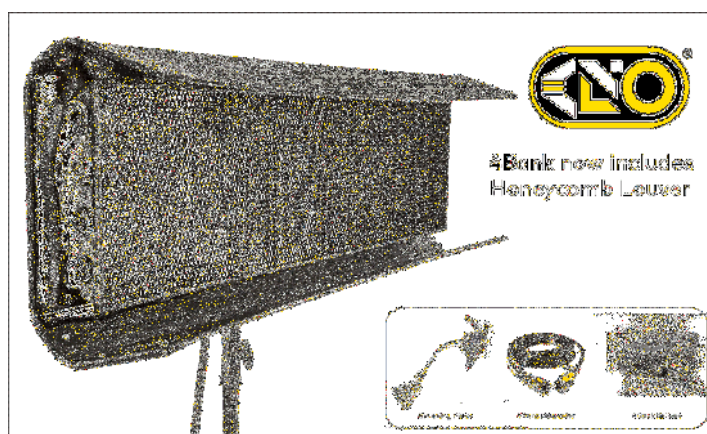


Figure 3.13. Kino Flo 4 Bank (Kino Flo Lighting Systems, 1987c)

Landau (2014, p.31f) defines that "Kino Flo", Figure 3.13, created the 3200K Tungsten and the 5600K Daylight sources. He also mentions the handling of the light, the tubes are easily breakable, which is also not really healthy material. Another significant point the author is mentioning is that the source should not be on a dimmer. There are some dimmers included into the set, these are okay, but the external dimmers can destroy the ballast.

3.6.2 Fresnels

The root of this light is in every household, this feature has a special lens which is crooked to emanates, the light to focus and route the beam. Advantage of the tungsten⁵ is that it can be used flood and spotted, so the focus of this light can be influenced. This light is a hard one, because of the inside of the lamp, the uneven underground makes this also hard (Landau, 2014, p.27).

Look at Figure 3.14, showing a 10k Baby Fresnel from the company Mole-Richardson Co..

⁵Landau (2014, p.270) describes that with the ember material inside, the source which is generating light and color temperature in Kelvin is such a lamp (see 3.3.2 Color Balance).



Figure 3.14. Mole-Richardson Fresnel Baby (Mole-Richardson Co., 2018b)

Brown (2016, p.246f) states that the Fresnel's advantage is the fact that the shadow is really clear. There are several sizes of this lamp available, for instance "Twenty" with 20000W, "Tenners", "Senior/5k", "Junior/2K", "Baby/1K", "Tweenie/650" and "Betweenie, InBetweenie, Inky and Pepper".

3.6.3 HMI Units

Brown (2016, p.240-245) states that HMI lights are an efficient power saver, because they have a lower power use but deliver more light than usually and therefore, less heat. The HMI bulbs "create an electrical arc that jumps from one electrode to another and generates light and heat in the process." The HMI light sources are available in different sizes and types. These features all have a place on the set, with their advantages and disadvantages. Look at Figure 3.15, showing a HMI lamp from ARRI.

Because of the components and the construction of this source it can be compared with the sun, for the outdoor use or for sets with much mixed light from outside. This is a tungsten hard light source, which can only be dimmed while using no ballast. It is created to output a lot of light. The ballast is an external control element, normally made out of metal, which is used to control the lamp. This light source needs a while to have the full lighting power (Landau, 2014, p.32f).



Figure 3.15. ARRI HMI AS18 (ARRI, 2017a)

This kind of light source has some special needs, for instance, the ballast should not get wet, the cable between the ballast and the head should be placed in a safe way and it needs to be made sure that the connection is working. When the lamp gets colder, it can influence the color temperature. After turning the lamp off it needs to cool down before moving the light (Brown, 2016, p.244f).

3.6.4 LED lights

This light source is explained in chapter 4, see 4.4.2 LED lights.

3.6.5 Natural light

Because of the natural behavior of the sun, such as intensity and movement, light and shadow can be really tricky. Therefore, the light of an light feature can be reflected, to control the intensity and behavior of the light. This light feature is more a part of the gripping department, because the light source is available, now it needs to be controlled. To control the light outside, there are several ways, materials or surfaces to bounce and control the light (Brown, 2016, p.254f).

3.6.6 Remote Phosphor LEDs

This light source is explained in chapter 4, see 4.4.3 Remote Phosphor LEDs.

3.6.7 Open face

Brown (2016, p.238ff) defines this features as open, they do not have a lens. But this light feature has two ways to focus the beam, such as a flood and spot function. The distinguished functions are that the light is crude, it is producing an irregular light but it delivers much light for the different sizes. The common uses of the open face light source are to bounce the light or use diffuser in front of it. This is the best light for a raw look, without

having to control it though a lens.



Figure 3.16. ARRI M18 (ARRI, 2017b)

Look at Figure 3.16, showing an open face lamp from ARRI.

Landau (2014, p.26f) describes the construction of the lamp as a bulb and a reflector in the back. The source of this lamp is producing a hard and bright light, with a large radiation range. These open faces are also known as "mickey or redhead". "Lowel" is a producer of open face light sources.

3.6.8 PARS

Landau (2014, p.28) defines the PARS, as a light source and a reflector behind this source. The specialty is the fact that the shape of the reflector is parabolic. The use of this reflector is producing more light than other tungsten light sources. There can be movable or unmovable lenses in front of this source. These lights are coming in 4 different ways as a "spot, medium flood, and sometime honeycomb and diffused", nevertheless these light sources are not able to switch between spot and flood.

Brown (2016, p.246f) states that the Fresnel's advantage is that the shadow is really clear.



