

NIGHT VISION IMAGING SYSTEMS

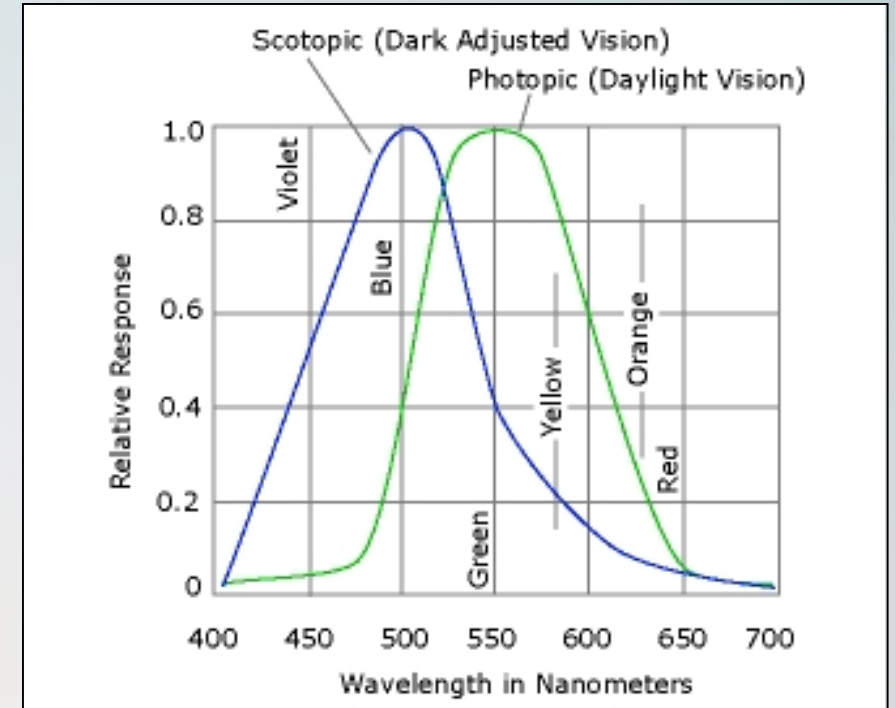
NVIS

Kopp Glass, Inc.
Research & Engineering Department



HUMAN EYE LIGHT SENSITIVITY

- ▶ **Photopic** – sharp daylight vision or bright illumination provided by cones – maximum sensitivity near 555 nm
- ▶ **Scotopic** – night, gray image vision provided by rods – maximum sensitivity near 515 nm
- ▶ **Mesopic** – twilight vision with both rods and cones activated



State where both rods and cones are active is Night Vision

NIGHT VISION GOGGLE SPECTRAL RESPONSE

- ▶ NVG greatest response and sensitivity in visible red and near IR range
 - ▶ Specifically the 600-930 nm range
- ▶ Not thermal imaging system (2-113 μm response)
- ▶ Generation III NVG intensifier tubes (GaAs) respond to starlight radiation
- ▶ Can amplify photon energy (incoming light) by 30,000 X



ELECTROMAGNETIC SPECTRUM – NVG RESPONSE

- ▶ NVG greatest response and sensitivity in the visible red and near IR range
 - ▶ Specifically the 600-930 nm range
 - ▶ Human eye cannot effectively view wavelengths beyond approximately 700 nm
 - ▶ Red color a potential NVG interference source
- ▶ Not a thermal imaging system (2-113 μm response)
 - ▶ Forward-Looking Infrared systems (FLIR – approximately 8-15 μm)



NVG AND COCKPIT LIGHTING



- ▶ NVG used to view outside crew stations
- ▶ Interference from light sources from both outside and inside cockpit
- ▶ To maximize NVG performance, suppression of energy output from other sources is required
- ▶ If outside energy sources are not suppressed, interference with NVG will cause “blooming” of image due to amplification of light



