Mt. Baker Research LLC

Measurement Services

& Calibration Certificates

Mt. Baker Research LLC
2921 Sylvan Street / P.O. Box 28370
Bellingham, Washington 98228-0370
360-650-0771

Certificate of Traceable Calibration

Customer:	SICPA SA
Contact:	Maarten Krupers
Tel:	+41 21 627 5555
P.O. No.:	20091110-02
Date:	09.12.14
CAL No.:	MBR-SCITR-091214-04

Laboratory Conditions

Mean T:	23.0 ± 0.2 °C
Humidity:	40%
Certified by:	John W. Root, Ph.D.

Measurement Parameters

Instrument:	X-Rite ColorEye 7000A (2008) NUV-VIS spectrophotometer; S/N 37132651108
Geometry:	(t/8°) SCI diffuse w/ 8° viewing; LAV aperture plate & LAV lens setting
Sample Port:	Circular w/ 25.4 mm diameter (illuminated) & 23.4 mm diameter (viewed) areas
Wavelength Pitch:	10 nm
Wavelength Range:	360 - 750 nm
No. Spectra per Measurement:	9 (3 repeated measurements w/ each averaging 3 consecutive spectra)
Delay between Spectra:	10 seconds
No. Averaged Measurements:	1 measurement per tile (w/ replacement & re-calibration); 3 geometries
Traceable Reference Standard:	X-Rite CERAM white Tile; NIST #2020c S/N 27073, 844/259504-98R (99.05.14)
Data Media:	24 Excel charts (attached) & CD Disk (certified data)
Samples Measured:	Diagnostic Tile Set; 16 ceramic transfer standards

Procedure

Spectral reflectance factors ("SRF") were measured at ambient temperature and humidity with an X-Rite ColorEye 7000A ("CE7000A") NUV-VIS spectrophotometer. The instrument was operated in the (t/8°) total hemispherical specular-included ("SCI") geometry. SRF data were measured from 360 - 750 nm in 10 nm intervals. CyberChrome OnColor QC Premium® software was used to control the spectrophotometer, to average the replicate spectra obtained during each measurement series, and to perform colorimetric analysis. The statistical analysis was based on proprietary algorithms developed at Mt. Baker Research L.L.C.

SRF values were measured for 16 diagnostic test tiles relative to the calibrated NIST traceable CERAM white reference tile supplied with the instrument. [REF: NIST #2020c S/N 27073, 844/259504-98R (99.05.14).] The metrological SRF scaling procedure monitored and corrected for instrument drift and optimized the statistical quality of the results. This was accomplished by bracketing 3 consecutive measurements of each tile with 2 measurements of the calibrated white reference tile.

Each data series consisted of 12 measurements performed using the following sequence: **C R R T1 T1 T1 R R T2 T2 T2 R R**. Here, **C**, **R**, **T1** and **T2** denote re-calibration followed by measurements of the white reference tile, the 1st test tile, and the 2nd test tile. As described below, in each of 3 configurations of the CE7000A this sequence was repeated 8 times in order to measure all 16 diagnostic tiles. Sample replacement and re-calibration of the instrument were performed between each series of measurements. [REF: Diagnostic Tile Set Instruction Manual.]

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Procedure -- Continued

Introduction: In this study a new procedure was developed to screen 16 diagnostic test tiles for translucency, and to measure the loss of reflectance that results from translucency. A translucent solid is not perfectly opaque. Part of the light incident on it penetrates the surface where it undergoes internal scattering and lateral diffusion away from the point of entry. Because these processes reduce the intensity of the reflected light, the Lambertian efficiency of the reflective surface is decreased.

As a result of lateral diffusion, the spectral reflectance of a translucent solid decreases as the size of the instrument's sample port is reduced. The loss of reflectance may lead to significant measurement errors, which vary from instrument to instrument depending on the characteristics of the sample, the optical geometry, and the sizes of the illuminated and measured areas.

Under conditions of over-illumination, the illuminated area of a mounted sample is larger than the measured area. If the sample is translucent, experiments in which over-illumination is systematically varied may be used to measure the loss of reflectance that results from lateral diffusion. As the over-illumination is decreased, the reflectance loss becomes detectable and measurable.

In commercial instruments that support diffuse illumination, the entire exposed surface of the sample is illuminated, and an optical system controls the size of the area viewed by the detector. Over-illumination is achieved by configuring the area viewed by the detector to be smaller than the illuminated area of the sample.

The CE7000A supports 4 sample ports and 4 lens settings, which determine the position and size of the area viewed by the detector. The 10 configurations supported by this instrument restrict measurements to over-illumination. In this report "LAV/LAV" denotes the LAV (large area of view) sample port of the CE7000A combined with the LAV lens setting. "LAV/VSAV" denotes the LAV port combined with the VSAV (very small area of view) lens setting, while "VSAV/VSAV" denotes the VSAV port combined with the VSAV lens setting. For the SCI geometry these combinations correspond to the CRIILL, CRIIVL and CRIIVV instrument configurations.

With the CE7000A over-illumination may be varied over an unusually large range. Although the LAV/LAV configuration is used during the majority of SRF measurements, in this configuration over-illumination is insufficient to prevent reflectance loss from typical translucent samples. Maximum over-illumination is achieved when the LAV sample port is combined with the VSAV lens setting. Because the reflectance loss is minimized, the LAV/VSAV configuration yields the best achievable measurement accuracy for a translucent sample that exhibits uniform surface quality. Minimum over-illumination is achieved when the VSAV sample port is combined with the VSAV lens setting. With the VSAV/VSAV configuration, lateral diffusion causes the largest reflectance loss that can be measured with the CE7000A.

