ALLNET® | the network people

Low-Light Technology

Stunning color video in near darkness

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1. CS<BACKGROUND

With security awareness spreading across the globe and particularly in the world's major cities, high-quality, 24/7 video surveillance has become a basic requirement. Since most crime happens at night, improving video quality during nighttime hours is one of the most important concerns of the video surveillance industry.

2. KEY TECHNOLOGIES

Lux refers to the unit of illuminance, and illumination at night is usually less than five lux. In general, less light means poorer image quality. Manufacturers have used various methods – increased gain, slow shutter, larger sensors or better lenses – to improve image quality in low lux scenes. ALLNET Low-Light Series cameras combine a larger sensor, a better lens design, along with multiple advanced technologies to provide excellent all-around daytime images, as well as high-quality color images in dark environments. This paper is an introduction to ALLNET's Low-Light technology.

2.1. LOW-LIGHT NIGHT VISION SENSOR

The image sensor is the core component of a camera. The sensor quality determines the image quality, especially in a low-illumination environment. ALLNET Low-Light Series cameras use specifically designed, nearly ½-inch sensors, yielding better photosensitivity, a high S/N ratio, and increased wide dynamic range. Their single pixel area is almost twice as large as that of a normal sensor and greatly improves the light passing quantity, which is an essential component in better low light performance.

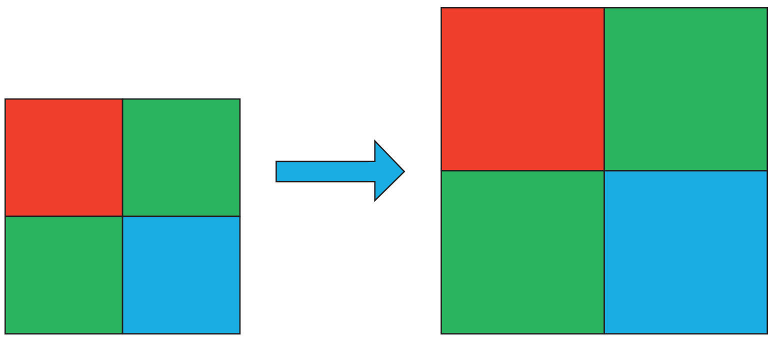

Figure 1 Single Pixel Area

At the same time, the Low-Light design modifies the order of the photosensitive layer and the metal layer in the sensor. Low-Light sensors move the photosensitive layer to the top to decrease light reflection and increase light usage. In this way, brightness improves by 30 percent. ALLNET calls this type of sensor a "backside illuminated sensor."

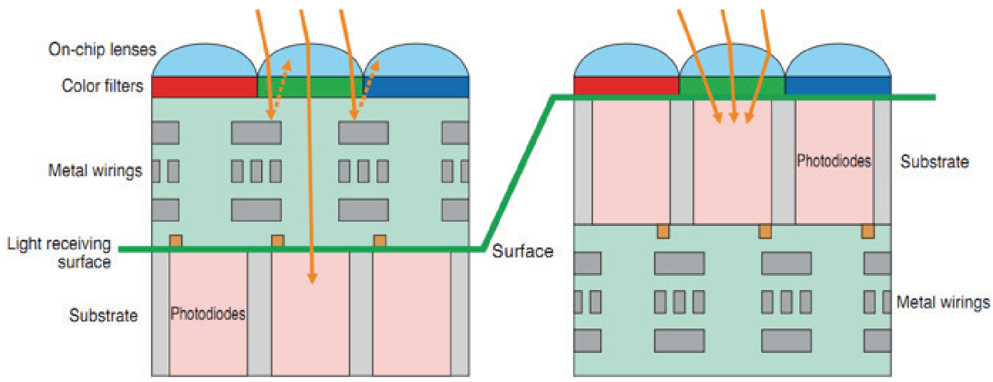

Figure 2 Sensor Pixel Cross-section, Standard (Left) and Low-Light (Right)

2.2. DARKEYE LENS

2.2.1. ASPHERICAL LENS

A standard camera lens consists of several spherical lenses and spherical lenses may cause image aberration because of their shape. In Low-Light cameras and DarkEye lenses, ALLNET adopts an aspherical lens to reduce image aberration. Unlike a spherical lens or a flat lens, an aspherical lens has a free-form surface. This allows the lens to process light from different points on the surface and to focus that light more precisely to improve image definition. With only one aspherical lens instead of several spherical lenses, the Low-Light camera solves the image aberration problem and improves light transmittance, which then improves image brightness at night.

