New Generation Solar Reflective Shingles

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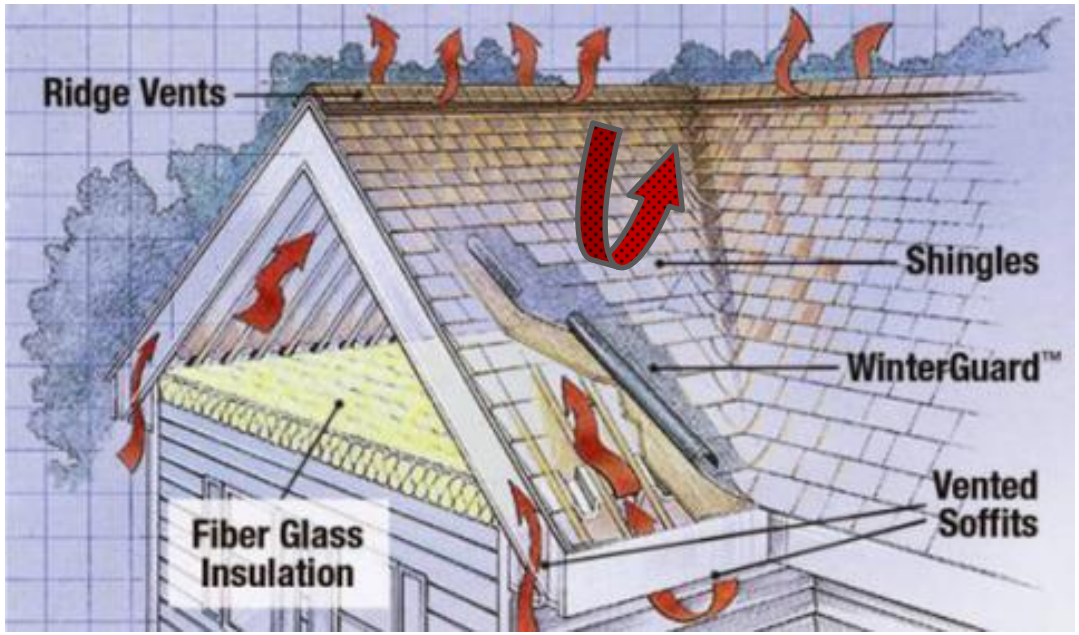
Agenda

- Why solar reflective (SR) roofs?
- Current asphalt shingle technology
- Color versus solar reflectance
- Next generation solar reflective shingles
- Field testing and aged performance
- Summary

Why solar reflective (SR) roofs?

- **Higher energy efficiency**
  - US spends ~$40 billion/year to cool buildings
    - 1/6 of all energy consumed
    - Reduced solar heat flux into conditioned space may reduce AC load

- **Approaches**
  - Insulation
  - Ventilation
  - Radiant barrier
  - **SR Roof**



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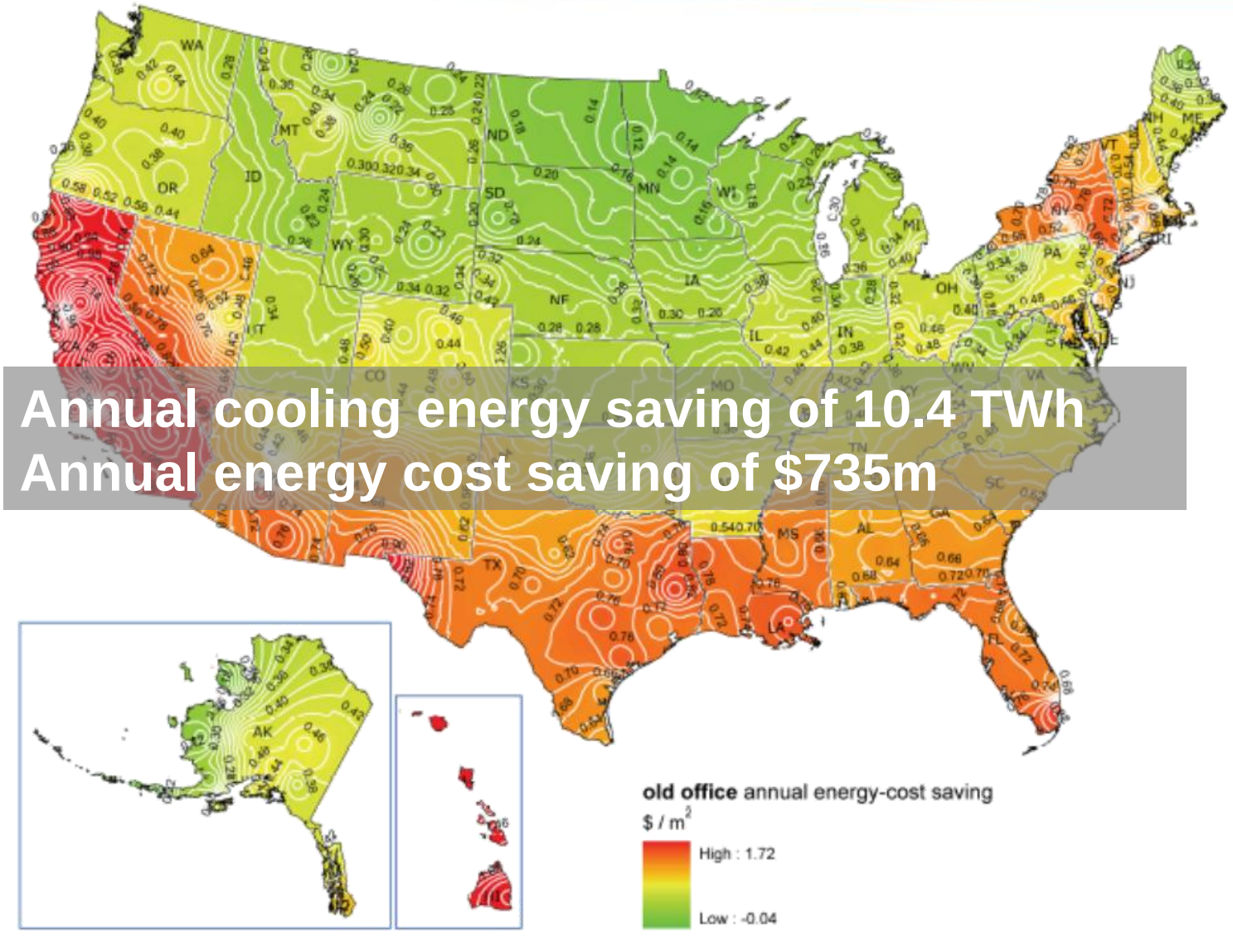


