SolarShield™

Colored Roofing Granules of High Solar Reflectance for "Cool" Shingles Manufacture

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Factors That Limit Asphalt Shingle Reflectance

- **Roofing Granules**
  - Low NIR Reflectance of typical rock bases
  - Low mean thickness of typical colored coating
  - “Hot” or “Warm” pigments are commonly used
  - Popular Dark colors are the least reflective
- **Asphalt Substrate Coverage**
- **Rough Granulated Surface**

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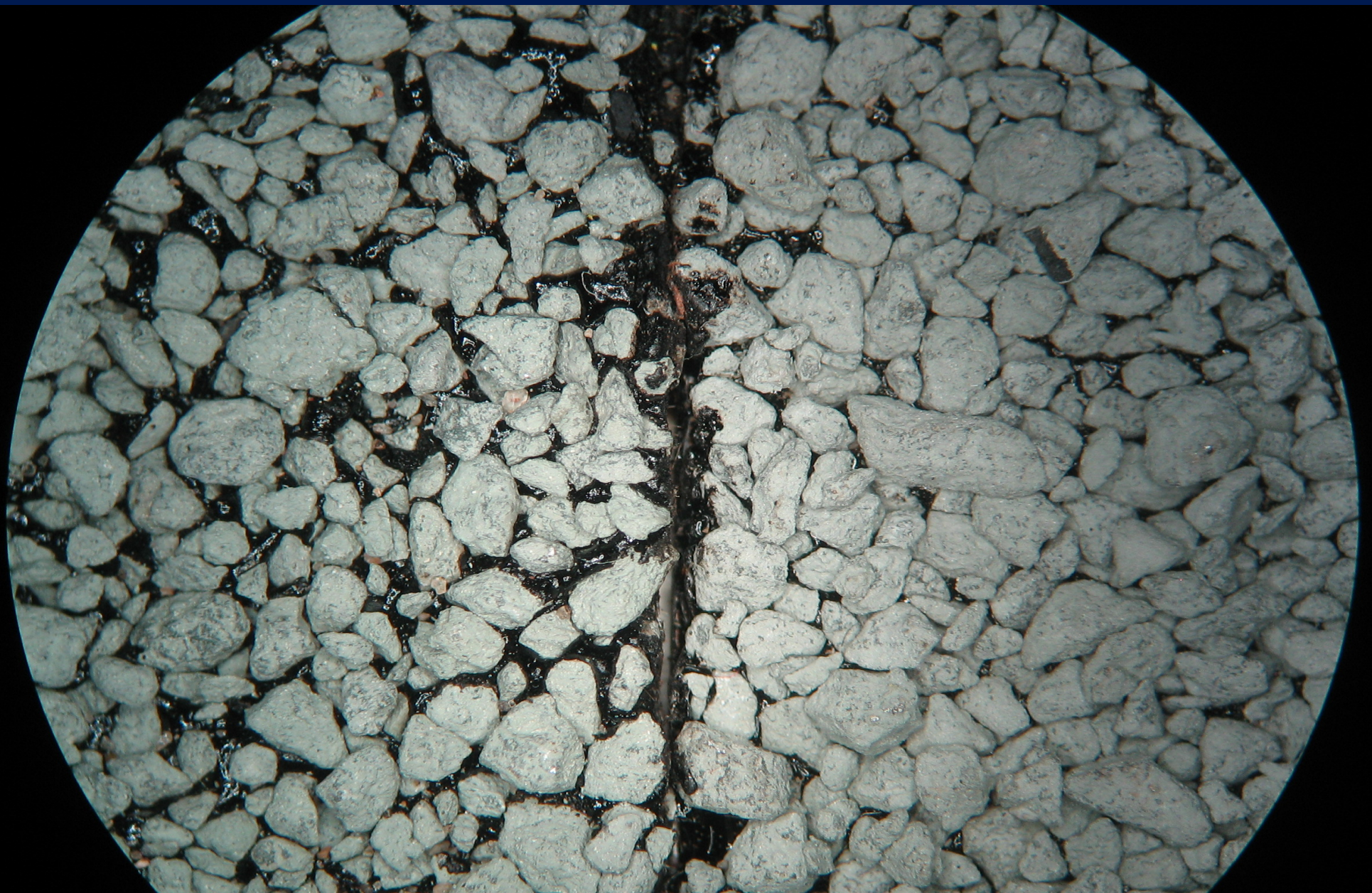
Asphalt Substrate Coverage