In the present study 16 diagnostic test tiles were measured with a CE7000A using the technique described above. The 3 independent sets of measurements combined the SCI geometry with the LAV/LAV, LAV/VSAV and VSAV/VSAV instrument configurations. In each configuration one complete set of measurements is sufficient to detect and measure the reflectance loss that results from lateral diffusion.

For each instrument configuration the total reflectance is defined as the sum over the SRF values measured from 360 - 750 nm. The Fractional Reflectance Loss ("FRL") is calculated from the difference in total reflectance between the LAV/VSAV and VSAV/VSAV configurations. In graphical terms, FRL (%) represents 100x the magnitude of the integrated area, which is enclosed between the LAV/VSAV and VSAV/VSAV SRF plots, divided by the magnitude of the integrated area enclosed beneath the LAV/VSAV plot. [REF: Diagnostic Tile Set Instruction Manual.]

Procedure -- Continued

Synopsis: The present study included 5 parts as follows: Part A: Traceable SRF calibrations were measured for 16 diagnostic test tiles in the SCI LAV/LAV instrument configuration. During each measurement the data were averaged from 3 consecutive spectra separated by a 10 second delay interval. [REF: Charts #9 to #12.] Part B: These measurements were repeated for the SCI LAV/VSAV configuration. [REF: Charts #13 to #16.] Part C: The same measurements were repeated for the SCI VSAV/VSAV configuration. [REF: Charts #17 to #20.] Part D: The SRF data from Parts A - C were combined as described above to test the 16 diagnostic tiles for translucency. [REF: Charts #1 to #8.] Part E: A new procedure was developed to characterize the statistical noise levels of the CE7000A instrument during Parts A - C. [REF: Charts #21 to #24. NOTE: The error bars shown on the charts in this report represent 2σ standard errors of estimate (95% confidence level).]

Accuracy Studies: In a separate study the absolute accuracy of a Konica-Minolta CM2500c (45°/0°) bi-directional instrument was measured using 9 ceramic transfer standards calibrated at NRC. Based on traceability to NRC/NIST and the standard metrological procedures described herein, the 2σ absolute accuracy of the Konica-Minolta CM2500c instrument was 99.2% ± 1.6%. This result was statistically equivalent to the 99.1% ± 0.4% accuracy value obtained for this instrument using our standard statistical analysis. Accordingly, the accuracy results reported below are estimates based on this same statistical procedure. [REF: NRC Calibration Report No. PAR-2008-2594. Mt. Baker Research L.L.C. Calibration Report No. MBR-(45/0)-091214-01.]

For the #D01 UltraWhite tile, the measured average 2σ standard errors of estimate in the LAV/LAV, LAV/VSAV and VSAV/VSAV instrument configurations were 0.57, 0.58 and 0.55. The corresponding relative standard errors were 0.0061, 0.0062 and 0.0059. For the #D09 Light Grey 60% tile the corresponding errors were 0.37, 0.38, 0.35, 0.0062, 0.0064 and 0.0059. For the #D21 Mid-Green tile the respective errors were 0.20, 0.20, 0.18, 0.0065, 0.0066 and 0.0061.

For all 16 diagnostic tiles in the LAV/LAV configuration the grand average 2σ relative standard error of estimate was 0.0076 ± 0.0017. In the LAV/VSAV and VSAV/VSAV configurations the corresponding relative standard errors were 0.0078 ± 0.0018 and 0.0069 ± 0.0012. On this basis, with traceability to NRC/NIST the estimated 2σ absolute accuracy of the certified SRF values in all 3 instrument configurations is 99.3% ± 0.4%.

X-Rite specifies an inter-instrument agreement for the CE7000A within ΔE^*ab = 0.08. [NOTE: For this test the average inter-instrument agreement is measured for 12 CERAM BCRA Series II tiles.]

Repeatability Studies: For the CE7000A instrument X-Rite specifies a repeatabity within ΔE^*ab = 0.010. [NOTE: This specification is based on 20 replicate measurements of the X-Rite CERAM white reference tile at 10 second intervals without replacement or re-calibration.]

In the present study repeatability measurements were based on the CERAM white reference tile. During Part A (LAV/LAV configuration), based on 45 measurements of the CERAM white tile without replacement or re-calibration, the repeatability of the CE7000A was ΔE^*ab = 0.0030 ± 0.0017. Based on 100 measurements with replacement but without re-calibration, the repeatability was ΔE^*ab = 0.0036 ± 0.0015.

During Parts B (LAV/VSAV configuration) and C (VSAV/VSAV configuration), based on 40 measurements of the CERAM white tile with replacement but without re-calibration, the respective repeatabilities were ΔE^*ab = 0.0047 ± 0.0021 and ΔE^*ab = 0.0049 ± 0.0021. [NOTE: The measurement uncertainties cited above represent standard deviations.]

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Procedure -- Continued

Noise Studies: In Charts #21 to #24 (Part E) the statistical noise levels are compared for the SRF measurements performed during Parts A - C. In Charts #21 to #23 the noise levels are shown for the LAV/LAV (Part A), LAV/VSAV (Part B), and VSAV/VSAV (Part C) instrument configurations. The average noise levels for all 3 configurations are shown in Chart #24. The wavelength-dependent noise data shown in these charts represent the precision-based random error contributions to the average relative standard error of estimate values.