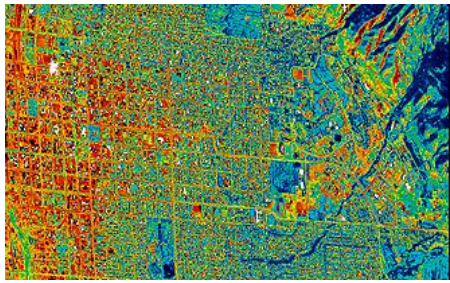
Annual cooling energy saving of 10.4 TWh
Annual energy cost saving of $735m

Data Source: Ronnen Levinson, Hashem Akbari, in *Energy Efficiency*, 3(1), pp.53~109

Why solar reflective (SR) roof?

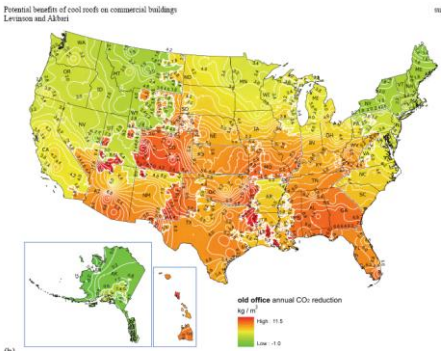
- **Achieve higher energy efficiency**
  - US spends $40 billion/year to cool buildings (1/6 of all energy consumed)
  - Reduce solar heat flux into conditioned space may reduce the AC load

- **Mitigate "Urban Heat Island" effects**
  - Increase surface Albedo to promote "global cooling"
  - Potential reduction in CO_2 emissions
  - Potential suppression in "smog" formation – reduce NO_x, SO_2 emissions



Source: Center for Architecture Science and Ecology

Source: NASA Defense Meteorological Satellites Program



Data Source: Ronnen Levinson, Hashem Akbari, in *Energy Efficiency*, 3(1), pp. 53 ~ 109

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Global Cooling: Increasing SR to 0.25 would yield significant offset of CO_2 emission

Row	Item	Value
1.	Area of the earth	510×10^{12} m^2
2.	Land area (29% of Earth area)	147×10^{12} m^2
3.	Dense and developed urban areas (1% of land area)	1.5×10^{12} m^2
4.	Roof area (25% of urban area)	3.8×10^{11} m^2
5.	Paved surface area (35% of urban area)	5.3×10^{11} m^2
6.	Potential emitted CO_2 offset for cool roofs [Row 4 × Row 6a Table 4]	24 Gt CO_2
7.	Potential emitted CO_2 offset for cool pavements [Row 5 × Row 8a Table 4]	20 Gt CO_2
8.	Total potential emitted CO_2 offset for cool roofs and cool pavements [Row 6 + Row 7]	44 Gt CO_2
9.	Projected 2025 world CO_2 emissions[a]	37 Gt CO_2/year

Source: H. Akbari, S.Menon, A. Rosenfeld,
***Climate Change* , 94, pp. 275~286**

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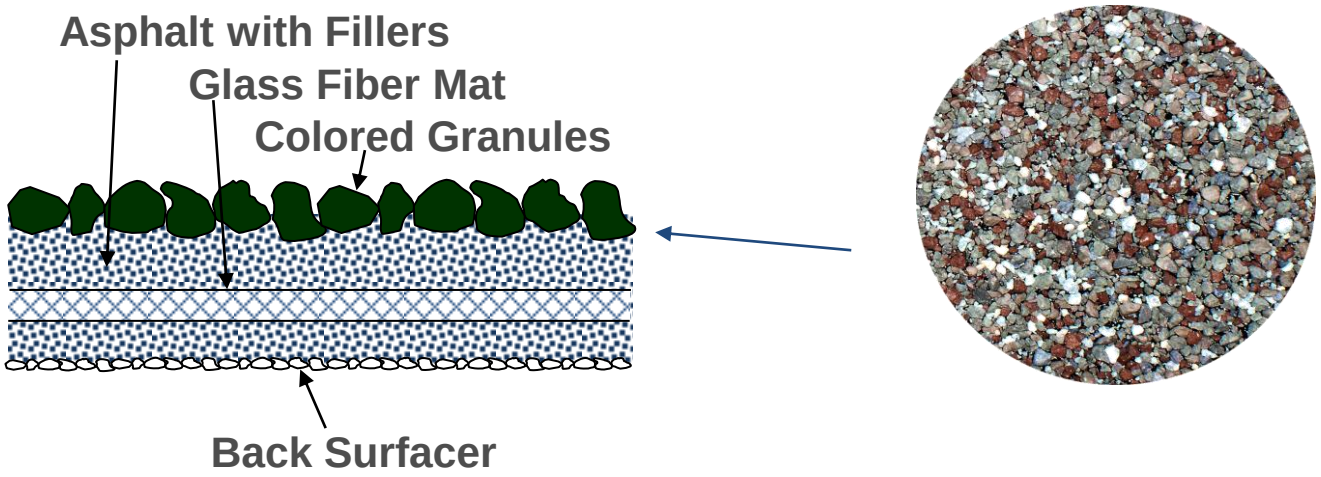
Asphalt shingles – current technology

- **A proven choice of roofing materials**
  - Lasting performance
  - Aesthetically pleasing
  - Class A fire rating
  - Ease of installation
  - Choice of colors & styles
  - Low cost to consumers