Plant Shingle

Lab Panel

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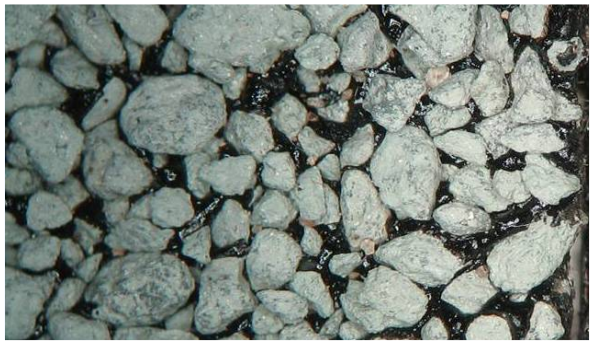
Reflectance Measurement

Plant Shingle vs. Laboratory Panel

SOLAR SHIELD™ PRODUCT	 PLANT SHINGLE TSR	 LAB PANEL TSR
GREY-GREEN (116R)	0.23	0.29
LIGHT-BLACK (341R1)	0.23	0.27
LIGHT-BLACK (341R2)	0.21	0.27

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Reflectance Loss From Rough Granulated Surface

TSR of Coatings on Granules vs. Drawdown Glass

IR-REFLECTIVE PIGMENT IN COATING	TSR OF GRANULES ON PANEL	TSR OF COATING ON DRAWDOWN
BLACK - Sample A	0.14	0.24
BLACK – Sample B	0.14	0.23
BLACK – Sample C	0.15	0.24
BLACK – Sample D	0.16	0.32
GREEN	0.17	0.37
BROWN	0.21	0.42