Translucency Studies: In Charts #1 to #8 (Part D) the SRF results from Parts A - C are combined in order to test the 16 diagnostic tiles for translucency. In Charts #9 to #20 the error bars represent the 2σ standard errors of estimate for the SRF values measured for the LAV/LAV (CRIILL), LAV/VSAV (CRIIVL), and VSAV/VSAV (CRIIVV) configurations. Because these standard errors represent estimates of absolute accuracy, they overestimate the actual differences measured for the LAV/LAV and LAV/VSAV configurations.

Chart #1 shows the 6 SRF data sets measured for tiles #D01 UltraWhite and #D02 Black. For each tile the solid-color plot points show the results for the LAV/LAV and LAV/VSAV instrument configurations, while the yellow-centered points show the results for the VSAV/VSAV configuration.

In Chart #1 the green and green/yellow plot points show the translucency test for Black tile #D02. The striking overlap exhibited by the 3 data sets is expected on theoretical grounds. The FRL value exhibited by a perfectly black test sample is zero. If the diffuse (Lambertian) component of the spectral reflectance is vanishingly small, changes in over-illumination do not lead to measurable changes in the SRF values.

The blue data points in Chart #1 show the translucency test for UltraWhite tile #D01. At the scale shown in this chart, the 2 sets of solid blue plot points overlap. This behavior is typical for ceramic tiles that exhibit low to moderate translucency. However, from 360 - 750 nm the SRF values exhibited by the blue/yellow points are systematically smaller, which unambiguously demonstrates that tile #D01 is translucent. The FRL value calculated from these results is 1.09%. [NOTE: For the FRL values reported herein the typical 2σ standard error of estimate is ±0.03.]

The tests for diagnostic tiles #D03 Deep Grey 10% and #D06 Grey 33% are shown in Chart #2. For both tiles the 3 sets of SRF data overlap. When the ordinate scale is expanded, both sets of solid plot points overlap, but the red/yellow points for the #D06 tile in the VSAV/VSAV configuration exhibit statistically significant decreases. Therefore, tile #D06 is translucent. The FRL values calculated for these tiles are 0.00% and 0.59%, respectively.

In Chart #3 the test results for tiles #D09 Light Grey 60% and #D11 Grey 85% are qualitatively similar to those shown in Chart #1. The FRL values calculated for tiles #D09 and #D11 are 0.91% and 0.17%.

In Chart #4 the results for the #D13 Deep Blue and #D14 Dark Blue tiles show that the losses in spectral reflectance that result from lateral diffusion exhibit complex wavelength dependencies. Because this phenomenon has not been reported previously, it is the subject of ongoing investigation at Mt. Baker Research L.L.C. The FRL values derived for these tiles are 3.14% and 2.51%.

The tests for the #D17 Greenish-Blue and #D20 Deep Green tiles are shown in Chart #5, and the calculated FRL values are 0.59% and 1.78%.

In Chart #6 the test results are shown for the #D21 Mid-Green and #D24 Yellow diagnostic tiles for which the calculated FRL values are 0.62% and 0.45%.

Procedure -- Continued

Chart #7 shows the results for the #D27 Deep Orange and #D28 Deep Orange-Red tiles. The blue and blue/yellow plot points for tile #D27 exhibit behavior that is typical for a moderately translucent ceramic material. At wavelengths greater than 570 nm the solid blue points for the LAV/VSAV configuration exhibit slightly larger values than the points for the LAV/LAV configuration. This difference arises because the LAV/VSAV configuration significantly increases the effective over-illumination.

For tile #D27 at wavelengths greater than 570 nm, the blue/yellow data points show that the SRF values are significantly reduced. This behavior is characteristic of moderately translucent ceramic tiles. Tile #D27 was included in the Diagnostic Tile Set to illustrate this phenomenon. The FRL values calculated for tiles #D27 and #D28 are 2.61% and 0.57%, respectively.

Chart #8 shows the test results for the #D29 Deep Red and #D30 Rose Pink tiles. Again, the wavelength dependencies are complex, and the calculated FRL values are 0.70% and 1.98%.

For the 16 investigated diagnostic tiles the FRL values range from 0.00% to 3.14%. The following guidelines are recommended for ceramic transfer standards that are used for testing and profiling instruments in the diffuse SCI geometry. For target instruments that support a typical LAV, MAV or SAV sample port together with over-illumination, the FRL values should not exceed 3.50%. For target instruments that support a VSAV sample port, the FRL values should not exceed 1.50%. [REF: Diagnostic Tile Set Instruction Manual. NOTE: Consult this reference for specifications of the LAV, MAV, SAV and VSAV sample ports of the CE7000A.]

For the #D13 Deep Blue and #D20 Deep Green tiles most of the reflectance losses occur at wavelengths greater than 720 nm, which are minimally important in color measurements. Because this is not the case for the #D14 Dark Blue, #D27 Deep Orange and #D30 Rose Pink tiles, their FRL values are more significant.

Summary: The 16 tested diagnostic tiles may be used to validate the performance of spectrophotometers that are equipped with all but the smallest sample ports. For validating small-aperture instruments, tiles #D14, #D27 and #D30 should be replaced with transfer standards that exhibit reduced translucency.