Asphalt shingles – current technology

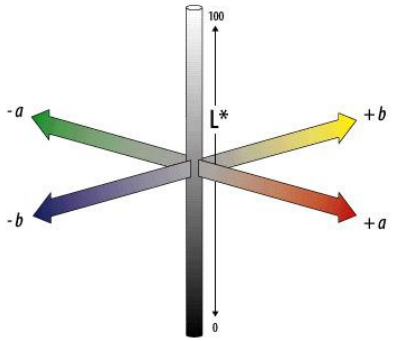
- **Traditional asphalt shingles are not designed to be solar reflective**



- **A large portion of shingle surface is covered by roofing granules**

Roofing granules – current technology

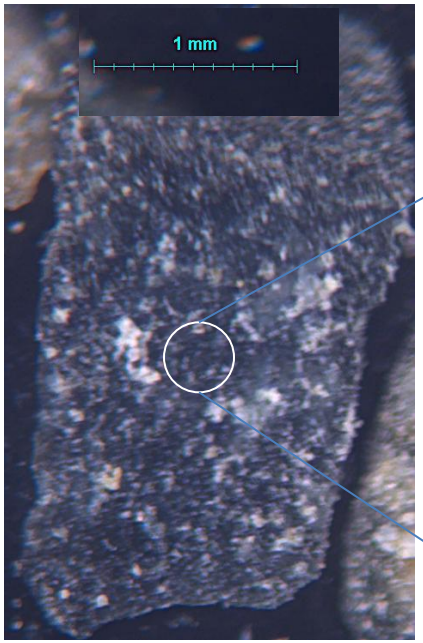
- **Traditional roofing granules are designed for functionalities & aesthetics, but not for SR**
  - Protecting asphalt from UV radiations
  - colored for aesthetics
  - Earth tone colors are among the popular choices

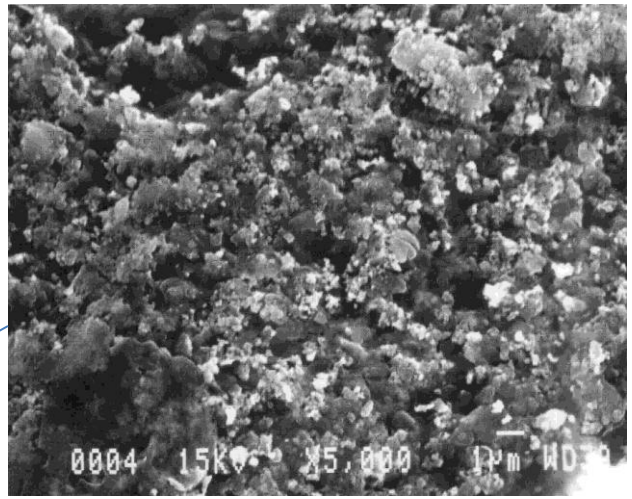


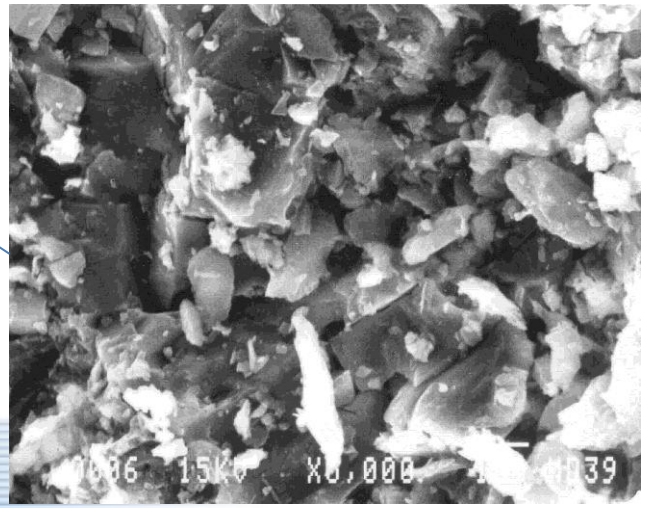
Color Description	L*	a*	b*	Averaged solar reflectance, %
Black	22.91	-0.11	-0.67	4
Gray	31.34	0.05	0.32	6.2
Dark brown	26.90	5.66	8.08	5.9
Brown	39.97	13.29	18.98	15.0
Buff	41.50	10.67	21.19	15.4
Olive	36.25	0.33	5.75	10.0
Light gray	48.53	-3.66	2.84	16.8
Light buff	55.92	6.41	19.65	25.4
White	67.54	-0.44	1.28	31.3