Figure 3.17. Mole-Richardson PAR (Mole-Richardson Co., 2018a)

Figure 3.17, shows a 1k PAR from the company Mole-Richardson Co..

3.6.9 Soft lights

Landau (2014, p.27) describes that the soft light has always a diffusing material, normally in the color white and the light gets directly lit through this surface, following that no light is coming directly to the actor. It is a soft light, which spotless or flood less feature can be made in all kinds of sizes.

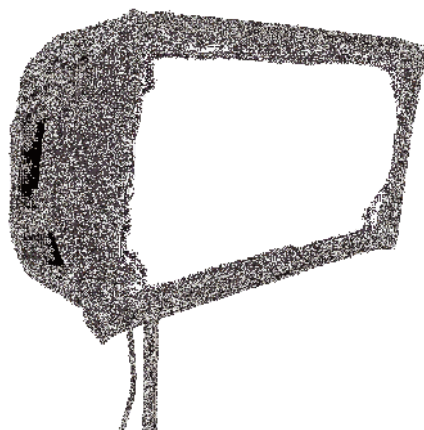


Figure 3.18. Kino Flo Snapbag is a softbox(Kino Flo Lighting Systems, 1987b).

Brown (2016, p.248ff) defines that the soft light, normally coming from a soft box between 1000 w and 8000 w of power, is really hard to control (see 3.4.1 The common lighting definitions) and to transport, because of its construction. This source often has a fix rigging in a studio. For example look at Figure 3.18 (see 3.6.1 Color-correcting fluorescents) and the "Barger baglights", these are big boxes with a 1000 w tube as the source, with a diffusion between the lamp and the glass front, to make it a soft light.

3.6.10 Xenons

Brown (2016, p.245) claims that this light source has similarities to the HMI light, it is also an arc which is based on a gas and controlled via a unit. The beam looks like a laser with relates from reflection form, which is parabola. One fact of this source is the really bigger output. The stronger the feature, the more carefully and dangerous this light can get. This sources are not losing their intensity after a few years, it is really constant. The sizes of this light are variable between 5 different steps, the less powerful can be used with a normal output of a house and for the higher ones a generator is working just fine.

3.6.11 Others

Brown (2016, p.251ff) states that next to the common light source, there are other types, for instance all kind of contracted or on set invented light source.

4 LED - light-emitting diode

This chapter shall compare the previous parts of the research with the LED lights. Therefore, it will be an overview of the LED technology and technique.

4.1 Definition for LEDs

Greule (2015, p.113f) states that the light-emitting diode technique is based on the principal of the electroluminescence. This is a particular form of producing light. It works like a radiant heater, the voltage is laying on a conductive solid, which is being drained by the current. The electroluminescent solid is saving the total electric energy in two forms, the lattice shrinkage and the electronic excitation. The III/V semiconductor is one of the important sources of radiation.

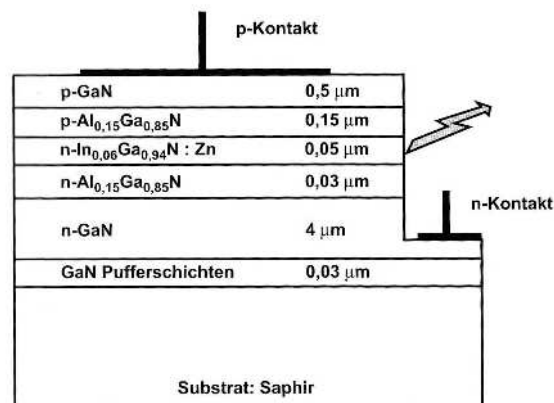


Figure 4.1. Blue LEDs (Greule, 2015, p.114)

Look at Figure 4.1, it shows the structure of one of the first blue LEDs.

The III/V semiconductor is solid material and it is construed with the elements from the periodic table, in particular from the third, fourth and fifth group. The combination and peculiarities of those elements is the reason for the electric conductivity. To produce light, the LED-clip has to have the following components: a electronic conduction, a perforated conduction (semiconductor crystals) and the relationship between both elements (Greule, 2015, p.114).

4.2 Technology of LEDs

Box (2010, p.247f) describes the four main components, which are typical for the LED fixture: "an LED emitter, the fixture's heat sink, driver and dimming control, and augmenting optics". There are several parts of the LED emitter with different areas of responsibilities. For instance, the diode is the LED chip and it is a part of the emitter, next to "thermal heat sink, lens", and other different parts. The distance between the "semiconductor", in other words the energy between the gap, makes the decision for the light color. Another part of the emitter is the thermal heat sink, its duty is the heat. It is important to reduce the heat next to the chip and this transmits the body of the fixture.

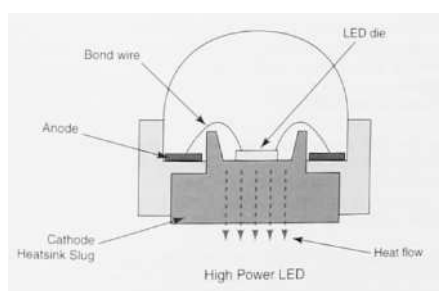


Figure 4.2. High Power LED (Box, 2010, p.247)

Look at Figure 4.2, it shows the parts of the LED emitter with all components for generating energy in light form.

4.2.1 Long live the LED

Box (2010, p.248) states that too much power, which is running though, can shrink the living hours of the lights. Therefore, it is important to use the LED in the right temperature and the amount of power which runs though the light should be controlled. Because of this, the manufacturers try to find the right balance between lightness, long-span of the feature, heat, and an elevated power. Therefore, the distance between the emitter and management of the heat can cost a limit for the manufactures. To avoid the problem of flickering, LEDs companies have invented the combination of an higher Hertz number (20000) for the supple of the energy and a special dimming method, to modulate the width of the pulse down.