Other Transfer Standards: The FRL values listed below were measured independently in the SCI geometry. For the 29 CERAM Series II tiles in our reference collection the FRL values ranged from 0.00% to 8.98%, as follows: White #1, 0.84%. White #2, 0.55%. White #3, 1.43%. White #4, 0.59%. White #5, 0.00%. Grey 80%, 0.21%. Grey 70%, 0.46%. Light Grey, 0.90%. Grey 50%, 0.89%. Grey 40%, 0.42%. Mid-Grey, 1.10%. Difference Grey, 1.21%. Dark Grey, 0.30%. Black, 0.00%. Deep Blue, 1.54%. Mid-Blue, 0.58%. Cyan, 0.66%. Deep Green, 0.84%. Difference Green, 0.59%. Pale Green, 0.37%. Yellow-Green 98/5, 3.12%. Greenish-Yellow 98/7, 2.12%. Yellow, 2.52%. Orange, 3.03%. Meta-Orange, 2.20%. Red-Orange 99/1, 8.98%. Red, 3.14%. Deep Pink, 1.03%. Brown, 1.07%.

An FRL value of 3.13% ± 0.02% was measured for one sample of MC20 Russian White Opal Glass. The single Konica-Minolta CMA103 white reference tile that was measured (S/N 18776042) yielded a value of 0.90% ± 0.02%. Typical samples of Fluorilon (sintered PTFE) yielded values ranging from 2.9% to 3.6%. The value measured for one sample of extruded PTFE was 22.85% ± 0.02%, while the values for White Vitrolite and White Carrera glasses were 18.86% ± 0.02% and 25.57% ± 0.02%, respectively.

Caveats: The tests for translucency described in this report may be adapted to other spectrophotometers that support variable over-illumination. However, the success of this method requires that the CERAM white reference tile supplied with the instrument must exhibit negligible translucency.

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Procedure -- Continued

As noted above, an FRL value of 0.00% ± 0.03% was measured for CERAM White tile #5. This is the white reference tile supplied with the 2008 CE7000A spectrophotometer used in the present study (S/N 37132651108). An FRL value of 1.43% ± 0.03% was obtained for CERAM White tile #3, the white tile supplied with our original 2003 CE7000A instrument (S/N 37116190602). When the white calibration tile of the instrument is translucent, the procedure for detecting and measuring translucency in other materials yields results that are more difficult to interpret. [REF: Diagnostic Tile Set Instruction Manual.]

Finally, the FRL values measured with different instruments, or with the same instrument in different optical geometries, are subject to systematic variations from the results reported above.

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Notes – Certified Data

1. The attached graphs of SRF data are provided for informational purposes only. The accompanying CD-R disk contains the certified SRF & colorimetric data for the calibrated tiles.

Notes – Basis for Traceability

1. NRC Calibration Report No. PAR-2007-2528, 2007, "0°:45° Radiance Factors of Two Ceramic Tiles, S/N: P-6-Light-Green, B-5-White," National Research Council Canada, Institute for National Measurement Standards, Ottawa, Canada, www.nrc-cnrc.gc.ca.
2. ASTM E1349-06, 2006, "Standard Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional (45:0 or 0:45) Geometry," ASTM International, West Conshohocken, PA, www.astm.org.
3. ASTM E1345-98, 1998 (2003), "Standard Practice for Reducing the Effect of Variability of Color Measurement by Use of Multiple Measurements," ASTM International, West Conshohocken, PA, www.astm.org.

Technical References

1. ASTM E275-01, 2001, "Standard Practice for Describing and Measuring Performance of Ultraviolet, Visible, and Near-Infrared Spectrophotometers," ASTM International, West Conshohocken, PA, www.astm.org.
2. ASTM E2214-02, 2002, "Standard Practice for Specifying and Verifying the Performance of Color-Measuring Instruments," ASTM International, West Conshohocken, PA, www.astm.org.
3. ASTM E1164-07, 2007, "Standard Practice for Obtaining Spectrometric Data for Object-Color Evaluation," ASTM International, West Conshohocken, PA, www.astm.org.
4. ASTM E308-06, 2006, "Standard Practice for Computing the Colors of Objects by Using the CIE System," ASTM International, West Conshohocken, PA, www.astm.org.
5. CIE 15:2004, "CIE Technical Report: Colorimetry," 3rd edition, International Commission on Illumination (Commission Internationale de l'Eclairage), Vienna, Austria, ISBN: 3-901-906-33-9, www.cie-usnc.org.
6. D.R. Wyble, D.C. Rich, "Evaluation of Methods for Verifying the Performance of Color-Measuring Instruments. Part I: Repeatability," Color Research and Application, 32(3), 166(10), 2007.
7. D.R. Wyble, D.C. Rich, "Evaluation of Methods for Verifying the Performance of Color-Measuring Instruments. Part II: Inter-Instrument Reproducibility," Color Research and Application, 32(3), 176(19), 2007.
8. J.W. Root, "Diagnostic Tile Set Instruction Manual," v. 2.1, Mt. Baker Research L.L.C., Bellingham, Washington, October 1, 2009.