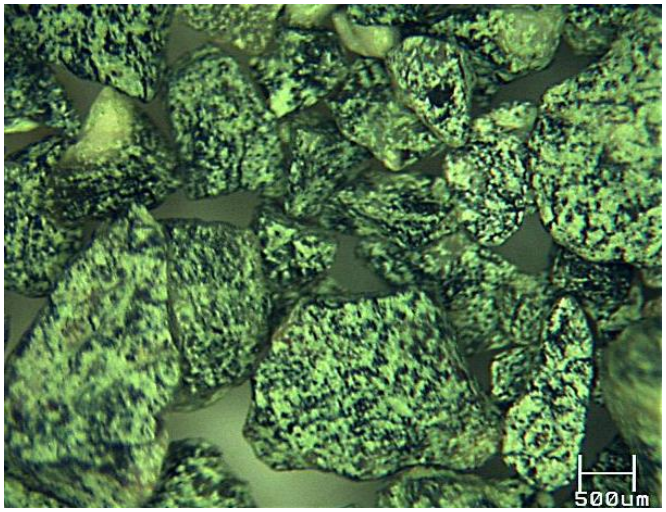
Granules for solar reflective roofs

- **Roofing granules have rough surfaces that may reduce solar reflectivity**





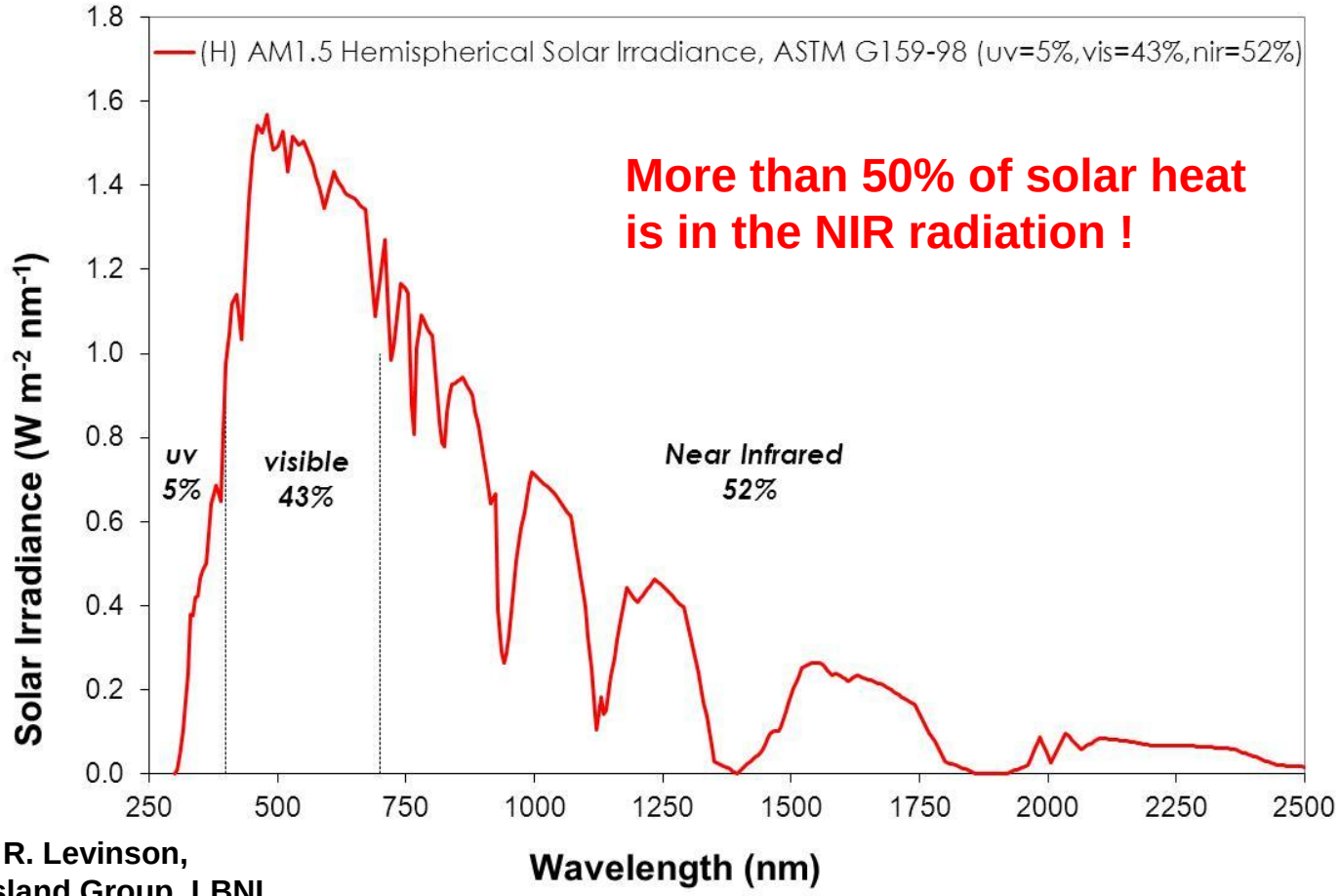




Standard non-SR granules in light grey color under microscope

SR roofing granules: challenges

- **Color vs. SR: how to maintain the color and the coolness at the same time?**



Data source: R. Levinson, Urban Heat Island Group, LBNL

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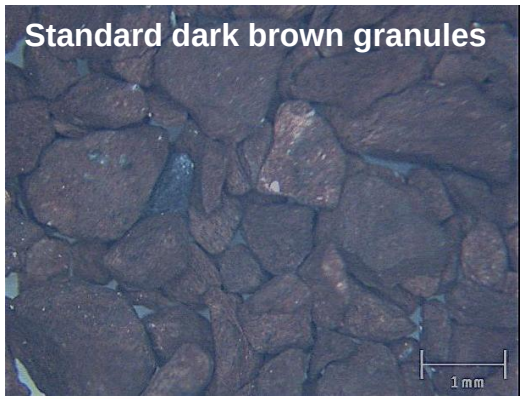
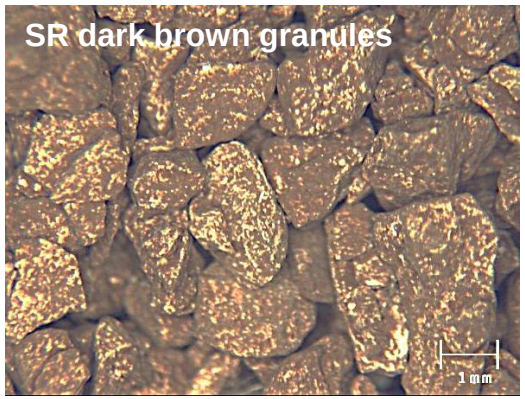
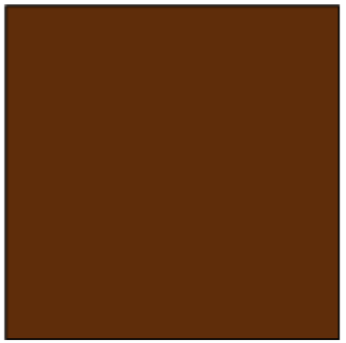
SR roofing granules: current technology

- **"cool" colorants to enhance the SR**
  - Commercially available "cool" pigments
  - High cost; limited in colors
  - Improvements are not drastic
- **Use of white reflective base coat followed by a 2nd color coat**
  - More efficient for SR increase
  - Higher cost; loss of color saturation





standard



solar reflectance = 0.08
thermal emittance = 0.85
roof temp – air temp = 45°C (81°F)

cool

solar reflectance = 0.27
thermal emittance = 0.85
roof temp – air temp = 36°C (65°F)