There is a factor which should kept in mind while using the LEDs, namely power. Some companies have listed a number with the charging power. This should be kept in mind while using a big amount of LED. This light source is really hard to kill. Before it breaks it will stop lighting. Their intensity, the power gets lower from time to time. The life of a LED is measured in the average of the life of the emitter in hours and the power in lumen. How this

criteria are chosen is in the hand of the manufacturers. For example "L70" the number next to the L is coming from the manufacturers, which shows the long-span of this LED. When this number is lower than seventy, this LED is unusable for the industry (Box, 2010, p. 249).

Greule (2015, p.115f) describes the two parameters (color point and light flux) are chosen wisely for the consistency of the LED and the colors. The temperature of the surroundings is also important for the virtue of the LED, because the light flux is changing with the temperature. The LED lights are more efficient when the LED chip has a power reduction, this is different to all the other lights sources.

4.2.2 Types of LEDs

Box (2010, p.228f) describes the color spectrum as one of the biggest issues for LED lights. To avoid this problem, there are three different types of LED features.

Phosphor-based white LED

Box (2010, p.228ff) states that the white LEDs can be one chip or two versions of emitters. The light which is being produced in the diode is blue or ultraviolet. The phosphor layer is important for changing the shorter into longer light waves, which is called shifting the stroke. To make the spectrum bigger, it is important to use different phosphor colors. There is an issue, with a not linear color spectrum, where some colors are more intensive than others, which is not ideal. Due to compromises of the power of the LED because of the higher number of temperature and range of the colors of the white LEDs, brightness and color need to be handled.

To guarantee the quality of the LED light, the providers are using the "binning". This process helps to stabilize the performance of the LED, because this process is influencing the performance, right color balance and the tilt for the colors green and magenta. To limit the differences between the colors, the manufacturers are using "MacAdam ellipse". It is the point where the eye makes two colors to one and because of this, it can make a LED compressed in one. To create the same color spectrum as a HMI feature, these LEDs are not the right choice. To avoid the limitations of white LEDs, in their short wavelengths, LEDs with multicolors can be used.

Multichip, wider color gamut, LED systems

Box (2010, p.229,p.231f) states that these types can be a mixture, more than 4 and less than 8 different emitter, every part in another color or with white. This LED system is improving the issue of the phosphor led, while including more color. This tricky and complicated process, with phosphor can not be handled alone. To get the full range of the color,

a more chip system is the best way. The calved LEDs is one benefit of this system for the producer, to get the right colors out of this source. The shadow side of this solution is the insertion of luminosity.

RGB, RGBW or RGBAW

Box (2010) claims that this kind of LED chips are now "white light", because of the pure colors of these chips and the fact that they deliver one color only. To create a colored light with RGB chips, the single colors (red, green, blue) are being mixed together in a controlled environment. The additive color space has millions of colors but not white. The not production of white light is a big problem for the RGB fixtures. To solve this issue the RGBW is created, to mix the main RGB colors and white. Not only RGBW is helping with this issue, also RGBA which includes amber, are trying to use the color space as efficiently as possible. To face this issue and to create a bigger color space for the LED color, some companies have created a bigger number of LED colors.

4.2.3 OLED- organic light emitting diode

Greule (2015, p.117f) states that there are two different kinds of OLEDs, semi-conducting polymers, synthetics and low-molecular connections, for instance "small molecules". The author describes the technology of the OLED, therefore, the anode stays in the position, where there are building holes and the cathode, which got injected. Those pieces are getting moved and both should clash at the emitter layer. The completion of this process is called exciton and in this process light and heat is set free. To control the color of the light, it is important to focus on the gap between the neutral and the excited-state of the elements. Also, the emitter has an impact on the color.

4.3 Working technique

Dunker (2014, p. 53) described a variety of advantages for the use of LED lights, such as the long lifespan, the stable construction, the low power drain, the fact that they are available as daylight and artificial light, they are dimable and the light is an efficient, soft and focused light. Because of the low energy use, the LED lights are flexible and mobile, due to the possibility of using the LEDs with batteries.

Iain Marcks (2017, p.40) wrote an article about the movie *Mother!*. The production has used a lot of LED features, the flexibility was necessary because of one location shot of this movie, to smoothly move this source to any place. For instance, the flexibility of the Skypanel in particular for the color controlling.

The LEDs are a special case, because they are used for tungsten and daylight. Due to the use of both bulbs, this is called "Bi-color". Another handy specialty is the dimmer of the LED lamps, to reduce the intensity of the light (Brown, 2016, p.238ff).

Iain Marcks (2017, p.40) states that in the movie *Mother!* they produced for all visual light features (practicals) in the shot Asian paper lamps, as they were using a more colored ribbon of LEDs with more of a level streak.

Christian Genzel (2017, p.19) claims that the lighting in the flat set from the movie *"Die Beste aller Welten"*, was next to the fluorescents light source, also LED features, because they had batteries and no cables.

4.4 Light fixtures

The first section gave a technological view on the LED source itself, this section is now showing the different kind of LED sources and lamps.

4.4.1 Good to know

CRI - Color Rendering Index

Brown (2016, p.238) defines the CRI as a classification for the light source, how good this source can recreate the colors of the sources in comparison with the natural source. Therefore, this index has a ranking, such as 90 or higher are needed for the film industry. Everything lower can not show the colors right.