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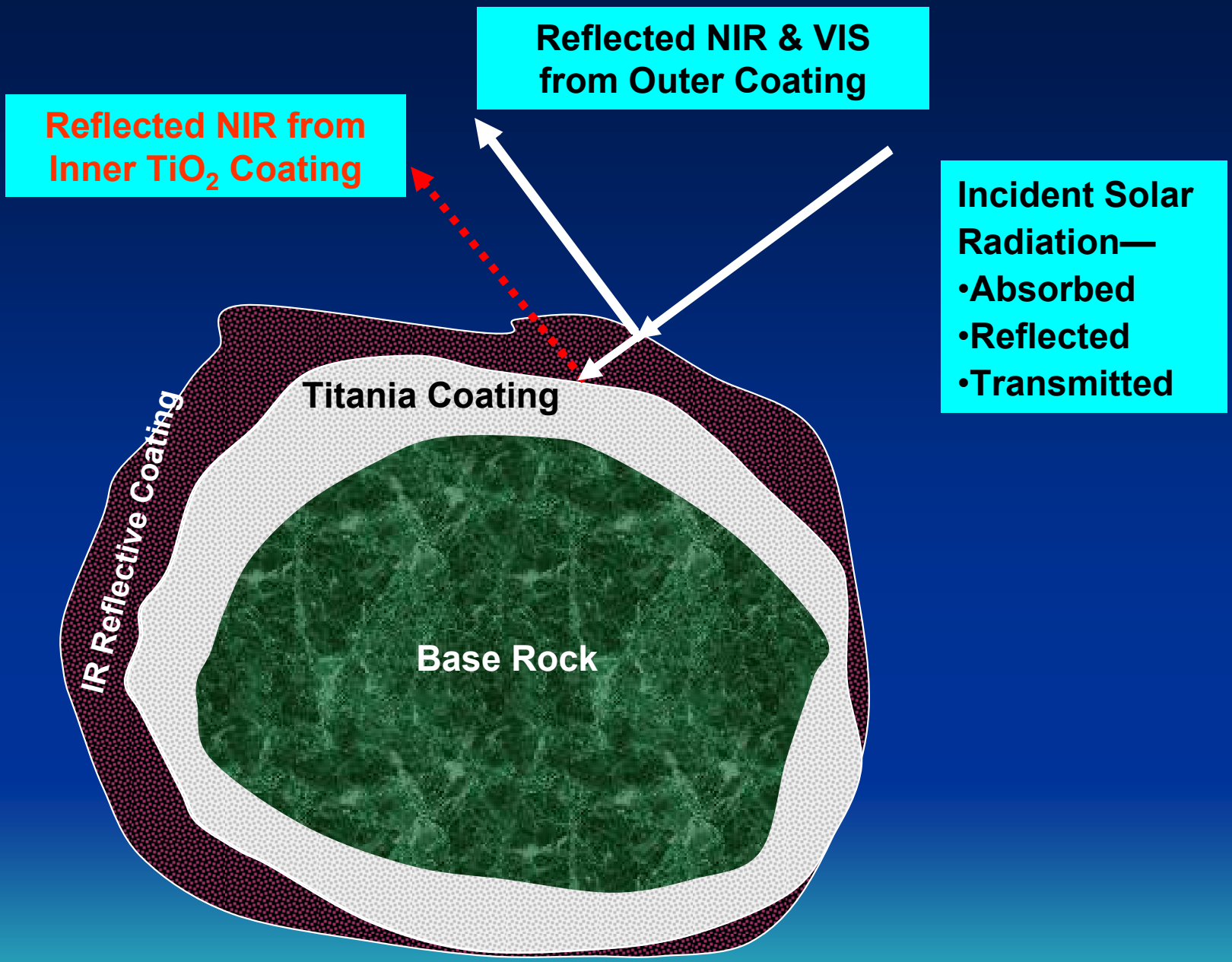
Reflectance Optimization

- **ROOFING GRANULES**
  - Use a more reflective granule base
  - Increase coating thickness
  - Eliminate “Hot” Pigments (carbon black, Black Iron Oxide, Copper Chromite, etc.)
  - Use IR-Reflective Pigments
- **SHINGLE MANUFACTURE**
  - Minimize Over-press
  - Maximize Asphalt Coverage

Current Approaches for Maximizing Roofing Granule Total Solar Reflectance

Current Two-Coat Reflective Granule



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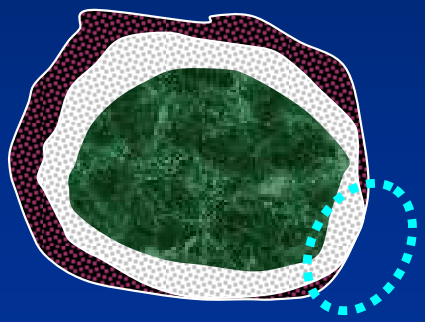
Current Two-Coat Reflective Granule