Cool Pigment Database: LBNL Cool Colors Project by Dr. Ronnen Levinson

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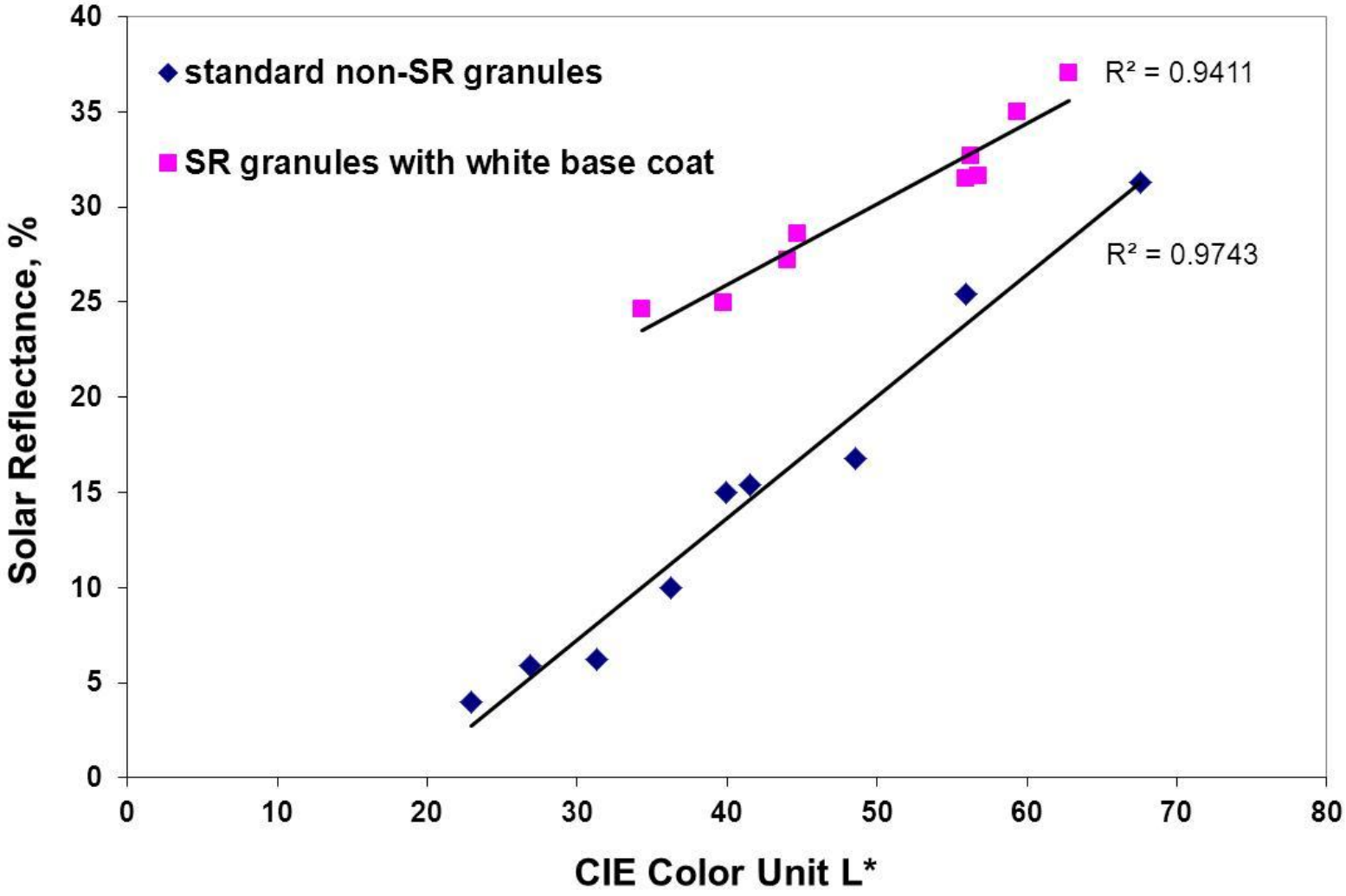
SR granules: current technology