Mike Wood (2010b, p.1-5) describes the CRI measure process, therefore, the light source gets lit on 14 samples of specified colors, the results are getting compared with the results of the same test with a light which functions as a reference. This measurement is not perfect, because this index shows only the color performance in a small part of the color range. This way of measurement is ideal for sources which are nearly similar to black body radiation. ¹ The author also states that the CRI was not made for white light sources, such as LED light features, in particular for the "RGB LEDs" this method is doubtful. Because of color on the sample, these are not intensive enough for this test to work right.

Alternatives

Jay Holben (2017, p.18-22) states that the "TLCI" ("Television Lighting Consistency Index") are using 24 colors on the color plot and this way is only measuring optimal for a digital

¹This light source is an ideal thermal-source, it is special because it can absorb and radiate really balanced (Schmidt, 2013, p.67).

camera sensor, therefore, this needs a particular standard. The author also mentions the "Color Quality Scale (CQS)² and the Gamut Area Index (GAI) ", this concepts were not really well developed. The "SSI spectral Similarity Index" was invented to scale the loyalty of the color for lights without a steady color range. This standard was intended to replace the inaccurate method (CRI) for the film industry. The companies only need to measure the outcome of the prismatic of the source, put this number into a scale and this result, which is a factor that is reliable. For instance is the number higher than ninety, the colors are well emulated, when this number is lower than seventy, this light can not handle the mimicry well.

4.4.2 LED lights

Brown (2016, p.239) lists some of the advantages of the LED, such as the power usage, less heat, the size and the flexible usage, the handy rigging and the be charged with battery. Tungsten lamps normally produce 10 percent light and 90 percent heat.



Figure 4.3. Sola 6+ (Vitec Videocom, Inc., 2015)

Figure 4.3 shows the Sola 6+ from the company Litepanel.

Landau (2014, p.33f) states that the "Litepanel", was the first producer of LED light for the film industry. Another benefit is the running time, this source can hold until one half of a century. One big issue of the LEDs is the color, which can not handle the full range of the spectrum. This issue can be changed when using the full spectrum, some companies are working on it. LEDs with 5600K can work good with other light sources, the 3200K have issues with the reproduction of the colors. Because most LED sources have more than one core, they are producing more shadows, and therefore, a diffusion is really helpful but it reduces the beam of light.

²This scale is a measure system, also based on samples, metric with a single figure (Mike Wood, 2010a, p.1-5).

4.4.3 Remote Phosphor LEDs



Figure 4.4. Cineo Remote Phosphor LEDs (Cineo Lighting, 2018)

Figure 4.4 shows the Cineo Remote Phosphor LED, with the name "TruColor".

Brown (2016, p.239) describes this kind of light is working with a clear surficial placed with a dip of phosphor. This method divides the phosphor into waves, which relates a clear separation for the base and thus, brings a "high-CRI white light". This kind of LED light does not have any change of color, in particular the color temperature. This is, because of the base, which stands in contrary to the standard white LED lights.

Landau (2014, p.34) defines "TruColor" as the first company, which made this LEDs with a cover made out of milk glass. This panel is producing the light, not the group of LEDs inside. The benefit is that there are not so many shadows because of the cover, this is a straight, soft lighting source. Since the panel lighting technology the companies can create sources with different phosphors to create the full range of the colors. Therefore, the colored panels can be mixed to get the right color spectrum and temperature. The life time is next to none, the production of heat benefits this source.

4.5 Varieties of Light features

This section gives an overview on light features, in the research process these light sources were the most used ones.

The author is handling the movie *"The Shape of Water"*, which was shot 85/15, with LEDs, such as "Kino Flo Celeb 401 and 201 units, and Arri Skypanel s60s" and other percentages with common features (Jean Oppenheimer, 2018, p.39).

This article was including also an interview with parts of the crew. Therefore, the author was asking Greig Fraser, ASC, ACS (Director of photographer), if they really only used LED lights for the whole movie *"Rogue One"*. The answer was a confirmation with a same exceptional. The reasons were that they were saving money by reducing the power, handling of the wires and color changing feature for the lamps (Benjamin B with John D. Witmer, 2017, p.37).

4.5.1 Creamsource Sky

Outsight Pty Ltd (2018, p.1f) states that the Sky is a soft light feature. This feature has the full color range with a high performance source. Therefore, six machines work in combination with a noiseless cooling system in pipe form (Figure 4.5). The benefit of this system is the color temperature, from "2,200K" up to "15,000K" with the control of the tilt between green and magenta, with "95" at the CRI between tungsten and daylight. Another benefit is the working field, it is build for water, wind and try mud. The light production of this system is really high, because of the out comings. This can be used for beauty shots while adapting a soft box. The head can supply 1,2kW power, also the company mentioned the possibility to dim this light.



Figure 4.5. Creamsource Sky (Outsight Pty Ltd, 2018, p.1)

4.5.2 Litegear LiteRibbon

LiteGear (2018) shows four different types of the LiteRibbon for the different types of field. The "Cinema series" is light featuring a LED with phosphor. This is the newest version of the ribbons in this series, with an output that is full range and higher than the ancestor. Every model of this series has their benefits, from the nailed color range to the trustworthiness of the system. Such as the "chroma", which is producing color light. Figure 4.6, shows the Litegear LiteRibbon Cinema Series.



Figure 4.6. Litegear LiteRibbon Cinema Series (LiteGear, 2018)

4.5.3 Kino Flo Celeb 401

Kino Flo Lighting Systems (1987a) describes this light feature as a panel, which is a soft and weight light source with a mobile power support. The benefits of this system are the light, the color temperature, from "2700 to 6500 Kelvin", with a "CRI 95", no shifting of colors and a dimmer with no flickering problems. This system is in the same magnitude as the fluorescing light source, describes the company. More benefits are the features for this source, it is flexible and expandable, shown at Figure 4.7.