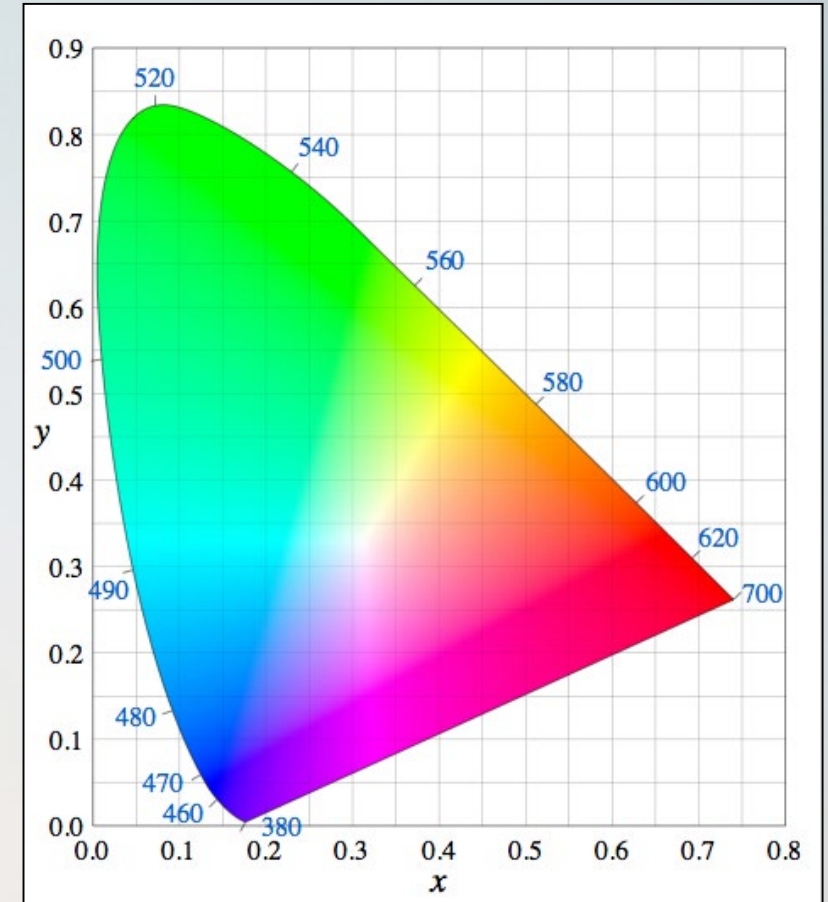
LIGHT INTERFERENCE SUPPRESSION

- ▶ Utilization of optical fibers – glass and polymer
- ▶ Critical NVIS compatibility per MIL-STD-3009:
 - ▶ NVIS Radiance (NR): NVG interference produced by a light source over wavelength range of 380-930 nm
 - ▶ Cannot exceed NR of starlit tree bark = 1.7×10^{-10}
 - ▶ Photopic Transmittance (Y%): Ratio of filtered light to unfiltered light
 - ▶ Contrast: Measurement of ambient light reflection from filter surface for daylight readability of display
 - ▶ Chromaticity: Four color regions for crew station lighting
 - ▶ NVIS Green A—Primary color for station lighting
 - ▶ NVIS Green B—Alternative green color for special components
 - ▶ NVIS Yellow—Represents caution and warning indicators
 - ▶ NVIS Red—Warning signals
 - ▶ NVIS White—Utility, map, work, and inspection lighting