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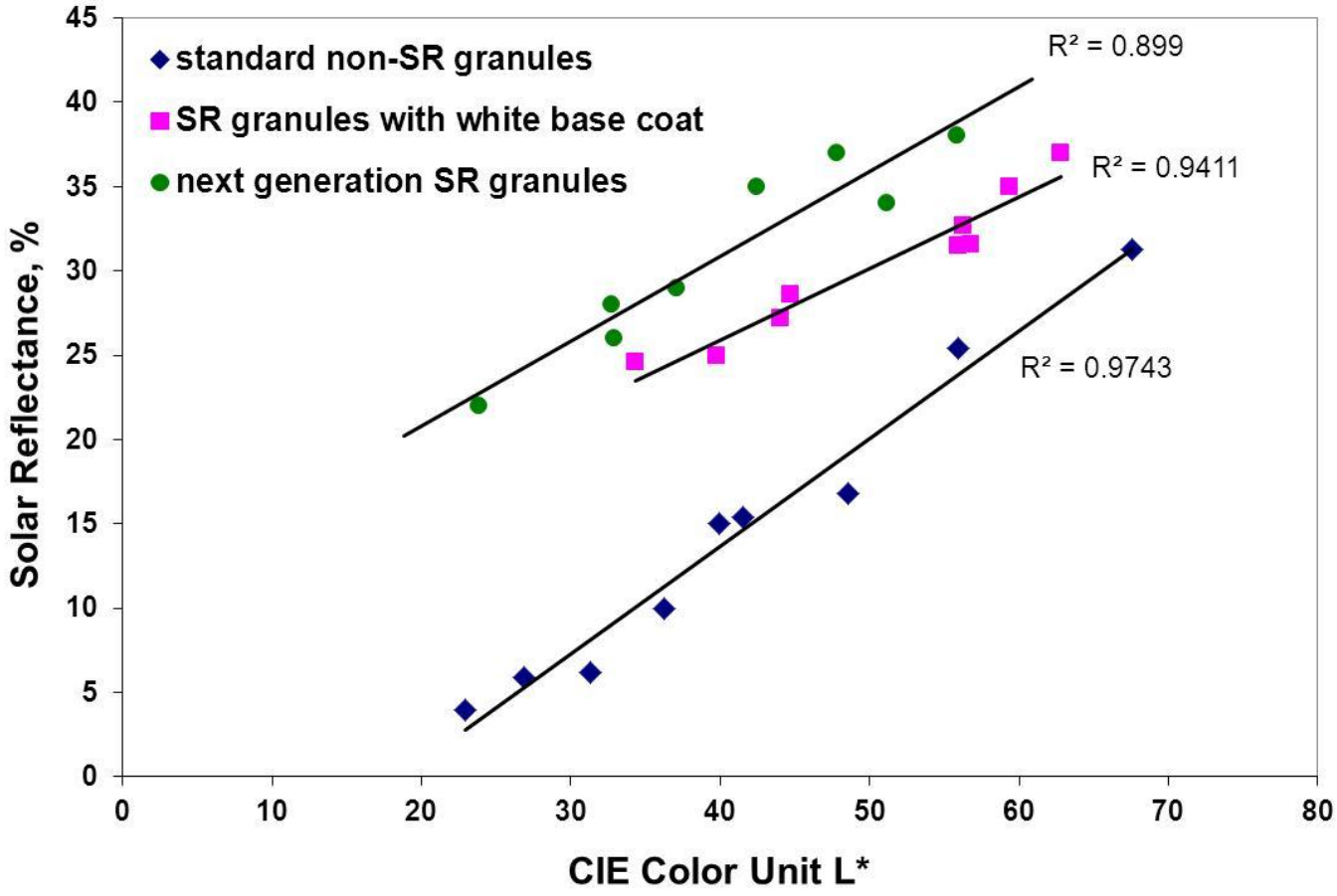
SR granules: new generation



- **Improved coating efficiency yields SR roofing granules that meet Title 24 and Energy Star® requirements in traditional earth-tone colors**

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New SR shingles in traditional earth-tone colors

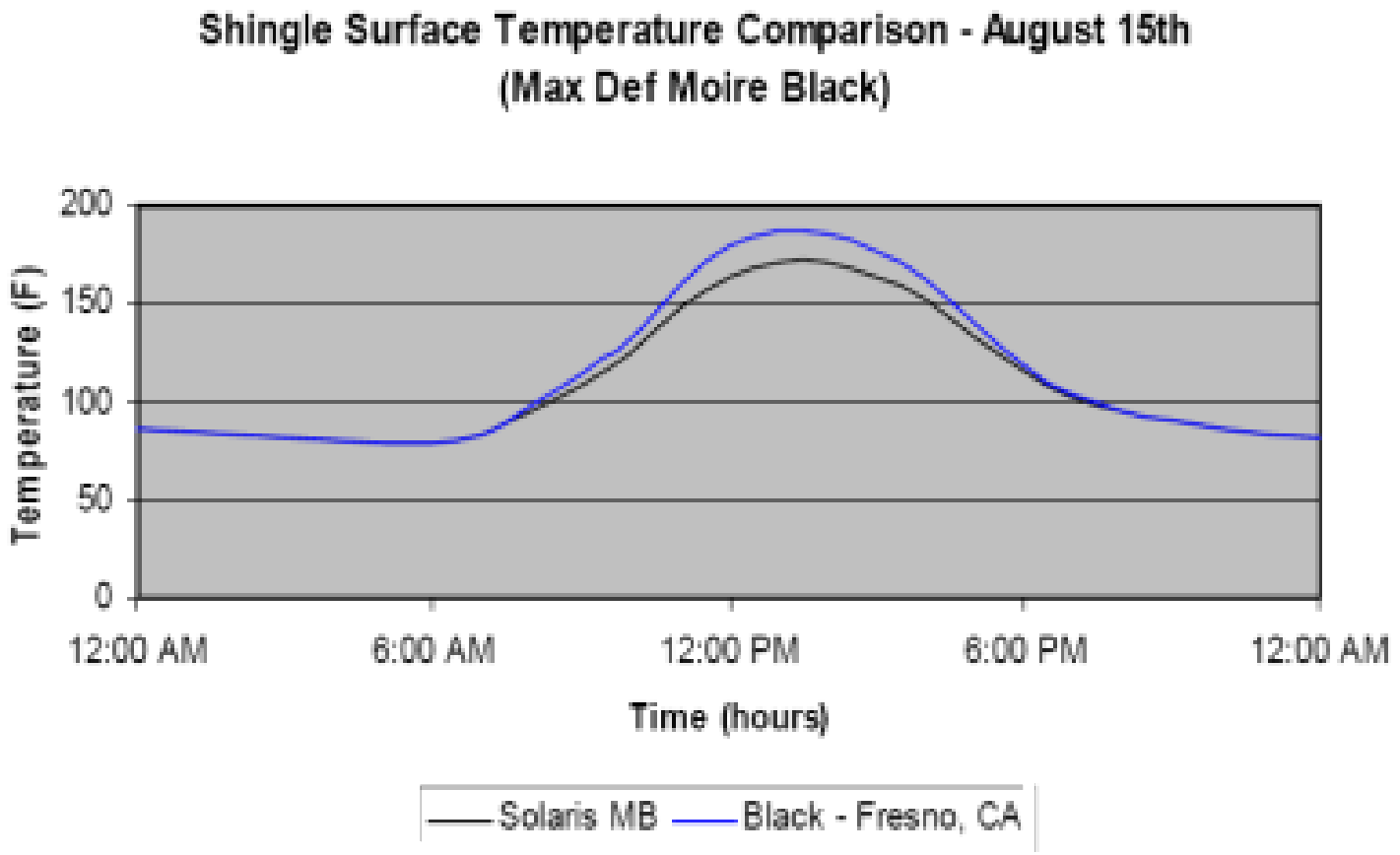
Traditional shingles → ← **New Generation SR shingles 25% total solar reflectance** → ← Traditional shingles