Figure 4.7. Kino Flo Celeb 401 (Kino Flo Lighting Systems, 1987a)

4.5.4 Digital Sputnik DS6

Digital Sputnik (2018a) describes that this model of the LED is the biggest one, the output of this light is "600W". The size, the easy and uncomplicated handling of this light are the benefits of this system. Because the movement of the framing, a softbox can easily be adjusted. This system can be controlled by a phone app. This light feature is a framing with a LED with RGB, which can be dimmed and actuated by the standard control protocol. The color temperature of this system is "from 1,500K to 10,000K" and the control function of the shade and satiation of the colors. For tungsten they have a CQS of "85 (10%), 80(100%)" and for daylight "86 (10%), 82(100%)". Look at Figure 4.7, showing the DS6 with the 6 lamps and the ballast to control the unit.



Figure 4.8. Digital Sputnik DS6 (Digital Sputnik, 2018a)

4.5.5 ARRI SkyPanel s60

Holshevnikoff (2016, p.22f) describes that the ARRI SkyPanel has been invented as the soft light model. The color temperature of the SkyPanel (Figure 4.9) is from 2800-10000K, it also has a color controlling system which can handle the issues with the color green. This painless system is able to control the colors with the controlling of the shade and satiation, temperature and tilt of green and magenta. It can be addressed with the standard control protocol.



Figure 4.9. ARRI SkyPanel S60-C (Holshevnikoff, 2016, p.23)

4.6 Other forms of light sources

This part of the paper is an excursion into the colorful, wide range of LED lights. During the research, I became aware of these species through their flexible use, efficient working or interesting application.

4.6.1 ReLamp

Nic Divischek (2017) describes the ReLamp as a way to upgrade the existing light source, by placing new LED bulbs. In particular the author mentioned the halogen lights, which can get refreshed. This way old light features get new technological input.

Visionsmith (2018) shows the benefits of the ReLamping system, such as the CRI of 98, with the company's own invented LEDs. The efficiency of this feature is much higher than for Halogen lamps and it is not producing heat. This fact is the reason why the company is working with lenses made out of acrylic, which gives a stronger beam of this source. The company also advertised with the special fitting of the light source and that there is no change of color while the lamp is dimmed.



Figure 4.10. ReLamp System (Visionsmith, 2018)

Figure 4.10 shows the different ReLamp systems of the company Visionsmith. This lamp can be used to upgrade old halogen lamps into LED light features.

4.6.2 Carpetlight

Carpetlight (2018) defines their products as handy and really light LED features. On the website of the German company, they are showing six different sizes (Figure 4.11) for handmade lighting carpets. This light feature is really flexible, because of the thinness (" $<10\text{mm}$ ") and the weight (" 1.000g to 2.000 per m^2 "). It is also easy to fix, by taping or knotting this feature. The color temperature is "between 2.800K and 6000K " and the CRI " 87 Ra " for red and for white " 95 Ra or more". The company is advertising with a stable image without flickering even with higher frame rates. The performance of the lamp is dependent on the size of the light feature. This light feature can be controlled via DMX and manual, which also can be dimmed.



Figure 4.11. Carpetlight Models (Carpetlight, 2018)

4.6.3 Digital Sputniks Voyager

Digital Sputnik (2018b) describes the Voyager as a handy package, which is coming out of the prototyping phase to be one of the new kids in town. This feature is including the spring of light, mobile power support and the control system in this one water-resistant multi-tool. To control the light, the user only needs a PC or Mobile device and therefore, there is no need for special handling of the control system. The company tries to combine the elements of older generations of light features with the technology and knowledge to create a practical feature. The company is trying to get this light source financed, but until now there are only prototypes finished. Figure 4.12, shows the two different types of Voyagers, the 2ft and 4ft.



Figure 4.12. Digital Sputniks Voyager (Digital Sputnik, 2018b)

5 Application of light

The last two chapters gave an overview on the theory of light in movies and LEDs, this chapter finally answers open questions and give an practical impression on the LEDs on sets and to get a state-of-the-art point of view.

5.1 Experts interview

During my research phase, I realized that my research question is too practical and too set oriented, to be found in books, because of the daily innovations. This is the reason why I approached some industry professionals, from Austria and the United States. Because of my semester abroad, I had the possibility to get some impressions from the US film industry as well as, different working processes in these two territories. I have used a combination of mail interviews and the articles in professional magazines, such as "Film & TV Kameramann" and "American Cinematographer".

5.1.1 Why is it important to use LED lights on movie sets?

"I think that LED lights are another great option to have in your toolkit. I don't think they have replaced traditional units, but they have definitely given us another tool to play with."
(Bianca Cline, 2018)

Bianca Cline (2018) states that this source is important because of the steadily amending and the worthwhile existing.

Bianca Cline (2018) states the interesting point of the LED light is this source is multi-faceted, what is really adjuvant.

Peter Zeilinger, ASC, BVK (2018) claims that the LED lights are not heavy, the system uses less energy, so they are really efficient. The saving of color correction gels is also a benefit. There is also not the problem of getting this system hot and the safety problem is nonexistent because of the current potential.

Judd Hillman (2018) states the important fact about the LEDs light, is state-of-the-art and it replaces outdated light sources. The reasons are the easy correction of the colors and the control function of the light strength of the LEDs.

