



Abrasion Resistant Coatings for Polycarbonate Transparencies

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Outline

- Project– Improved DLC coatings for visors/glasses
 - Ballistic testing
 - Abrasion testing
 - Optical testing
- Introduction to Acree Technologies Inc.



SBIR Project

Sponsored by the Office of the Secretary of Defense (Phase I and II)

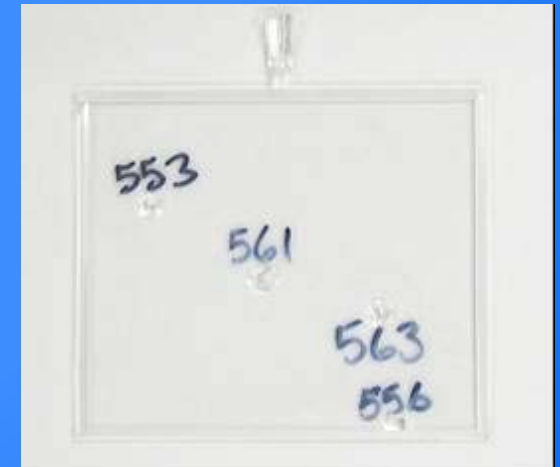
- To develop Diamond-Like-Carbon (DLC) coatings to improve the performance of eye-protection for the warfighter
 - *Improved ballistic performance (reducing the debit introduced by hard coatings)*
 - *Improved abrasion resistance*
 - *High visible transparency (no interference effects or coloration)*
 - Adhesion (tape pull)
 - Environmental durability (high temperature/humidity cycling, chemical exposure, weathering) MIL-C-48497A, MIL DTL 43511D



Ballistic Testing

Hard-Coatings used for abrasion resistance can degrade ballistic performance of polycarbonate via increased spallation originating in the coating. Testing focused on assuring no degradation in ballistic performance.

- Testing in accordance with MIL-V-43511D (T37, 17 grain, 0.22 cal, velocity 550-560 ft/sec)
- Samples were specific polycarbonate blanks used for ballistic testing by Gentex
- Coatings successfully passed ballistic testing



Abrasion Testing

Oscillating abrasion testing of coatings showed clear improvements relative to conventional polysiloxane hardcoatings.