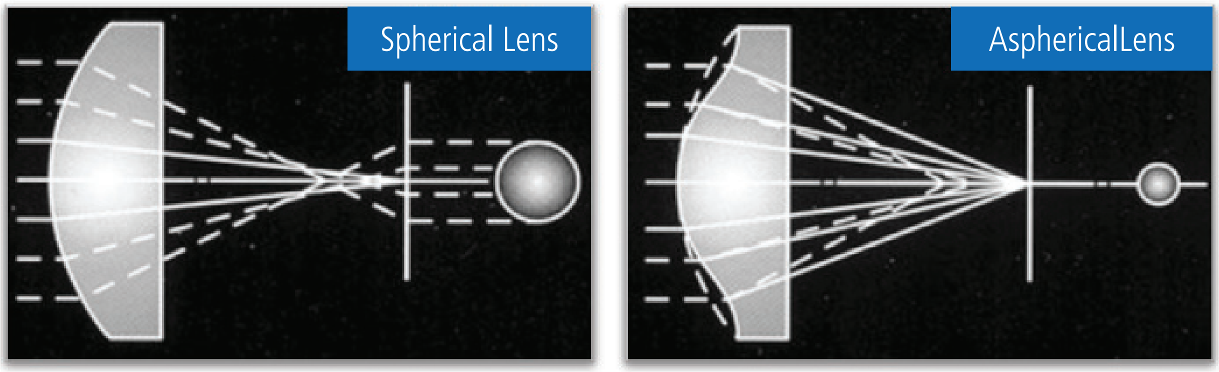

Figure 3A Spherical Lens and an Aspherical Lens

2.2.2. MULTI-LAYER ANTI-REFLECTION COATING

Light can lose intensity when it enters a different medium. Coating the surface of the lens reduces the reflection rate of visible light to less than three percent. This also improves the anti-reflection effect in the near-infrared spectrum (>700 nm). Multi-layer AR (anti-reflection) coating technology can maximize the light transmittance of the lens and limit the reflection rate of lights (including visible light and near-infrared band light) to less than 0.5 percent. With this technology, the image performance under low illumination is improved and can also prevent the influence of stray light and a halo-effect from a vehicle light or street lamp. At the same time, since the light transmittance of the near-infrared light is enhanced, we can achieve increased IR performance without increasing the performance of the IR lamps.

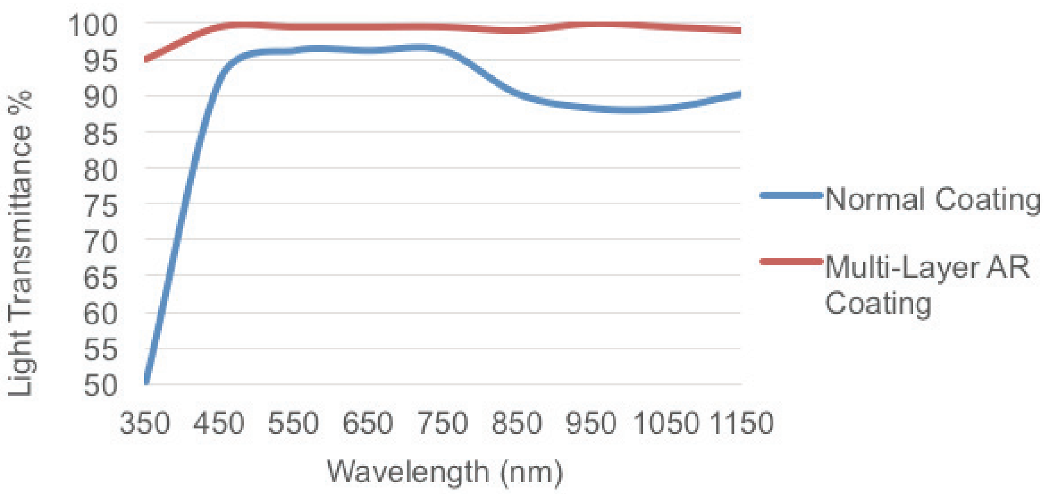

Figure 4 Light Transmittance of Different Coating Technologies

Figure 5 Night Vision Photo of ƒ/1.5 Lens (Left) and ƒ/0.95 Lens (Right)