5.1.2 What changes concerning the handling?

Benjamin B with John D. Witmer (2017, p.33) describes that for the Movie *"Rogue One"*, the camera team had used mostly LEDs. Such as "Digital Sputnik units, Creamsource fixtures from Outsight, LiteGear's Lite Ribbon, and units from Arri Lighting." This light sources had some different functions on the set, the mounting on top, to get much power output and to set a colored light.

Bianca Cline (2018) states that the handling improved in order of the size and form of these light sources. For instance, the use of light in a streaky form, can easily be concealed anywhere.

Peter Zeilinger, ASC, BVK (2018) states that this light source is giving more creative possibilities, while influencing the color and the color temperature and not only affecting the concentration of light and shadows.

Judd Hillman (2018) claims the biggest change of the work flow is the possibility to wish the colors in particular the temperature. Also the current drain is lower, for instance on a set, this can be structure with less lights.

5.1.3 What changes concerning the technology?

Benjamin B with John D. Witmer (2017, p.37) led the question with DOP Fraser on colors in combination with LEDs. Flexibility of color controlling of the LEDs, such as RGBW is the benefit Fraser is mentioning. He describes the time saving because not mounting a foil. Fraser's point was also that this system is making the handling easier, because the light setting can be made on set and not only on the monitor. There is one more dimension to be used as a tool. This tool can control every single color by itself.

Peter Zeilinger, ASC, BVK (2018) states that the controlling systems via WIFI and Bluetooth are being in the ascendant.

Bianca Cline (2018) claims that the weight of the LEDs in the field of the technology, which has change the flexibility for the lights, in contrast to the other light features. Because this can easily be placed on blankets, autos and humans, well using tape or lift them around.

Judd Hillman (2018) states that he is working over 5 years ago, he mentioned the initial problem, such as the tenuous construction of the lights, the interpretation of colors and frequency, between light and camera could be some troubles.

5.1.4 What changes concerning the technique?

Timo Landsiedel (2017, p.20) describes that the first impression of the LED from Summerer (Director of photography of Netflix-Original-Serie "*Dark*"), was a skeptical view, because in his opinion you can see the quality of the light on the skin of the actors. The brownie points, he also mentions, are the saving of movie and time. He used two light sources, "Litemate" and "ARRI Skypanel". The first features benefits such as the flexible and quick versatility handling, for instance the feature fixed on a wall, with tape. The easy controlling of color and range of the color were the benefits for the second feature.

Peter Zeilinger, ASC, BVK (2018) states the LED can be easily power with a battery or used in combination with a drone, this is only working with LED light features.

Bianca Cline (2018) describe the control function of the programs is a benefit for the technique of this system, this is a possibility to program a chronology for the light well shooting a scene. Another point the LEDs have is to sham any kind of light, for instance a glow, to bias this effect of the light to the discretion. The camera can be dubbed with the light, to use them as kind of flashlight.

5.1.5 Advantages and disadvantages

Peter Zeilinger, ASC, BVK (2018) states that the issues that the use of LEDs can have are using really strong light, these systems are too expensive and need an amount of energy which is too high.

Bianca Cline (2018) claims that the benefits for the LEDs is the handling is that you can place this feature in tiny places, such as cabinets and blankets. This flexibility of the system is one point, also the LED can be producing soft light, even when the light source is small, not comparable to other none LED light sources, there, it is only working when the source itself is soft. To understand a LED source is producing a hard light, but because of the number of source it is a soft light. Another significant point is the many sidedness, for instance on set using of different color, this control function is helping to economizing, to need less time and no foils, which is saving money. Not only well building phase the color controlling is really efficient, also well shooting the color changing is a supple tool.

Peter Zeilinger, ASC, BVK (2018) mentions that LEDs are less noisy than HMI ballasts. The incandescent lamp is hotter and needs more energy but it is less noisy than LEDs.

Bianca Cline (2018) claims the benefit of the LEDs in contrast to other light source, is the temperature of the source is low, because this feature is not producing much heat. This

function is a benefit for the working atmosphere on a set, for the talent. The quick and flexible position change of the source, without any trouble of safety.

Peter Zeilinger, ASC, BVK (2018) states that the LED lights are flat and are spreading too much, this can be a issue for the imitation of the sun light. Because this light should really be a hard light and therefore, other light sources than LEDs should be used.

5.1.6 Handling of colors

Peter Zeilinger, ASC, BVK (2018) states that the Digital Sputnik is handling the spectrum, while emitting only those wavelengths that the sensor can handle, so it is not a missing spectrum.

Bianca Cline (2018) defines the improve of the output of colors was amended, for instance the reduction the excess of green as a color aspect of this light source. Now the real colors and the reduction of the color, the improvement have convinced.

Judd Hillman (2018) describe the change because of the bicolor aspect of the LEDs as significantly. Therefore he mentioned the avoiding of using gels or other light source because of the changing radical the colors.

6 Conclusion

To begin with the conclusion, it has to be mentioned that the topic light in movies is huge. The first part is the light in general, secondly the LEDs and the third part are interviews and article from experts for the application of the LED. This part is quiet revealing, to answer the research question, "Why is it important to use LED lights on movie sets and what changes concerning the handling, technology and technique?" and to clear some other open points.

It is to say, that the LEDs have found they place in the film industry, because of the easy and flexible using of this sources, the weight, the color controlling function and all the other benefits for this system. The LED manufactures are constantly trying to sought solutions to improve the current technology, and to increase the quality of the light, make the work flow better and to advance the technique, to save money, power, gels and time.