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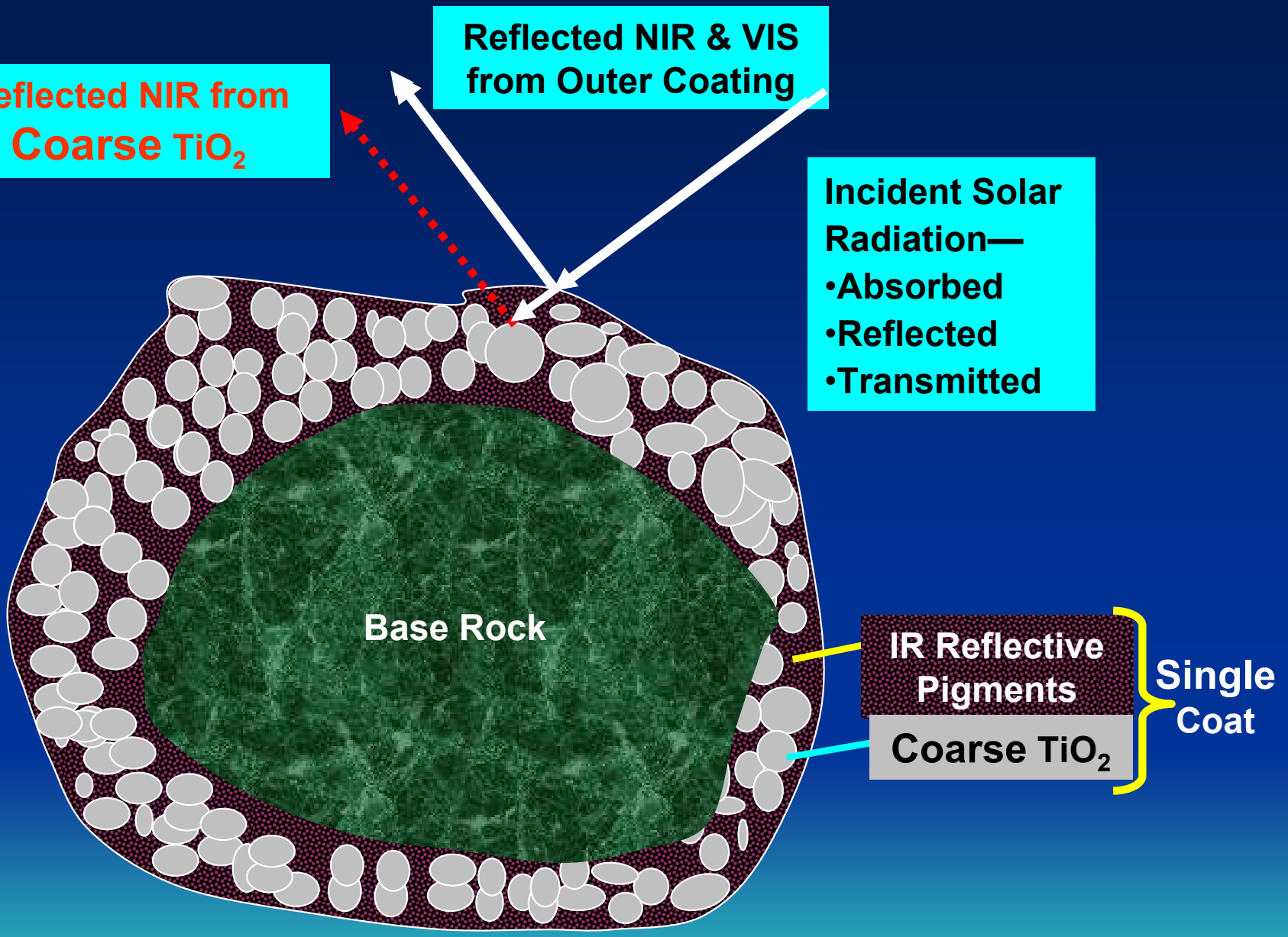
ISP One-Coat Approach – SolarShield™



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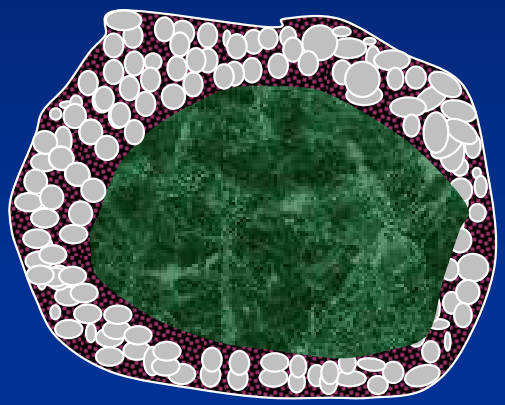