2.2.3. ULTRA-LARGE APERTURE

The aperture (ƒ/ number) is a key factor that affects the image brightness. The larger the aperture, the more light reaches the sensor in the same duration. ALLNET constant aperture lenses employ larger apertures (in some cases as large as ƒ/0.95) and are able to provide brighter images with less noise and more details.

2.2.4. CONSTANT LARGE APERTURE

The nominal aperture value of an ordinary vari-focal lens usually refers to the aperture value when the lens focuses at the wide-angle end. As the lens focuses toward the telephoto end, the focal length increases and the aperture decreases. The ALLNET constant aperture lens retains the same aperture value even when the focal length is adjusted. Thus, the image remains bright when the focal length varies.

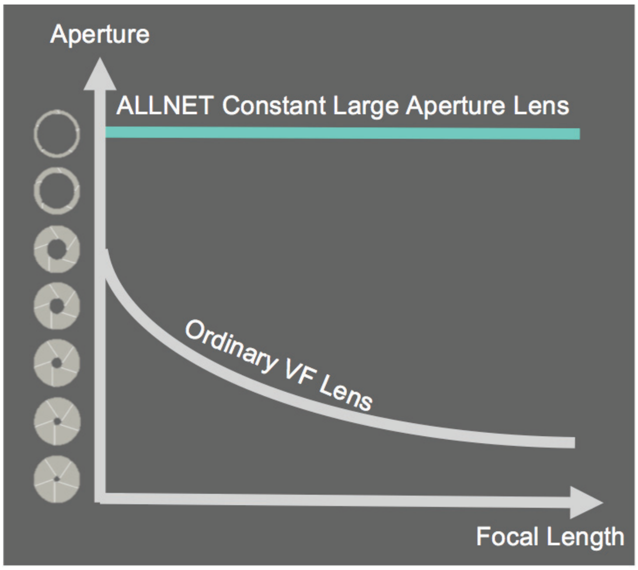

Figure 6 Constant Aperture

2.3. SELF-ADAPTIVE ISP* TECHNOLOGIES

2.3.1. SMART GAIN CONTROL

The gain value refers to the amplification of the image signal. When the camera is in a low illumination environment, the gain can be increased to amplify the signal intensity and improve the image brightness. However, if the gain is increased too much, image noise will increase as well. ALLNET's strategy to get the best image quality at night is to dynamically control the multiple gain values according to the actual image by taking into consideration sensor stability, image noise, and color.

* ISP – Image Signal Processing

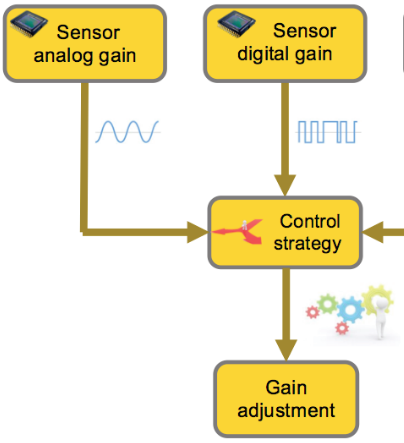

Figure 7 Smart Gain Control Flow

2.3.2. AUTO NONLINEAR IMAGE ENHANCEMENT

A camera sensor linearly transmits an optoelectronic signal, while the human eye nonlinearly senses light. ALLNET Low-Light cameras are able to enhance the image signal similar to the human eye, by adjusting the gamma curve nonlinearly.