The film industry has been using light for many decades now and there are many ways, understandings and uses of light, which would go beyond the scope of this bachelor thesis. After carefully weighing up the arguments, it can said that the comparison of the systems is not really significant, because every light source has there eligibility and the important fact is to know, how to use it and why it is the choice.

Undoubtedly, there are some points, questions or parts which were not considered in this research paper, there where mention in the concept of this paper, but due to the fact that the coverage of this paper is not big enough and/or there are no sources which cover the points, at this time. That can be recommend for future research. Such as "the light setting for different genres and the change of light", "the change of framing, the use of perspective and the point-of-view due to technological innovations" or "Light and how to setting the light, a theoretical and practical view".

Finally, it can be said, that light is not light. This is an obvious conclusion but sometimes the comprehension of the obvious makes it different. From my point of view the theoretical aspects and understanding are really important. The combination of researching and the practical usage of the light as a cinematography tool, during my exchange semester at Utah Valley University, help me to get a better knowledge for this tool, which I will expand.

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A Appendix

A.1 ECAMPUS UPLOAD AND CD

This medium contains all literature, in book, magazine, paper, and website form, including the associated snapshots. In addition, the data medium contains all mail interviews in PDF format, the transcribed interviews can be found in part B of the appendix.

B Appendix

This appendix includes all transcribed mail interview about the use of LEDs on set, in alphabetic order.

B.1 Mail Interview with Bianca Cline

Could you please introduce yourself?

My name is Bianca Cline and I am a cinematographer.

How long have you been working with LEDs on the film sets?

I have been using LED's on set for about 5 years.

Why is it important to use LED lights on movie sets?

LED's are quite interesting and continually improving.

What makes the use of LEDs in movie sets interesting?

I think LED's are helpful because they are so versatile. s

What changes in the handling of the light? Are there other approaches (eg. in production, creative use and working methods, workflow and handling)?

You can make any shape or size of light source that you need. I started using LED as strip lights which are so great because you can hide them behind anything that you need.

Does this technology change the workflow on the set? If so how?

The first LED's that I used were less than 1" wide and could be as long as we needed them to be. I have used LED light pads that are custom made to fit the bottoms of Coke bottles. I have used LEDs to fit into small cracks in our sets. They can also be very large. I have used LED lights that are 2'x8' and they are only 2' thick.

What are the advantages (benefits) and disadvantages of LEDs in general?

They are great for hiding in ceilings or closets or any small spaces we might need. Even though they are so small they are also very soft which is counterintuitive to working with tungsten, HMI or other traditional light fixtures. They are soft because in the aggregate they create a broad source. Each LED light creates very hard light, but because there are so many of them it creates a softer source. The other great advantage to using LED's is their versatility. With RGB control we can create nearly any color which saves time on set,

in testing, and in the expense of not buying gels. The LED's can change smoothly change from one color to another in shoot.

Especially for the handling and the workflow?

They are programable so you can have them run a lighting sequence during a take. LED's can also be easily manipulated to simulate fire, or a tv, or any other lighting effect you may want. LED's can work as a strobe light and can be synched to the camera to simulate the effect of a flash bulb.

What's changing in technology in recent years? (OLED, LED)

LED's are also much more lightweight than than their tungsten or HMI counterparts. They are easier to attached to ceilings, cars, and even people. They are easy to carry around handheld for certain shots. They can be fixed to ceilings with paper tape when necessary.

Color fastness, noise level, durability, durability, heat consumption, color temperature, light shaping, ... How are these issues / limitations dealt with?

LED's put out much less heat than tungsten or HMI units. That lower heat emission allows us to keep the set cooler which helps the actors in most situations. The lower temperature also allows us to put lights into places, or even touching elements of the set, that normally would melt or burn the set pieces.

How far have the LED lights changed in recent years to improve the color fast?

I've used LED light units in very remote regions or on boats and other places that would typically require a generator of some sort.

What changes in terms of technology?

LED lights are getting more powerful all the time, but I still love tungsten and HMI sources. If you need a very large light source then LED's are not quite there.

Which manufacturers are customary with your last sets? And why were they used? Did you have any specialties?

I love the quality of light that tungsten units create too when I have the space and need for them. I think that tungsten still creates a more pleasing light on faces than LED's. If you need a hard source then I use tungsten, HMI or xenon lighting units.

How does the bicolor aspect change the workflow on the set?

I think LED's have greatly improved their color output in the last several years. They have reduced the green spike which is what stopped me from using them originally. The green spike is unnoticeable and the color is very true.

How common are the LEDs on film sets?

I think that LED lights are another great option to have in your toolkit. I don't think they have replaced traditional units, but they have definitely given us another tool to play with. I often use LiteGear and Arri make great LED units.

Did you hear that there are sets that you can use to turn old lights into LEDs? If so, how practical is this system?

Are people placing LED lights inside of older lighting fixtures? I have used LED lights that are inside of fresnel housings and inside of Kino bulbs. I think it would be great to have LED lights in fresnel units but they are not nearly as strong as tungsten or HMI yet.

What change with light brings this light source with it? (Working method, handling ...)

I use LiteGear's Litemat series a lot and I am in love with Arri's Skypanels. I also often use Cream Sources which are very bright for their power consumption. All of those units are soft and malleable in terms of color. I also enjoy using Kino Flo's LED bulbs. They work and look like typical Kino bulbs, but they are RGB controllable.

Do you have preferred manufacturers? If so, which and why?

I have LED lighting units on almost every set I work on.

B.2 Mail Interview with Judd Hillman

Could you please introduce yourself?