Potential energy savings by the new generation SR shingles:

- **DOE Cool Roof calculator shows typically ~10% saving in cooling load**

		Cooling Load			
		Base	Solaris	Difference	Difference
Fresno, CA	Energy Costs	(Btu/ft^2 yr)	(Btu/ft^2 yr)	(Btu/ft^2 yr)	(%)
R19	Summer Elec. $/KWH	3515	3143	372	10.6
R30	0.1434	2227	1986	241	10.8
R38	Natural Gas $/THERM	1785	1589	196	11.0
	1.173				
Elpaso, TX					
R19	Summer Elec. $/KWH	3904	3501	403	10.3
R30	0.1258	2479	2218	261	10.5
R38	Natural Gas $/THERM	1991	1779	212	10.6
	1.384				

New generation SR shingles



- **WUFII simulations predict ~10° cooler roof temperatures**

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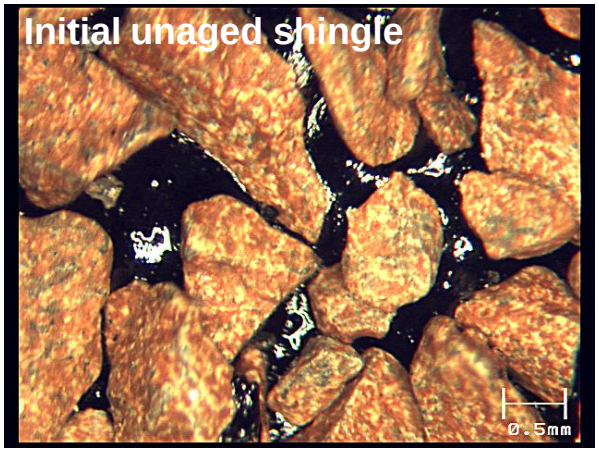
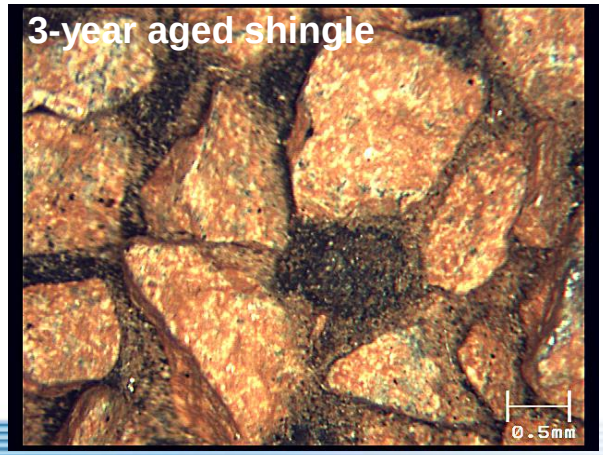
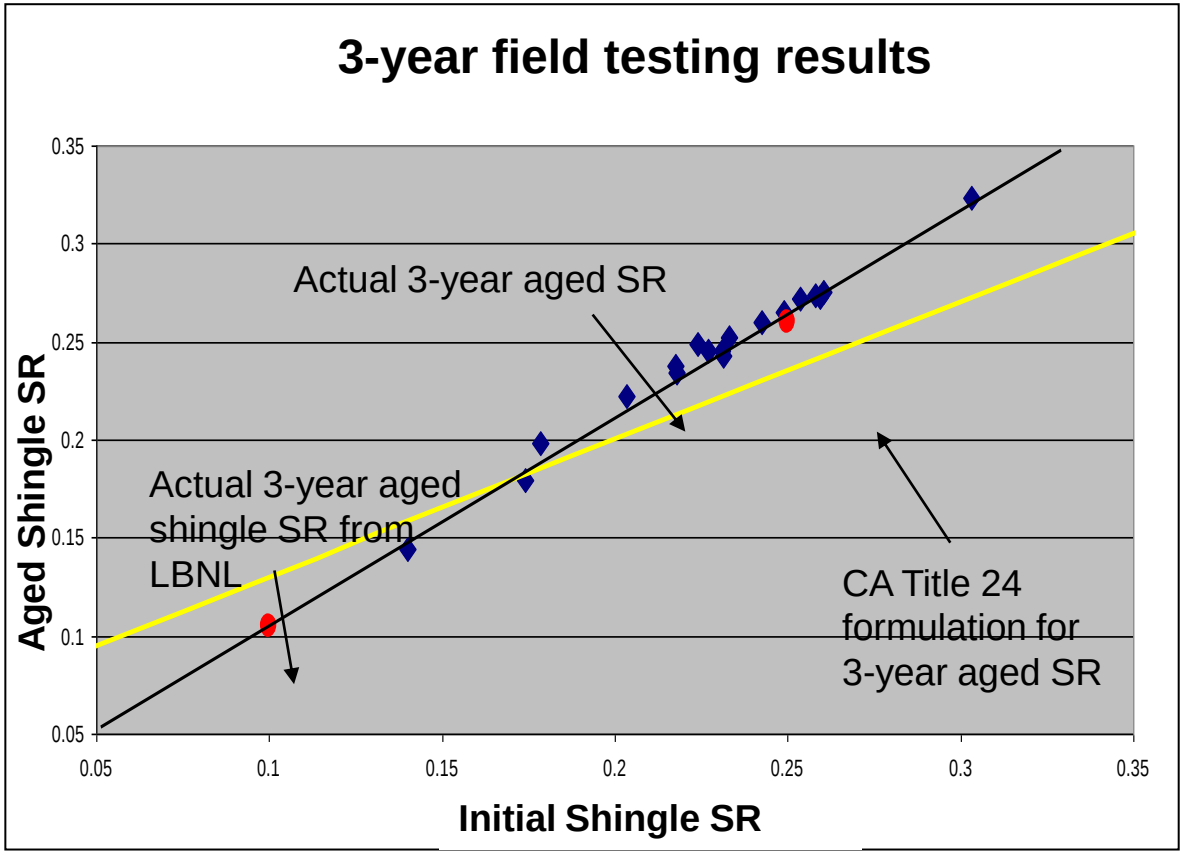
Field testing and aged performance