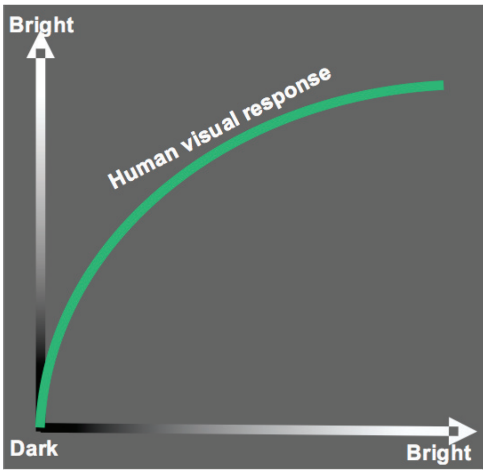

Figure 8 Nonlinear Light Response of Human Eyes

ALLNET's self-adaptive nonlinear image enhancement technology is based on illumination. The technology adopts a self-adaptive gamma curve to enhance the image to get more details in a low illumination environment. The illumination parameter decides the gamma curve. The different illuminances correspond to the different values, thus generating the best gamma curve. When the camera is in a dark environment, the gamma curve automatically rises to increase the brightness of the dark area.

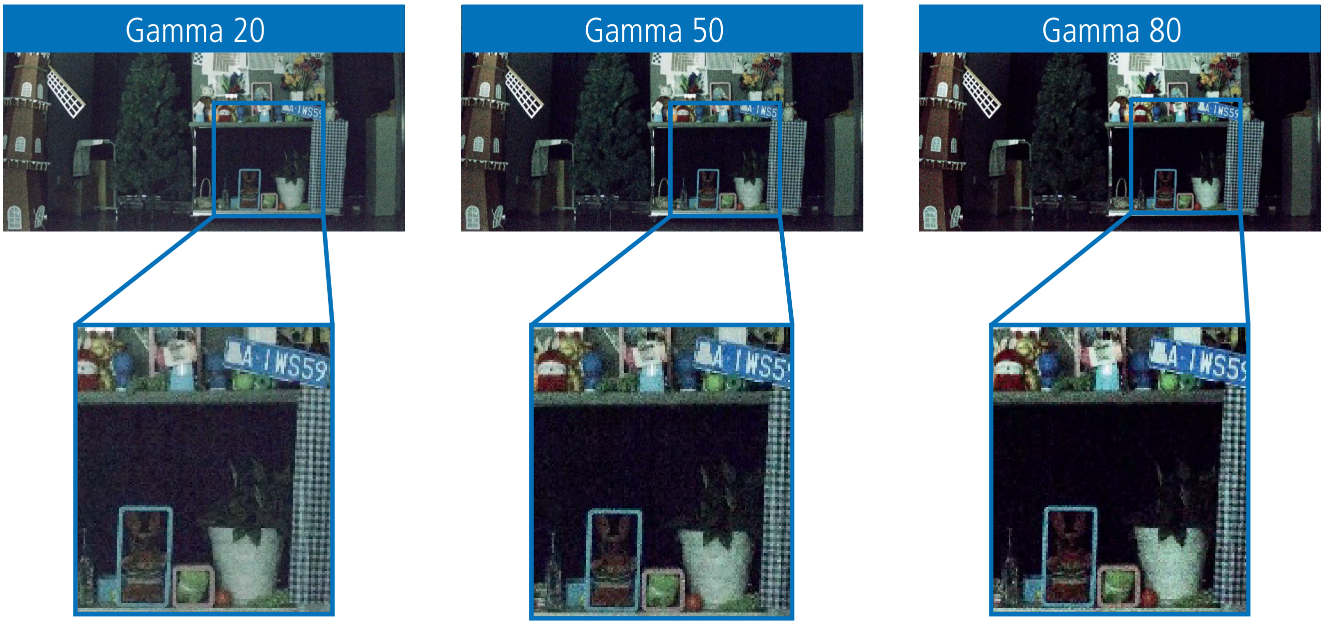

Figure 9 Image with Different Gamma Curves

2.3.3. MULTI-EXPOSURE

When a camera is in a dark environment, the low illumination often results in an inadequate charge on the sensor and a reduced S/N ratio. To increase the image brightness and the signal intensity, ALLNET Low-Light cameras use multi-exposure technology, which increases the dwell of the charge accumulation. See the photos below.