General References

1. ISCC Technical Report 2003-1, 2003, J. Ladson, A.W. Springsteen, J. Sefl, H.S. Fairman, M.H. Brill, and J. Zwinkels, "Guide to Material Standards and Their Use in Color Measurement," Inter-Society Color Council, Reston, VA, www.iscc.org.
2. R.S. Berns, "Billmeyer and Saltzman's Principles of Color Technology," 3rd edition, John Wiley & Sons, Inc., New York, 2000, ISBN: 978-0-471-19459-0, www.wiley.com.
3. M.D. Fairchild, "Color Appearance Models," 2nd edition, John Wiley & Sons, Ltd., Chichester, England, 2005, ISBN: 0-470-01216-1, www.wiley.com.
4. "Spectrophotometer CM-2500c Instruction Manual," Konica-Minolta Sensing Americas, Inc., Ramsey, NJ, www.se.konicaminolta.

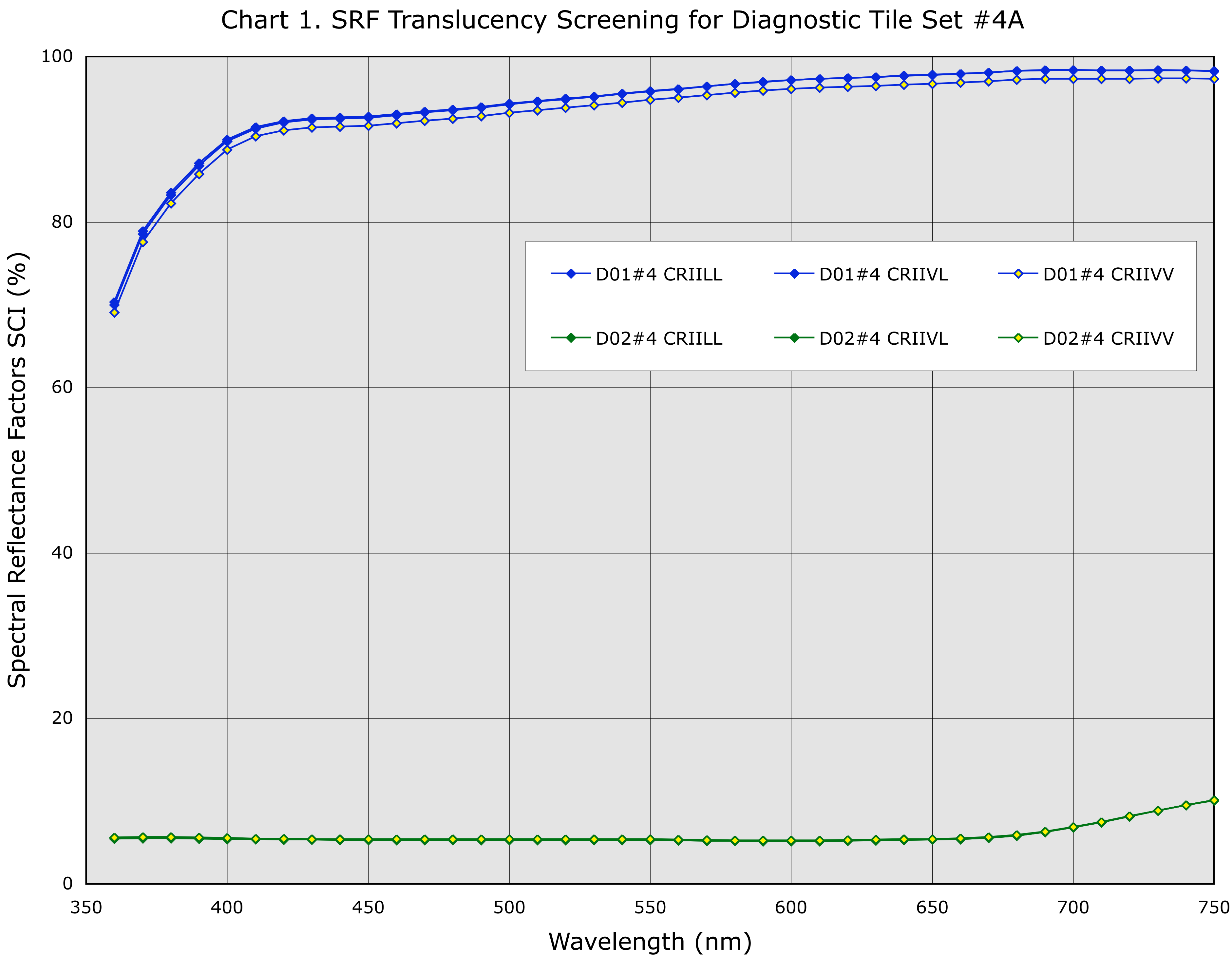


Chart 1. SRF Translucency Screening for Diagnostic Tile Set #4A
Spectral Reflectance Factors SCI (%)
Wavelength (nm)
0
20
40
60
80
100
350
400
450
500
550
600
650
700
750
D01#4 CRIILL
D01#4 CRIIVL
D01#4 CRIIVV
D02#4 CRIILL
D02#4 CRIIVL
D02#4 CRIIVV