LIGHTING CHROMATICITY

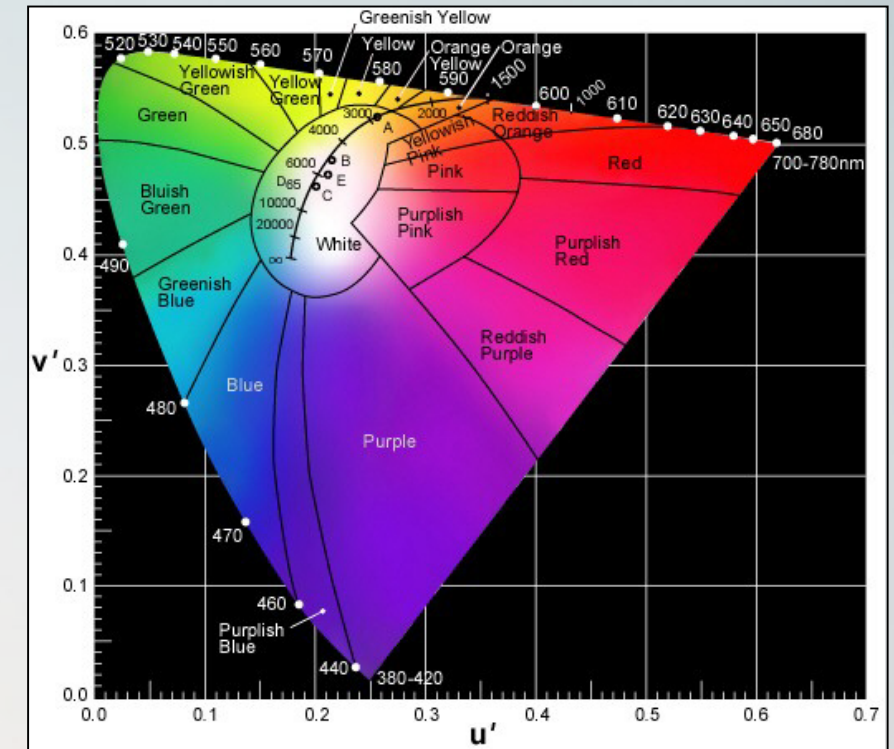
- ▶ 1931 CIE used to quantify color for wide range of applications
 - ▶ Aviation colors
 - ▶ Indicator colors
- ▶ Coordinates note fraction of color
 - ▶ x – **RED**
 - ▶ y – **GREEN**
 - ▶ z – **BLUE**
 - ▶ $x + y + z = 1$
- ▶ Color uniformity best illustrated using ellipses
- ▶ NVIS colors utilize the 1976 UCS (Uniform Chromaticity Scale) diagram



1931 CIE

NVIS LIGHTING CHROMATICITY

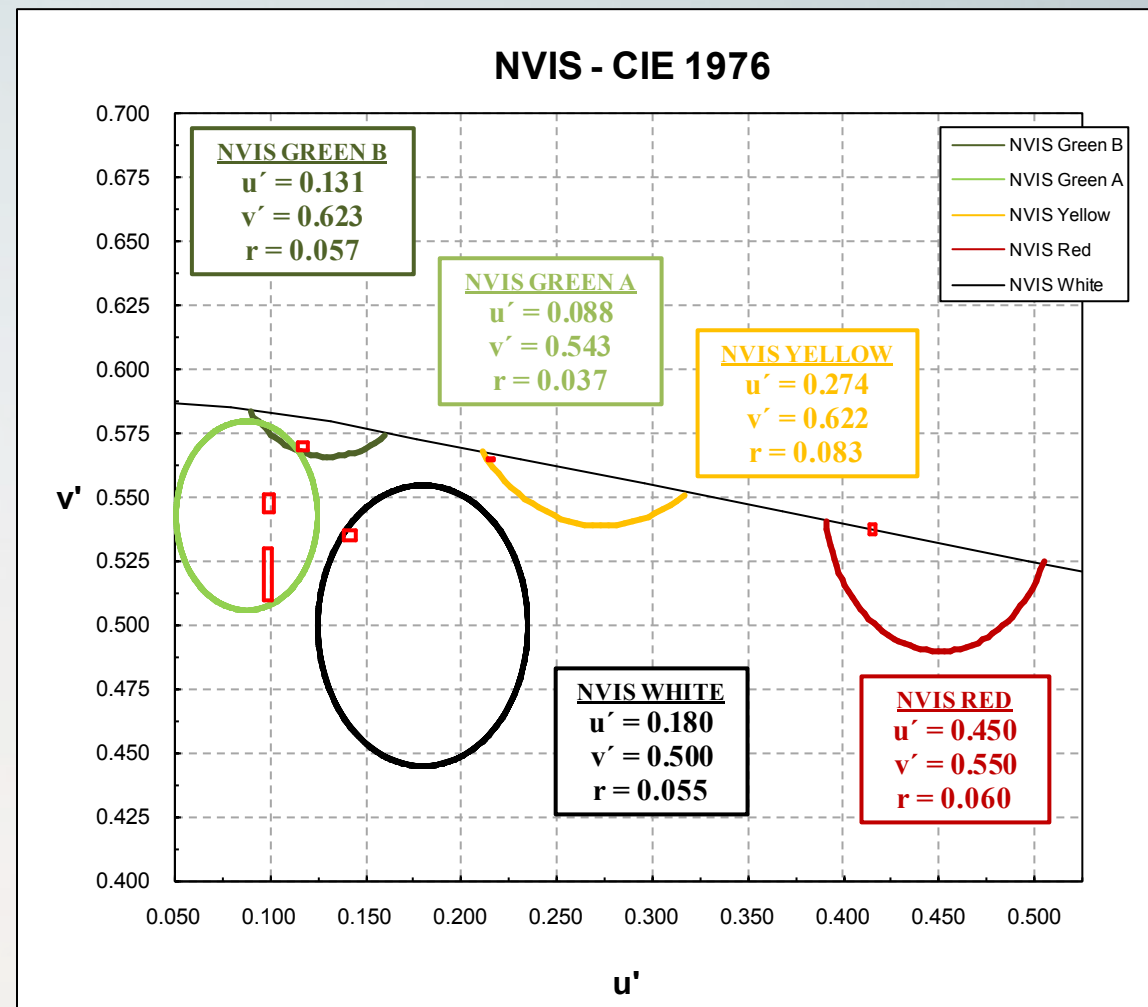
- ▶ NVIS uses 1976 CIE color diagram
- ▶ Convert color coordinates (x and y)
 - ▶ $u' = 4x/(-2x+12y+3)$
 - ▶ Represents fraction of **RED**
 - ▶ u' must remain relatively low due to NVG sensitivity
 - ▶ $v' = 9y/(-2x+12y+3)$
 - ▶ Represents fraction of **GREEN**
 - ▶ Green maximizes color region of maximum visual acuity
- ▶ Color uniformity
 - ▶ Circles on 1976 CIE
 - ▶ Ellipses on 1931 CIE