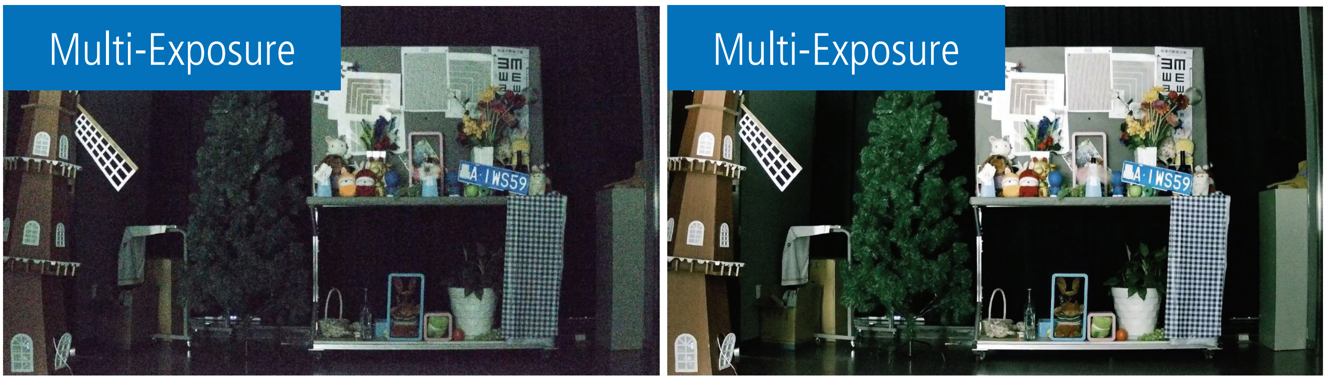

Figure 10 Multi-Exposure Off (Left) and On (Right)

ALLNET combines smart gain control with multi-exposure technology and develops an auto-adjustment algorithm that is similar to human eyesight.

2.3.4. SELF-ADAPTIVE DETAIL ENHANCEMENT AND NOISE REDUCTION

Limited by the S/N ratio, the noise in the output image from the sensor cannot be removed. In a dark environment, the camera will amplify the signal to improve the image brightness and definition, but the byproduct noise is also amplified. The 3D DNR module in the ISP can reduce the noise both spatially and temporally. To obtain an image with high definition and low noise, the image enhancement and the noise reduction levels must be balanced. Please refer to our white paper on Noise Reduction at www.allnet.de, for more information about this topic.

But the core element of Low-Light technology is a self-adaptive detail enhancement and noise reduction algorithm, which can automatically adjust the image, similar to the way the human eye does. This algorithm is based on the image content and the gain, and it is able to adjust the image in low illumination to the best effect.

Figure 11Comparison of Different Image Adjustment Parameters

2.4. HARDWARE NOISE REDUCTION

Beyond software noise reduction, ALLNET implements full-frequency suppression technology, a hardware noise reduction method, to further reduce noise. First, full-frequency suppression technology prevents "power noise" from influencing the sensor, thereby ensuring a more noiseless image signal in a low-illumination environment. Second, the power chip releases static noise at different temperatures to reduce random noise influence through the use of a linear power supply with a thicker copper layer that limits the static noise intensity within 20µV (root mean square - 10 Hz to 100 KHz). Finally, to avoid the noise interference caused by the analog and digital noise crosstalk, ALLNET's mixed wiring and digital-analog isolation further reduces noise interference and improves the video quality.