MY name is Judd Hillman, I have been working the movie industry for close to 25 years. The vast majority in the lighting department. Currently i am the Best Boy Electric for Disney's ANDI MACK- Television show

What are the most interesting aspects of the LED lights for you?

The ability for easy color correction and the cool nature of most fixtures

How long are you working with LED lights on the movie sets?

Begun using LEDs about five years ago. However early generation LED fixtures could be poorly made, poor color rendition and bad frequency problems with cameras.

Why is it important to use LED lights on movie sets?

These days many LED fixtures have made former workhorse fixtures, namely, KINO FLO fluorescents obsolete mainly due to the ease from color correction and intensity change on the fly

What changes concerning the handling of the light? ■ Does this technology change the workflow on the set? How?

The most significant change in work flow of LED fixture on set, is the ability to change color temp and intensity rapidly. However the ability to design a stage set with lower wattage than units

Which manufacturers are common on your last sets? And why have you used them? Did they had any specialties?

We use mostly ARRI LIGHT PANELS as our large source LEDs and the LITEMAT series as smaller LED sources

How does the bicolor aspect change the workflow on the set?

Very important, the ability to make subtle or drastic color changes w/o gells or a different fixture is one of the great advantages of the new lines of LED fixtures

How common are the LEDs on movie sets now a days?

About 1/3 of the fixtures on my set/location package are LED

Did you hear that there are sets with which you can convert old lamps into LEDs? If so, how practical is this system?

I personally think buy new tested fixtures instead of conversion. There are too many variables that could make life difficult once a camera records data

B.3 Mail Interview with Peter Zeilinger

Können Sie sich bitte vorstellen?

bitte Informationen aus www.zeitlinger.camera beziehen, oder IMDB

Was sind die interessantesten Aspekte der LED-lights für Sie?

Sie sind leicht, verbrauchen wenig Energie (hocheffizient) werden nicht heiss und sind in Farbe und Farbtemperatur ohne Folienverbrauch veränderbar.

Wie lange arbeiten Sie mit LEDs an den Filmsets?

Seit es sie gibt, aber meist gemischt mit konventionellen Glühlicht und HMI

Warum ist es wichtig, LED-lights an Filmsets zu verwenden?

Energie und Umweltbewusstsein, Effizienz

Was macht den Einsatz von LEDs bei Filmsets interessant?

Sie sind leicht, verbrauchen wenig Energie (hocheffizient) werden nicht heiss und sind in Farbe und Farbtemperatur ohne folienverbrauch veränderbar, meist niedrige Spannung macht auch safety issues zu nichten

Was ändert sich im Umgang mit dem Licht? Gibt es andere Herangehensweisen (zb.: in der Produktion, bei der kreativen Verwendung und bei der Arbeitsweise, des Workflow und des Handling) ?

meistens sind die Lampen eher flächig oder steuern zu sehr, daher muss man immer noch andere Lampen verwenden, wenn man zum Beispiel hartes Sonnenlicht nachmachen muss.

Ändert diese Technologie den Workflow am Set? Wenn wie?

Bietet mehr kreative Möglichkeiten Farbe und Farbtemperatur zu beeinflussen, weniger die Schatten und Lichtkonzentration zu beeinflussen.

Welchen Vorteil (Nutzen) und welchen Nachteil Haben LEDs im Allgemeinen? Insbesondere für die Handhabung und den Workflow?

MEIST EBEN DIE FLÄCHIGKEIT DES LICHTES UND BEI BILLIGEN LEDS fehlen Teile des Spektrums , nicht zum Beispiel bei Digital Sputnik

Was ändert sich in den letzten Jahren in Bezug auf Technologie? (OLED, LED)

Tendenz geht in Richtung WiFi Steuerung und Bluetooth

Welche Probleme/ Einschränkungen gibt es bei der Verwendung LEDs für Film?

für sehr starkes Licht ist der Einsatz abgesehen von der Strommenge meist zu teuer

Farbechtheit, Geräuschpegel, Lebensdauer, Haltbarkeit, Wärmeverbrauch, Farbtemperatur, Formung des Lichts, ... Wie werden diese Probleme/ Einschränkungen behandelt?

Vorschaltgeräte von HMI sind meist lauter als alle LEDs, Glühlicht ist leise aber dafür heiss und braucht zu viel Strom.

Wie weit haben sich in den letzten Jahren die LED lights verändert um die Farbechtheit zu verbessern?

DigitalSputnik zum Beispiel emittiert exakt die Wellenlänge, die der Sensor aufnimmt, es ist also kein fehlendes Spectrum.

Was ändert sich in Bezug auf die Technik?

LED kann man leicht auch mit AkkuPower betreiben. Oder auf Drohnen hängen, das kann man mit keinem anderen Licht machen

Welche Hersteller sind bei deinen letzten Sets üblich? Und warum wurden diese verwendet? Hatten diese irgendwelche Spezialitäten?

DigitalSputnik und ARRI

Wie verändert der bicolor Aspekt den Workflow am Set?

Was ist ein bicolor Aspekt?

Wie häufig sind die LEDs an Filmsets?

Eigentlich Standard

Haben Sie gehört, dass es Sets gibt, mit denen Sie alte Lampen in LEDs umwandeln können? Wenn ja, wie praktisch ist dieses System?

das ist mir nicht bekannt, denn die LED technologie bedarf anderer Konstruktion

Welche Änderung mit Licht bringt diese Lichtquelle mit sich? (Arbeitsweise, Handhabung...)

oben schon gesagt

Haben Sie bevorzugte Hersteller? Wenn ja, welchen und warum?

DigitalSputnik und ARRI

Lichteinheit, farbeinheit und leichte bedienbarkeit