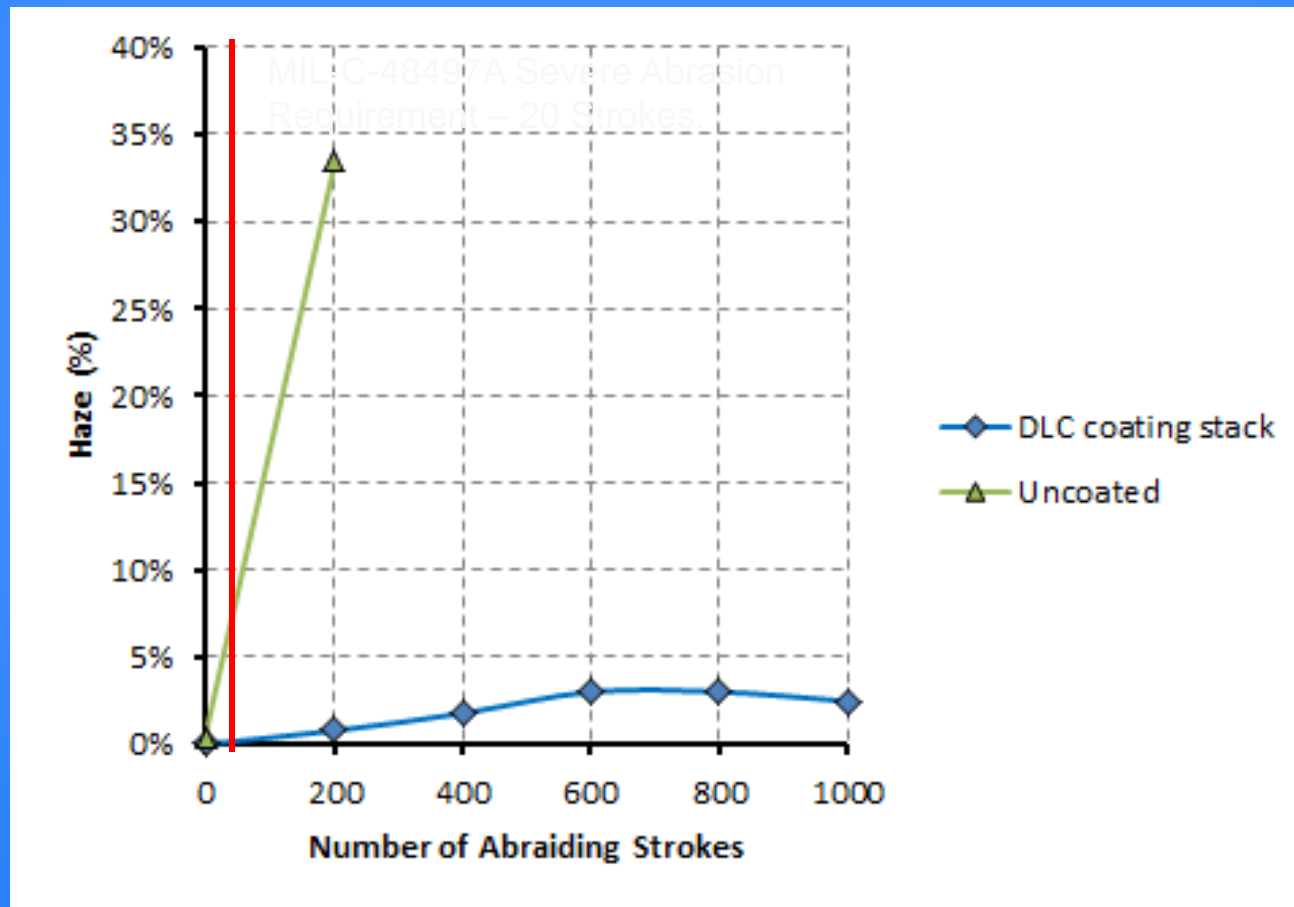


Micrographs of abraded regions of DLC, standard hard-coatings and uncoated polycarbonate



Abrasion Testing

Abrasion testing has demonstrated coating performance to 50x the number of strokes required by MIL-Spec.





Abrasion Testing

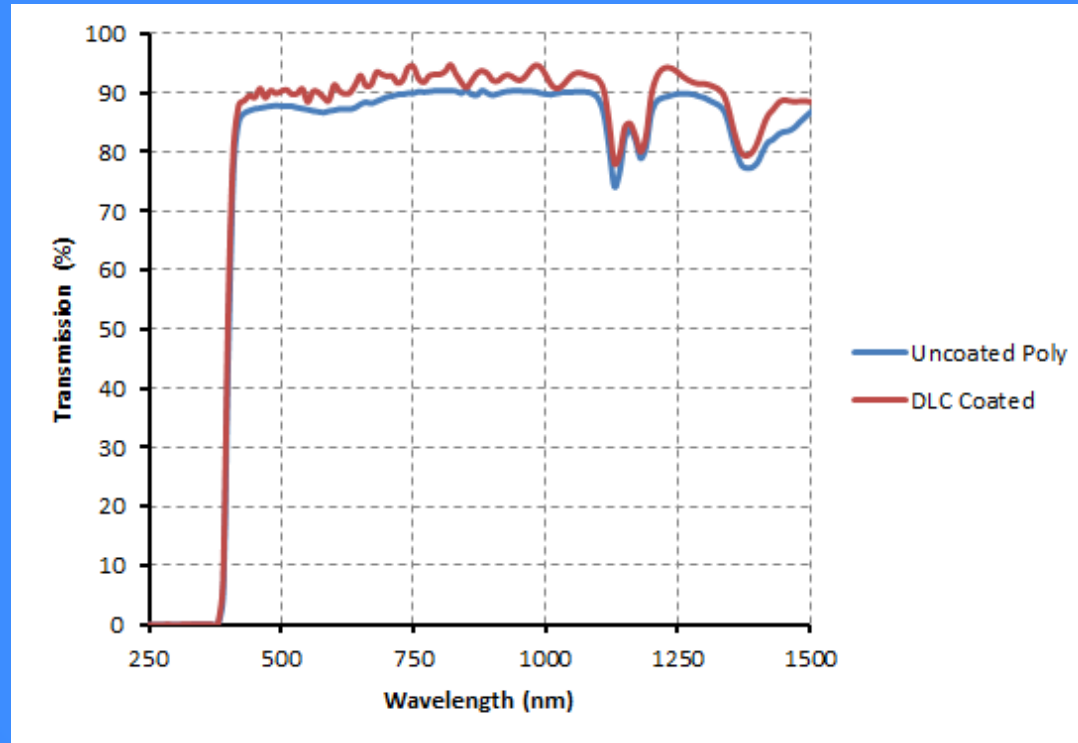
Additional abrasion testing has been performed through another project related to canopy coatings for rotor-craft.