Figure 12 Normal Image

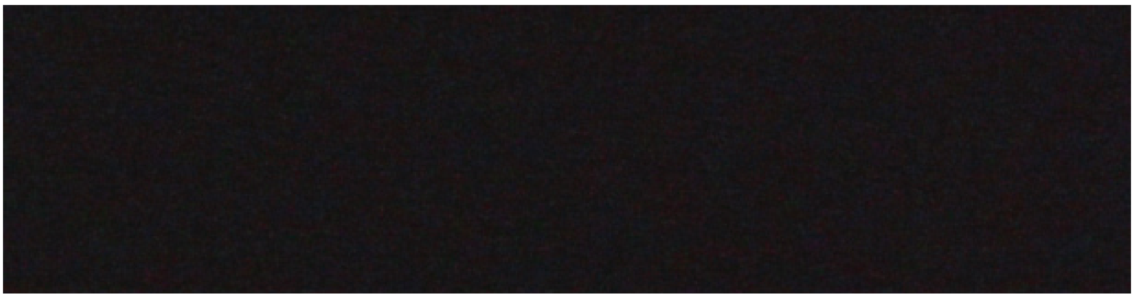

Figure 13 ALLNET Low-Noise Image

2.5. ANTI-FOGGING GLASS

To ensure image definition at night, anti-fogging measures are implemented inside the camera's bubble. ALLNET Low-Light cameras use an anti-fogging method that employs multiple coatings. The coatings are hydrophilic and can reduce the surface tension of water. Even in a cold environment, there is an extended anti-fogging effect.

Test photos of anti-fogging glass and normal glass are shown below.
Glass samples were placed five centimeters above a 60° C (140° F) hot water surface for 15 minutes.

Figure 14 Test Result of Anti-Fogging Glass (Left) and Normal Glass (Right)

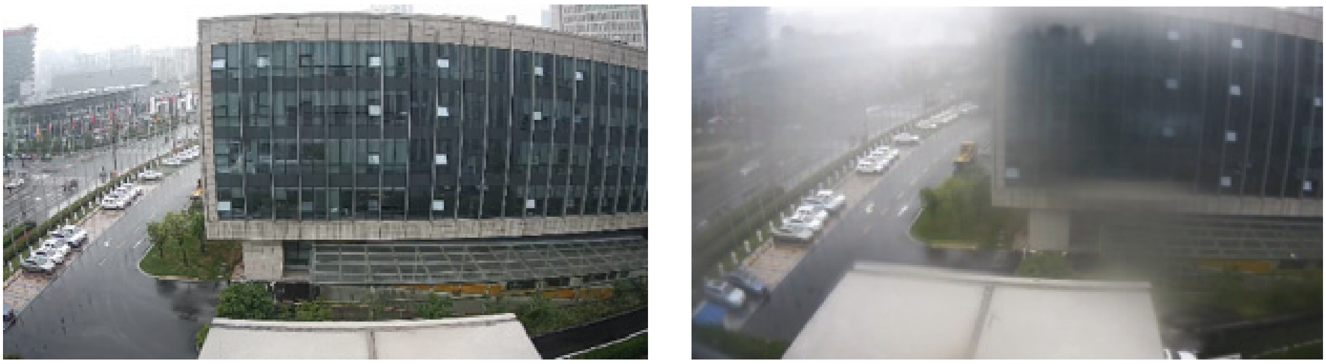

Figure 15 Camera Images with Anti-Fogging Glass (Left) and Normal Glass (Right)

2.6. NON-SILICON OIL HEAT CONDUCTION AND DISSIPATION

The sensor temperature greatly affects image quality. When the sensor temperature gets too high, the image noise increases and affects the camera's night vision. To obtain good image quality, ALLNET uses a heat conduction material that has high-heat conductivity, ultra-low heat resistance, and no silicone oil. It can quickly absorb heat, clear any sensor hot spots, and transmit heat to a metal sheet, which expands the heat dissipation surface.