- **Outdoor exposure testing (hot/wet, hot/dry, cool/wet climates)**
- **Excellent color and SR retention after 3 years**







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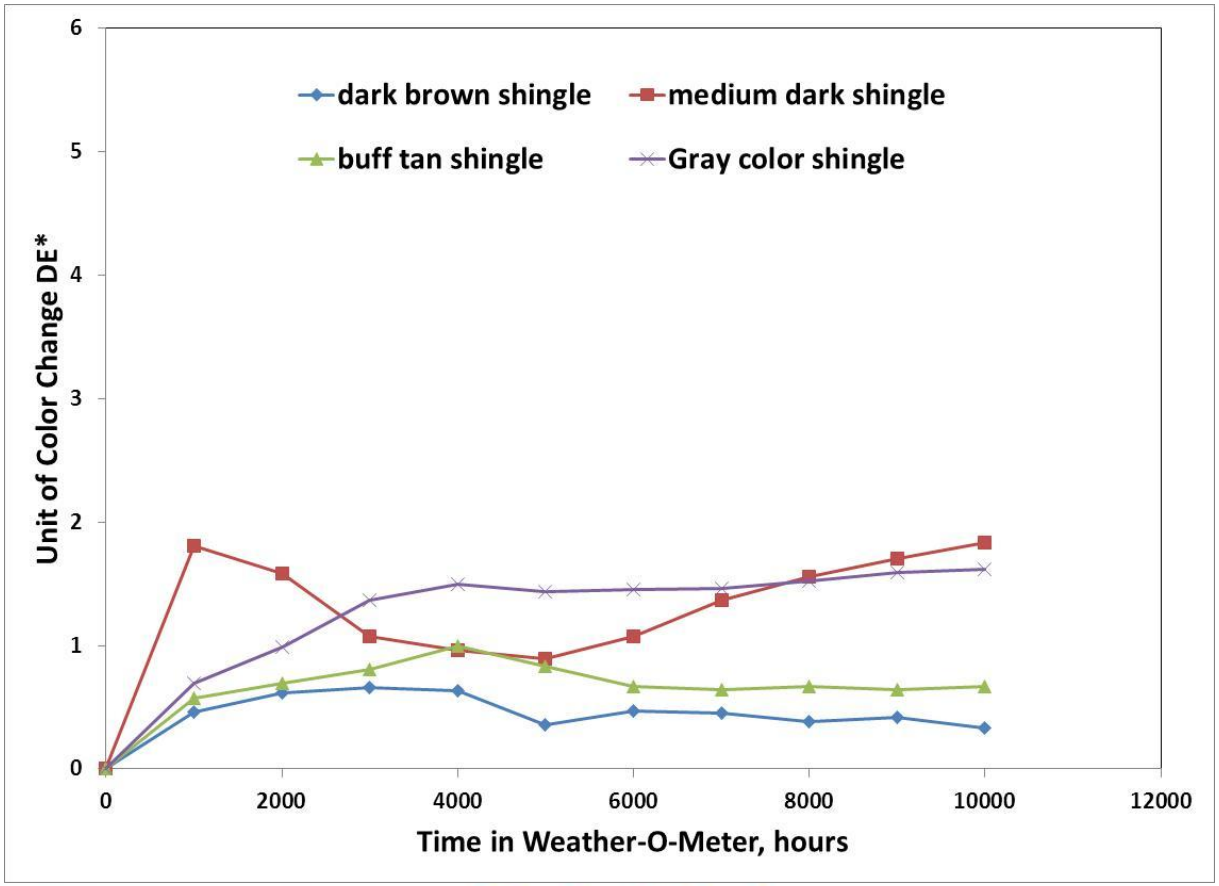
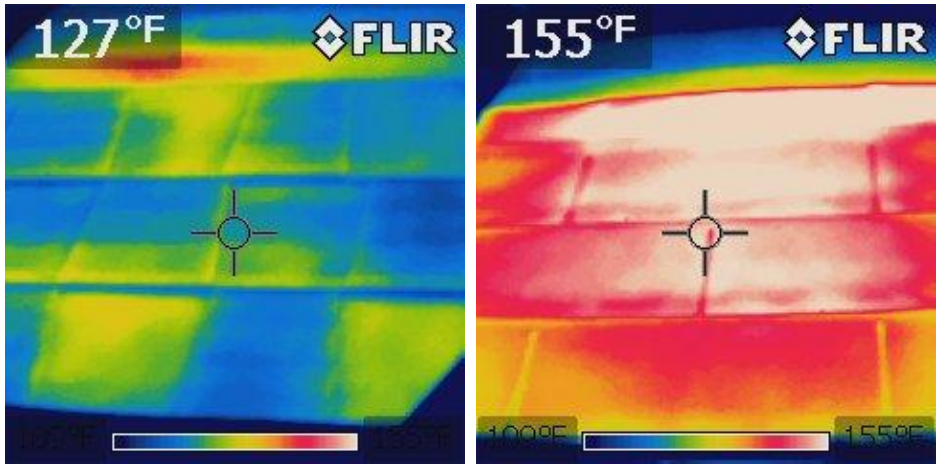
New generation SR shingles: aging performance

- **Accelerated artificial aging test also confirms the color and solar reflectance are maintained**



Future of solar reflective shingles: Shingles that go beyond 25% SR

- **Shingles SR values ≥ 40%**



IR camera image showing temperature differences between traditional non-SR shingles and shingles with SR at 40%

Summary

- The solar reflectance of traditional shingles can be improved by increasing the solar reflectance of their covering roofing granules
- With improved coating technology, new generation solar reflective roofing granules can deliver both the high SR and desirable earth-tone colors
- 3-year field weathering tests in various climates show that the SR and color are maintained.
- Significant energy savings can be accomplished with the use of solar reflective shingles

Thank You !

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