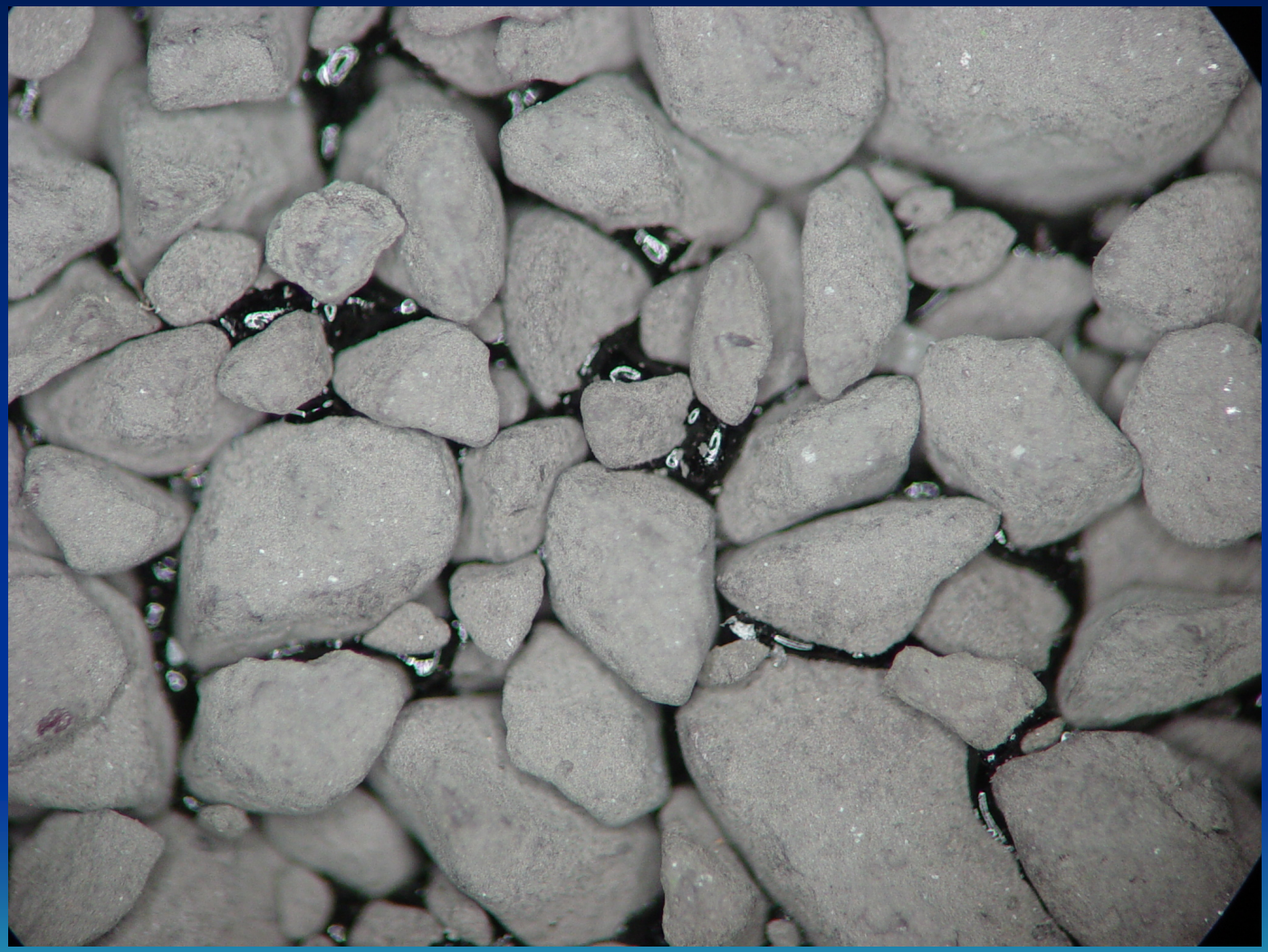

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Special SolarShield™ Raw Materials