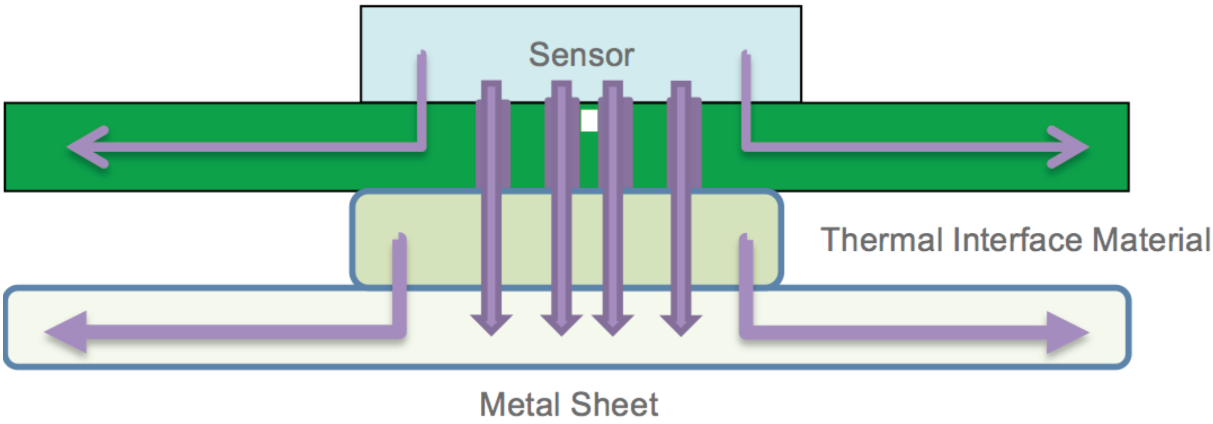

Figure 16 Non-Silicon Oil Heat Conduction and Dissipation

The Thermal Interface Material (TIM) has low hardness and high compression ratio properties, as indicated in Figure 17. The figure indicates little change of the TIM under different compression ratios and therefore minimizes shape changes of the PCB plate and any related defocusing.

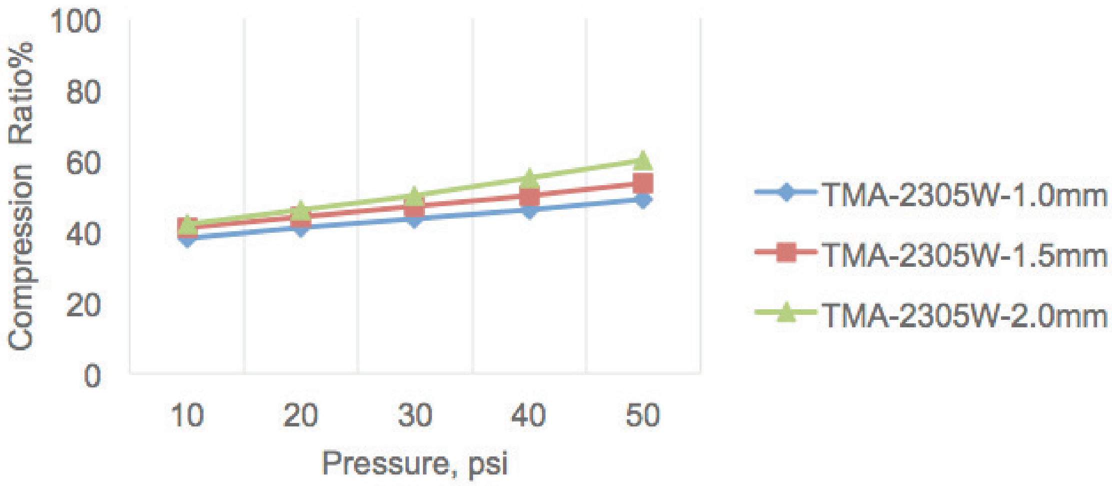

Figure 17 Compression Ratio Curve

3. APPLICATIONS AND ACTUAL EFFECT

Low-Light technology has been applied to various cameras. The technology excels in any low illumination environment that requires high-quality video surveillance. Therefore, Low-Light Series cameras are commonly installed in parking lots, schools, airports, factories, hotels, museums, or any area where lighting is a challenge.

Scene 1: Parking Lot

Figure 18 Photos Taken with iPhone 6s (Left) and Low-Light Camera (Right)

Scene 2: Field

Figure 19 Photos Taken with iPhone 6s (Left) and Low-Light Camera (Right)

4.SUMMARY

Low-Light cameras implement a larger sensor, a larger lens aperture, and smart gain control technology to dramatically improve nighttime image performance. Noise reduction improvements in hardware and software effectively reduce image noise in low illumination scenes. Finally, anti-fogging and non-silicon oil heat conduction and dissipation enhance image definition and ensure Low-Light cameras output bright, clear, high-quality color images at night, thus providing highly effective video surveillance around the clock.

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