1976 CIE

NVIS CHROMATICITY REGIONS

- ▶ Color uniformity
 - ▶ Colors appear different within MIL-STD-3009 circles
 - ▶ Kopp Glass has reduced acceptable color range
 - ▶ Color is different with different light sources
- ▶ Color uniformity is critical to avoid
 - ▶ Undesired distractions
 - ▶ Color saturation can lead to eye fatigue
- ▶ Circle equations are less complex and easier to use vs. ellipse equations
 - ▶ $(u' - u'_0)^2 + (v' - v'_0)^2 \leq r^2$



KOPP GLASS NVIS PRODUCTS

For cockpit lighting filter use

Molded and pressed products are a separate product line

▶ NVIS Product Nomenclature – 02YX

- ▶ **02**YX – First two digits represent glass composition series
- ▶ 02**Y**X – third digit represents the applicable light source
 - ▶ 0 = incandescent source
 - ▶ 2 = white LED source
 - ▶ 3 = green LED source



▶ 02Y**X** – Final digit represents nominal thickness of glass plate

- ▶ 1 = 0.5 mm
- ▶ 2 = 0.75 mm
- ▶ 3 = 1.0 mm
- ▶ 4 = 1.5 mm
- ▶ 5 = 2.0 mm
- ▶ 6 = 2.5 mm
- ▶ 7 = 3.0 mm
- ▶ 9 = 4.0 mm

▶ NVIS Product colors

- ▶ 0200 series – NVIS Green B
- ▶ 0300 series – NVG White
- ▶ 0400 series – NVIS Green A
- ▶ 0500 series – NVIS Green A (Intruder)
- ▶ 0600 series – NVIS Yellow B
- ▶ 0700 series – NVIS Red





HIGH-PERFORMANCE GLASS

- **FLEXIBLE VOLUMES:** Flexibility to scale volumes and minimize lead times through a range of production capabilities, glass melts that can range from 0.5lbs — 2,500lbs.
- **GLASS SCIENCE:** In-house engineering specialize in formulating on the atomic level. Custom glass development and formulations.
- **GLASS TESTING LAB:** Sophisticated measurement and testing instruments — thermal properties, spectral transmission, chromaticity, refractive index, and more.
- **PRECISION MOLDED:** Integrated manufacturing capabilities with in-house mold designers and fabricators. Our unique molding process allows for a variety of complex shapes and unique forms. Filter glass is molded to nominal thicknesses.

CONTACT

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STATS

Year Founded: 1926

Ownership: Closely Held

Location: Pittsburgh, PA, USA

Number of Employees: 150

Facility: 127,000 square feet

Quality System: ISO: 9001 Certified

MISSION

Our mission is to make the world safer and more productive through excellence in glass science, collaborative innovation, and the production of technical glass for unique and demanding applications.