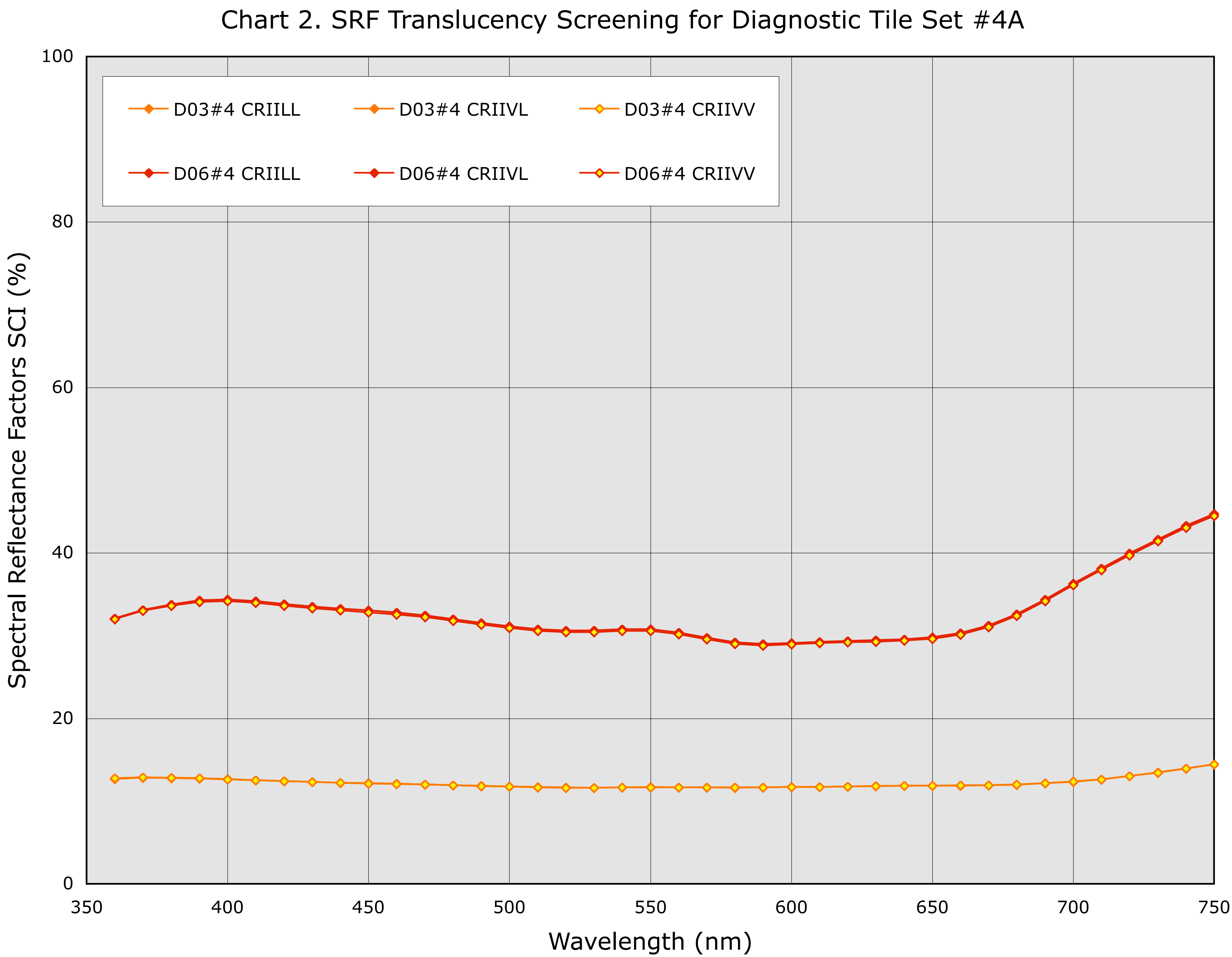


Chart 2. SRF Translucency Screening for Diagnostic Tile Set #4A
D03#4 CRIILL
D03#4 CRIIVL
D03#4 CRIIVV
D06#4 CRIILL
D06#4 CRIIVL
D06#4 CRIIVV
Spectral Reflectance Factors SCI (%)
100
80
60
40
20
0
350
400
450
500
550
600
650
700
750
Wavelength (nm)