- Oscillating sand abrasion testing (ASTM F735-06)
- Testing by our partner has found currently available DLC coatings fail to meet the performance of current Polysiloxane coatings
- Testing of our coatings has demonstrated superior performance to both Polysiloxane coatings, not demonstrated by current available DLC
- Test results show benefit of both the developed plasma treatment and coating

ID	Adhesion Promoter	Coating	Visible Transmission	% Change Haze 2000 Strokes
DLC-1 on Poly	CPS Treatment	DLC	88.1	5.7
DLC-2 on Poly	Polysiloxane dip + CPS Treatment	DLC	91.9	3.4
Dip Coat - 1	Polysiloxane dip	Polysiloxane	NM	9.4
Dip Coat - 2	Polysiloxane dip	Polysiloxane	NM	9.9
Polycarbonate	None	None	NM	63

Optical Testing

Coating provides excellent transparency through-out the visible, increasing transmission above uncoated polycarbonate.



ID	Color on Glass					
	x	y	Tc	L	a	b
1/8" Uncoated Poly	0.310	0.317	87.23	94.84	-0.46	0.31
Coated Poly (both sides)	0.311	0.317	89.92	95.96	0.06	0.48



Acree-About Us

- Founded in 2004
- Revenues are approximately 60% R&D, 40% commercial production
- 6,000 sf production and R&D facility
- ISO9001 and AS9100 Certified Production Facility
- Specializes in coating development and production
 - Erosion and Wear Resistant Hard coatings
 - Coating of large parts and/or small high precision components
 - Conductive transparent coatings, ITO, AZO, IZO
 - Optical coatings, oxides, Al_2O_3 , MgO etc.
 - Metals and alloys for corrosion resistance and other applications
- Serve both commercial and government customers
 - Aerospace and Medical companies
 - Air Force, Navy, Army, OSD, DARPA, DOE





Acree Technolgy

- In house coating capabilities include:
 - Remote plasma sources for treatment and coating of polymers
 - Cathodic arc (with or without magnetic filtering)
 - Pulsed filtered cathodic arc
 - Magnetron sputter deposition (DC, RF, mid frequency)
 - High Power Impulse Magnetron Sputtering (HiPIMS)
 - PECVD
 - Sources and chambers generally constructed in house to meet specific customer/production needs

- In house diagnostic/test capabilities include:
 - Optical testing (UV/Vis/NIR and FTIR)
 - Oscillating Taber abrasion testing (MIL 48497A, MIL-E-12397)
 - Electrical testing (4 point probe, Hall effect)
 - Profilometry
 - Scratch Adhesion Testing (Microphotronics)
 - Nanoindentation Hardness Testing (CSM NHT²)
 - Scanning electron microscopy with EDS
 - Erosion testing



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