



INFRARED WINDOWS

Infrared windows are used in specialized military and defense and scientific applications to protect the sensor or camera being used to collect information. Different infrared wavelength bands use different materials as their substrate.

Infrared windows require an anti-reflective (AR) coating on both surfaces of the window. There are two main types of AR coatings used.

- **High-Efficiency Anti-Reflective (HEAR)** coating is used to maximize light. This coating helps improve the efficiency of optical instruments, enhances contrast in imaging devices, and reduces scattered light that can interfere with the optical performance.
- **Diamond-Like Carbon (DLC)** coating is used when an AR coating is needed on optics that need to withstand harsh environments. A DLC coating is amorphous, extremely durable, has exceptional abrasion resistance, is electrically insulating, and optically transparent.

EMF has designed a custom DLC coating chamber and developed a proprietary PE-CVD technique that produces dependable, long-lasting DLC coatings on virtually all IR substrates.

Ideal Window Materials for IR Wavelengths

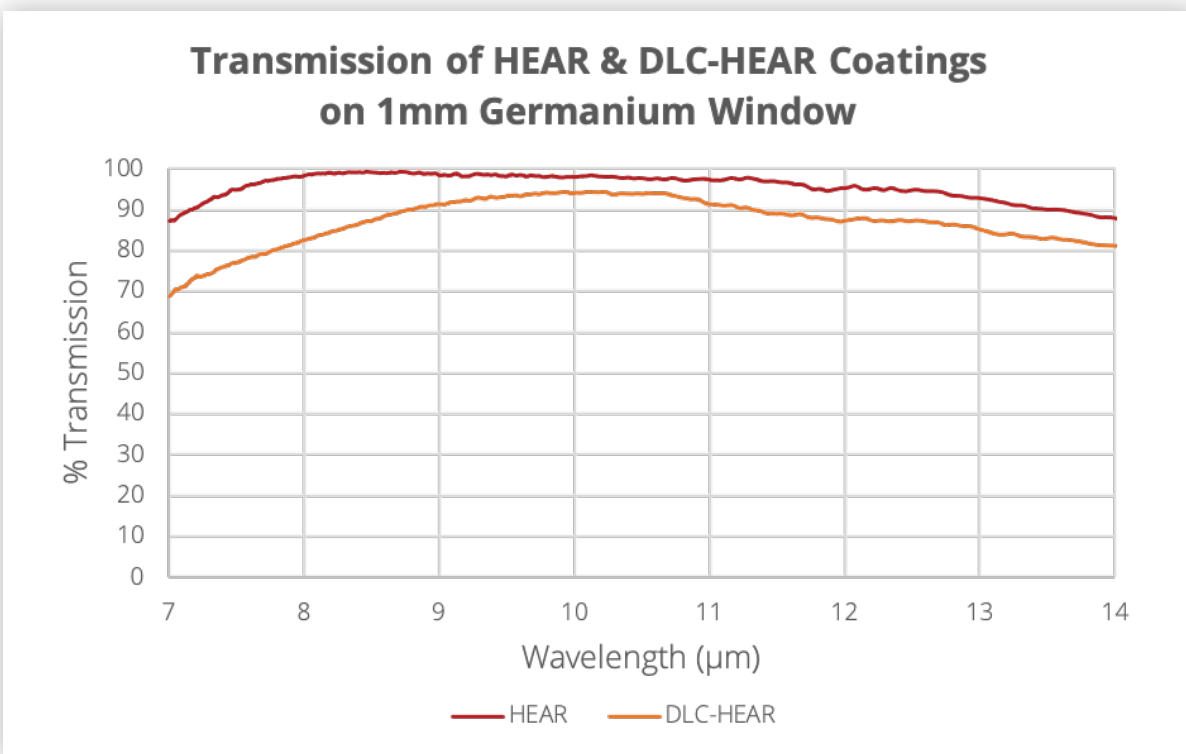
Wavelength Band	Wavelength Range	Materials
SWIR	0.9 – 2.7 μ	Glass Sapphire Calcium Fluoride Zinc Selenide Zinc Sulfide
MWIR	3.0 – 5.0 μ	Sapphire Calcium Fluoride Silicon Germanium Zinc Selenide Zinc Sulfide Chalcogenides
LWIR	7.0 – 14.0 μ	Silicon Germanium Zinc Selenide Zinc Sulfide Chalcogenides Barium Fluoride
MWIR- LWIR	3.0 – 14.0 μ	Silicon Germanium Zinc Selenide Zinc Sulfide Chalcogenides Barium Fluoride

Window Manufacturing Tolerances

IR Window Production

Materials	Glass, Sapphire, Germanium, Silicon, Zinc Sulfide, Zinc Selenide and Chalcogenides	
Shapes	Circular, Square, Trapezoidal, Free-form	
	COMMERCIAL	PRECISION
Diameter	4 - 200mm	4 - 200mm
Diameter Tolerance	+0/-0.100mm	+0/-0.025mm
Thickness	±0.100mm	±0.050mm
Clear Aperture	80%	90%
Power (P - V)	3.0λ	1.5λ
Irregularity (P - V)	1.0λ	λ/4
Bevel (Face width @ 45 degrees)	<1.0mm	<0.5mm
Surface Quality	80-50	40-20

Transmission Chart for HEAR & DLC-HEAR Coatings



DLC AR 8-12µm on External Surface

Specification	Test Conditions	Result
Reflectance	0-20° AOI	$R_{avg} \leq 3.0\%$ and $R_{max} \leq 8\%$ per surface
Transmission	0° AOI	$T_{avg} \geq 90\%$ from 8µm – 11µm $T_{avg} \geq 88\%$ from 8µm – 12µm using DLC & HEAR
Humidity	24 hrs, 95-100% RH, 120+/-4°F	Meets MIL-F-48616 / MIL-C-48497C
Temperature	-80°F to 160°F for 2 hrs at each temperature	Meets MIL-F-48616 / MIL-C-48497C
Solubility and Cleanability	Immersion test in acetone and alcohol for 1 hr instead of using trichloroethylene	Meets MIL-F-48616 / MIL-C-48497C
Adhesion	Adhesion (cellophane tape test with quick removal)	Meets MIL-F-48616 / MIL-C-48497C
Abrasion	Severe abrasion (20 cycles under 2 lbs force)	Meets MIL-F-48616 / MIL-C-48497C
Salt Fog	>72 hrs	Meets MIL-STD-810C, Para 509.1
Wind screen wiper	In a mixture of sand and water for 30 min at 100-200 rpm	Meets TS 1888, Para 5.4.3

HEAR 8-12µm on Internal Surface

Specification	Test Conditions	Result
Reflectance	0-20° AOI	$R_{avg} \leq 0.5\%$ from 8µm – 12µm
Humidity	24 hrs, 95-100% RH, 120+/-4°F	Meets MIL-F-48616 / MIL-C-48497C
Temperature	-80°F to 160°F for 2 hrs at each temperature	Meets MIL-F-48616 / MIL-C-48497C
Solubility and Cleanability	Immersion test in acetone and alcohol for 1 hr instead of using trichloroethylene	Meets MIL-F-48616 / MIL-C-48497C
Adhesion	Adhesion (cellophane tape test with quick removal)	Meets MIL-F-48616 / MIL-C-48497C
Abrasion	Moderate abrasion (25 cycles under 1 lb)	Meets MIL-F-48616 / MIL-C-48497C