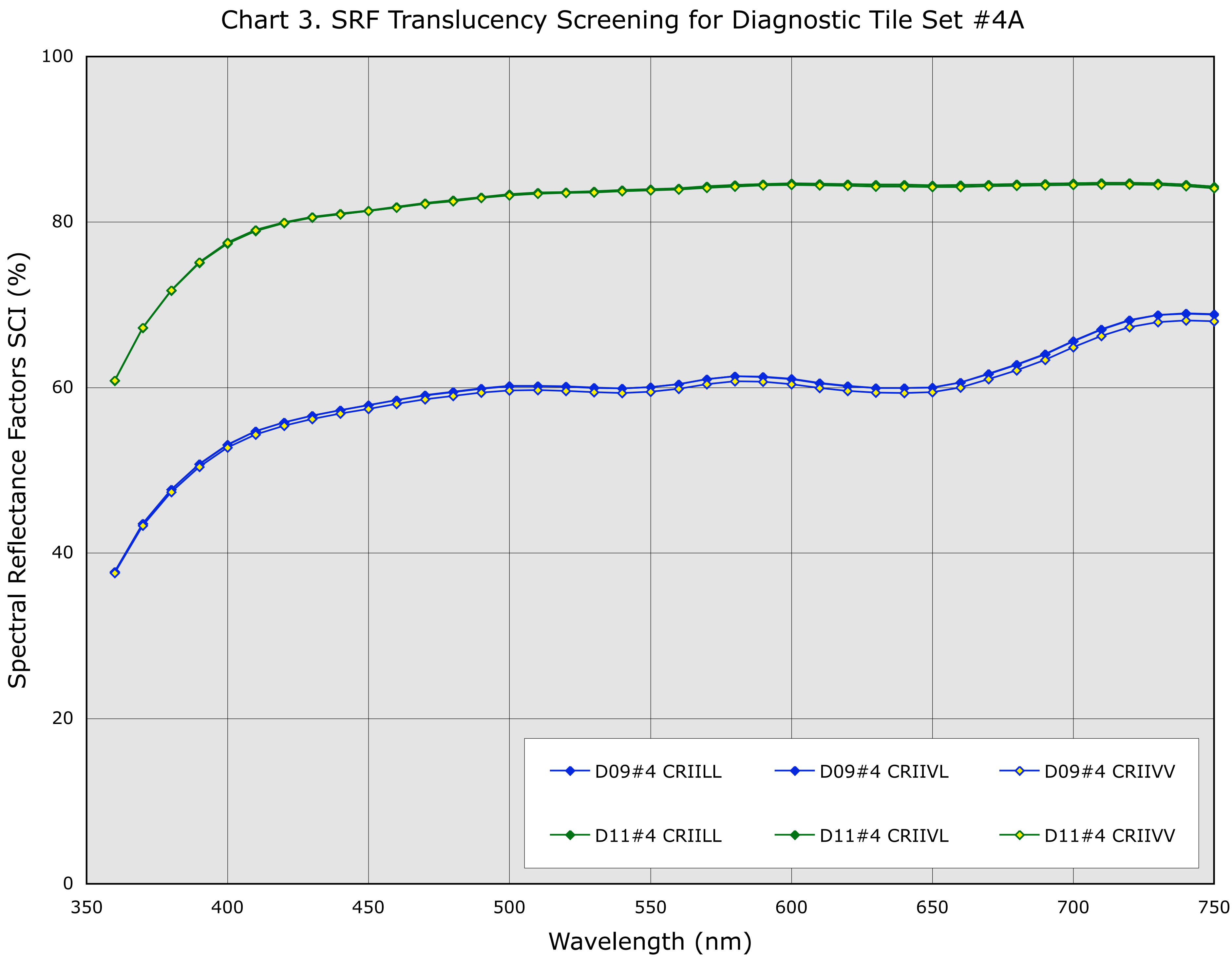


Chart 3. SRF Translucency Screening for Diagnostic Tile Set #4A
Spectral Reflectance Factors SCI (%)
Wavelength (nm)
0
20
40
60
80
100
350
400
450
500
550
600
650
700
750
D09#4 CRIILL
D09#4 CRIIVL
D09#4 CRIIVV
D11#4 CRIILL
D11#4 CRIIVL
D11#4 CRIIVV