- **Reflective TiO_2**
  - Enamel Grade
  - 100% between 0.5 – 10 micron
  - Act as internal coating “reflectors”
  - Minimal impact on Viscosity and Color
- **IR Reflective Black**
  - Chromium Iron Oxide
  - Average Particle Size = 0.4 micron
  - Brownish Black Color
- **IR Reflective Brown**
  - Chromium Iron Oxide
  - Average Particle Size = 1.8 micron
  - Reddish Brown Color

ISP Annapolis SolarShield™ Product Summary

STANDARD ISP PRODUCTS			ISP SOLAR SHIELD PRODUCTS		
Product CODE	Product Name	Total Solar Reflectance	Color vs. Standard	Total Solar Reflectance	% TSR INCREASE
A-116	GRAY-GREEN	0.27	SAME	0.32	19%
A-340	BLACK	0.03	LIGHTER	0.22	633%
A-341	LIGHT BLACK	0.08	LIGHTER	0.29	263%
A-546	CINNAMON	0.21	SAME	0.28	33%
A-552	BROWN	0.07	LIGHTER	0.27	285%
A-555	TAN	0.26	SAME	0.31	19%
A-556	GOLD	0.23	SAME	0.30	30%
A-720	WHITE	0.37	SAME	0.42	14%
A-760	GRAY	0.29	SAME	0.35	21%
A-801	ACCENT	0.13	LIGHTER	0.29	123%
A-901	DARK AR	0.14	LIGHTER	0.29	107%

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ISP Ione SolarShield™ Product Summary

STANDARD ISP PRODUCTS			SOLAR SHIELD PRODUCTS		
Product Code	Product Name	Total Solar Reflectance	Color vs. Standard	Total Solar Reflectance	% TSR Increase
I-116	GRAY-GREEN	0.19	SAME	0.29	53%
I-207	TERRACOTTA	0.23	SAME	0.30	30%
I-340	BLACK	0.03	LIGHTER	0.20	567%
I-341	LIGHT BLACK	0.07	LIGHTER	0.28	300%
I-546	TAN	0.16	SL. LIGHTER	0.27	69%
I-552	BROWN	0.06	LIGHTER	0.28	367%
I-555	TAN	0.22	SAME	0.27	23%
I-556	GOLD	0.17	SAME	0.26	53%
I-560	BUFF	0.29	SAME	0.34	17%
I-720	WHITE	0.34	SAME	0.38	12%
I-760	GRAY	0.24	SAME	0.30	25%
I-801	ACCENT	0.11	SAME	0.28	155%

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SolarShield™ Products and Blends

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COLOR AND TSR CHANGE OF SOLAR SHIELD PRODUCTS AFTER WEATHEROMETER EXPOSURE

SOLAR SHIELD PRODUCT	SAMPLE TYPE	HOURS EXPOSED	HUNTER ΔL	COLOR Δ a	CHANGE Δ b	INITIAL TSR	FINAL TSR
I-116R	PANEL	5,600	1.4	-0.1	1.6	0.26	0.28
I-116R	SHINGLE	4,800	1.1	-0.3	2.4	0.23	0.25
I-207R	PANEL	6,800	0.7	-0.8	-1.2	0.28	0.28
A-341R	PANEL	5,600	1.4	-0.3	0.6	0.25	0.25
A-341R	SHINGLE	4,800	1.2	-0.4	1.6	0.22	0.24
A-552R	PANEL	7,600	0.7	-0.2	0.2	0.25	0.24
I-555R	PANEL	6,800	0.5	-0.5	0.3	0.27	0.27
I-556R	PANEL	7,600	0.3	-0.3	0.7	0.26	0.26
I-560R	PANEL	7,600	-1.3	1.1	0.3	0.31	0.30
I-720R	PANEL	6,800	1.6	-0.1	2.5	0.36	0.37
A-801R	PANEL	7,600	0.4	-0.1	0.4	0.27	0.26

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