APPLICATION NOTE: Optical Components for SWIR Imaging

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As a manufacturer of turnkey optical solutions, including coatings that range from mid-UV into visible and out to near-infrared wavelengths, Precision Glass & Optics (PG&O®) is acutely aware of the challenges that low-light imaging can present. For many applications in harsh or low-light environmental conditions (nighttime, fog, smoke, water vapors, etc.), devices operating in the visible range of light cannot process or provide a high quality image because of unfavorable lighting and significant shading. The challenges in capturing high quality imagery can be overcome by using the short-wave infrared (SWIR) range of light. Light emitted in the short-wave, mid-wave, and long-wave infrared ranges is invisible to the human eye. However, MWIR and LWIR are referred to as thermal imaging in which they detect the heat given off by the object of interest. While this is useful in applications where the detection of an object is desired, MWIR and LWIR are less useful in identification or recognition of a specific object. Short-wave light, on the other hand, is reflected, transmitted, and absorbed by an object and provides object imaging with a strong contrast and high resolution. The SWIR light source may be natural light emitters like sunlight, moonlight, starlight, or nightglow. The useful SWIR range is from approximately 1 - 1.4 µm to 2.5 µm, which is higher than the near-infrared range of 0.75 to 1.4 µm, and is more tolerant to low-level noise sources like fog and smoke, and lower than the atmospheric absorption band of 2.5 to 3 µm, and therefore can image through such conditions with greater detail. For instance, you might be able to see a person carrying a long object on a dark road at dusk as a glowing object with little or no detail using MWIR or LWIR. Using SWIR, it is likely you can see enough detail to identify whether the person is carrying a broom or a rifle.

Most of the optical materials used for components that operate in the visible range – glasses and coating materials – are also transparent in the SWIR range. Therefore, in the SWIR spectral range, optical components can be made of the same materials with the same technologies as conventional, low-cost components used in the visible range. However, to obtain the very best optical quality and imaging performance, SWIR optical components must be specially designed.

Advantages to SWIR imaging devices include the combination of high sensitivity and resolution with small size, low power consumption, and the sensors do not require cryogenic cooling, which can be quite costly. These unique features make the short-wave infrared wavelength detectors ideal for many critical applications, including:

- Electronic board inspection
- Solar cell inspection
- Product inspection
- Agricultural inspection
- Semi/Solar inspection
- Laser beam analysis
- Hyper spectral imaging
- Range phenomenology
- Astronomy
- Identifying and sorting

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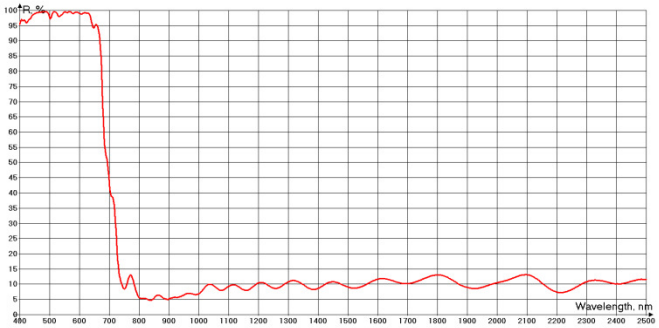
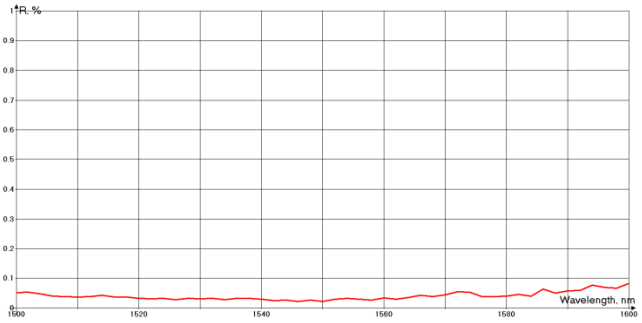
- Medical inspection
- Hi-temp defect inspection
- Hi-temp process monitoring
- Process quality control
- Non-destructive testing
- Emission microscopy
- Imaging spectroscopy
- Surveillance
- Anti-counterfeiting
- Machine vision
- Night vision
- Through smoke and fog vision
- Military laser see spot (1064 and 1550nm lasers)

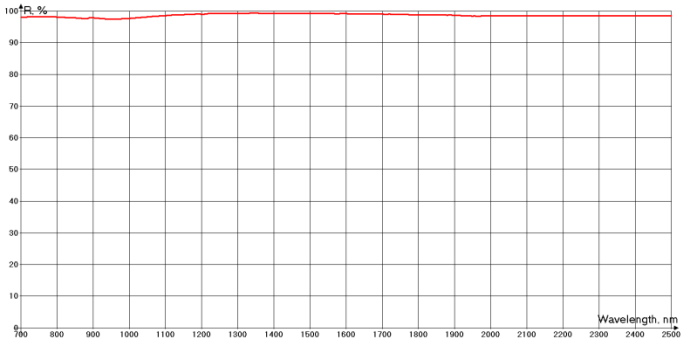
The following graphs show actual data from PG&O's optical thin film coating lab:



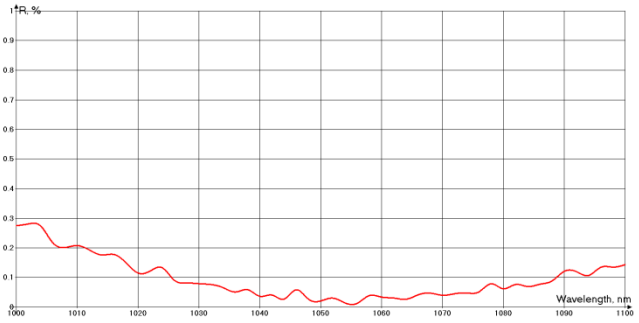
Cold mirror blocking visual range of light and transmitting NIR and SWIR ranges



Antireflection coating for 1550 nm



Enhanced metal mirror for NIR and SWIR ranges



Antireflection coating for 1064 nm

As shown in the graphs above, the multilayer cold mirror coating blocks (reflects) more than 98% of visual light and transmits 90% of NIR and SWIR radiation. Antireflection coatings provide very low (less than 0.1%) reflectance at the given wavelength of NIR and SWIR range. The enhanced metal mirror reflects wide range of both NIR and SWIR radiations. It is important to note that the metal mirrors are enhanced with hard dielectric layers, providing not only very high reflectance but also excellent durability. **Figure 1** shows a variety of optical thin film coatings manufactured by PG&O.

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Figure 1

PG&O can custom design coatings to meet each customer's detailed specifications. Big volume coating machines feature oil-free, cryo-pumping systems, electron beam evaporation, substrate heating, ion-beam source for substrate cleaning, ion-beam assisted deposition, and optical and quartz crystal process monitoring (**see Figure 2**). In addition, the coating machines are specially designed for the highest coating uniformity and planetary tooling. All coatings are manufactured to MIL specifications, including metal and dielectric mirrors, beamsplitters, filters, antireflection coatings, neutral density filters, transparent electro-conductive coatings, and other hard and dense optical coatings for highest performance and durability. For more information, please visit www.pgo.com or call 1-714-540-0126.

Figure 2 – Large volume, thin film coating chamber.

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About the Author:

Vladimir M. Chutko, Ph.D. is a recognized specialist in optical coatings, vacuum engineering, technological ion sources and ion beam technologies. He developed the ion beam figuring of precise optical surfaces technology and equipment, a few technological ion sources, vacuum engineering software, worked as the head of an optical coating department. Since coming to the USA in 1998, Mr. Chutko has been working on optical coatings deposition and on technological ion beam sources and processes. He worked at Reynard Corp. from 1998-2001; from 2001-2006, he continued his work as an independent contractor and consultant. In 2007, Mr. Chutko joined the team at Precision Glass & Optics as the coating lab manager. A seasoned professional in the field of optical coatings, he has 40 articles and patents on ion sources, ion beam technologies, and thin film coatings.

About Precision Glass & Optics (PG&O®):

Precision Glass & Optics is a global supplier of optical components and precision thin film coatings, including complete turnkey optical solutions for military and defense, biomedical, life science, aviation, aerospace, and digital cinema. The company's optical thin film coating expertise covers wavelength ranges from the mid-ultraviolet (UV) spectral region into the visible and out to the near-infrared (NIR). PG&O operates a full optics fabrication shop, three large coating chambers, and an expert, in-house engineering department to deliver cost-effective, highly reliable optics and advanced thin film optical coatings on a variety of substrate materials and a host of shapes and sizes.

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