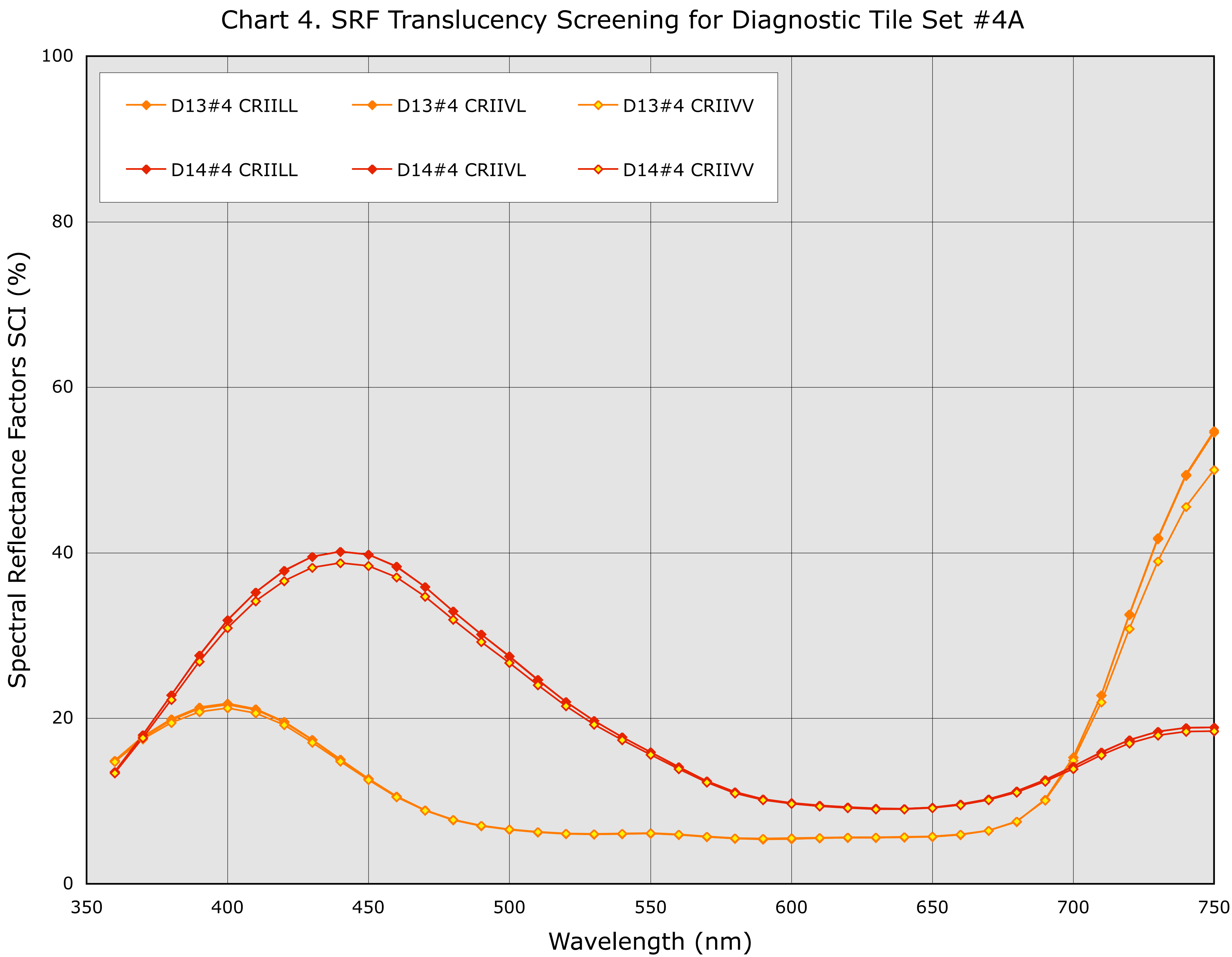


Chart 4. SRF Translucency Screening for Diagnostic Tile Set #4A
D13#4 CRIILL
D13#4 CRIIVL
D13#4 CRIIVV
D14#4 CRIILL
D14#4 CRIIVL
D14#4 CRIIVV
Spectral Reflectance Factors SCI (%)
0
20
40
60
80
100
Wavelength (nm)
350
400
450
500
550
600
650
700
750

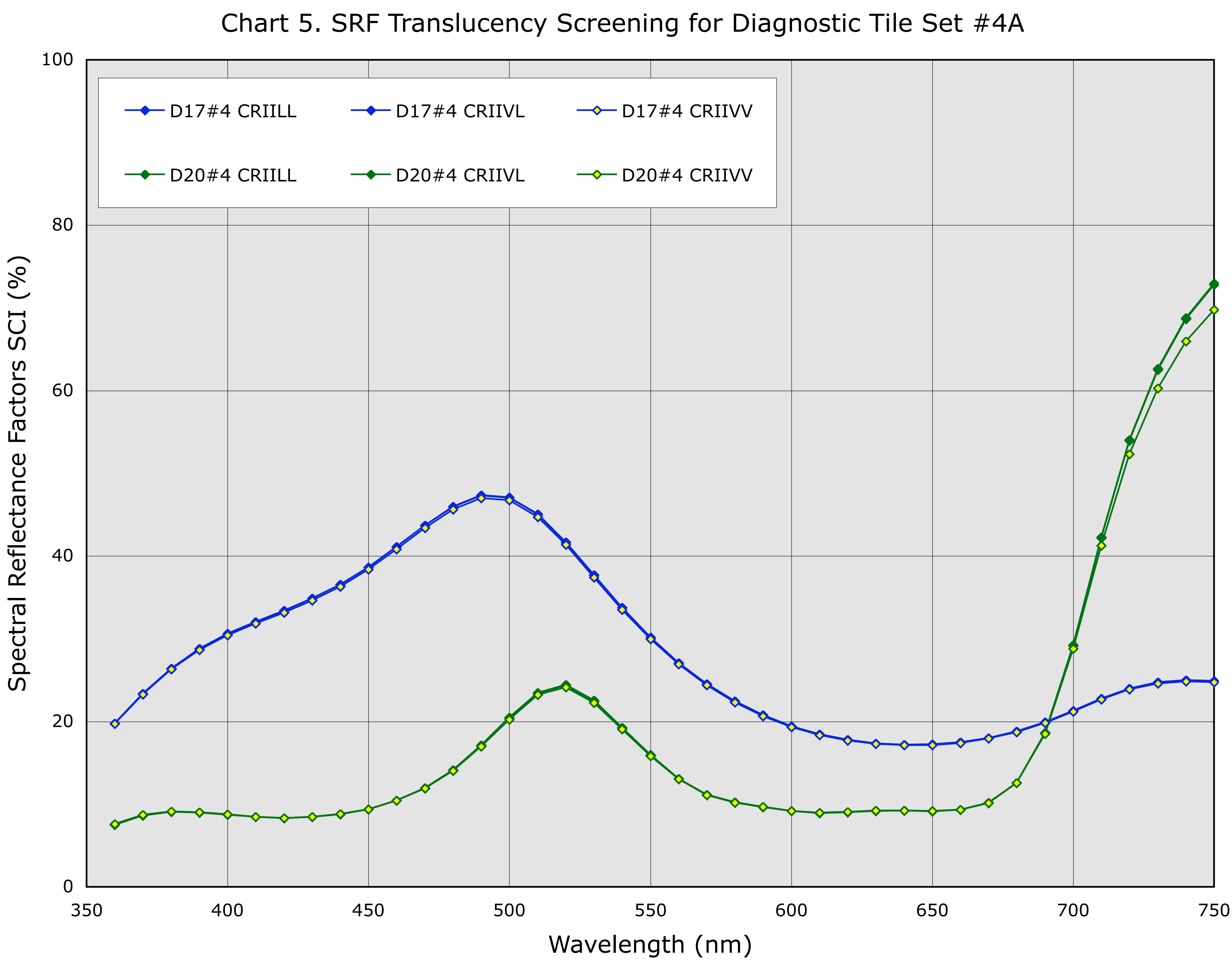
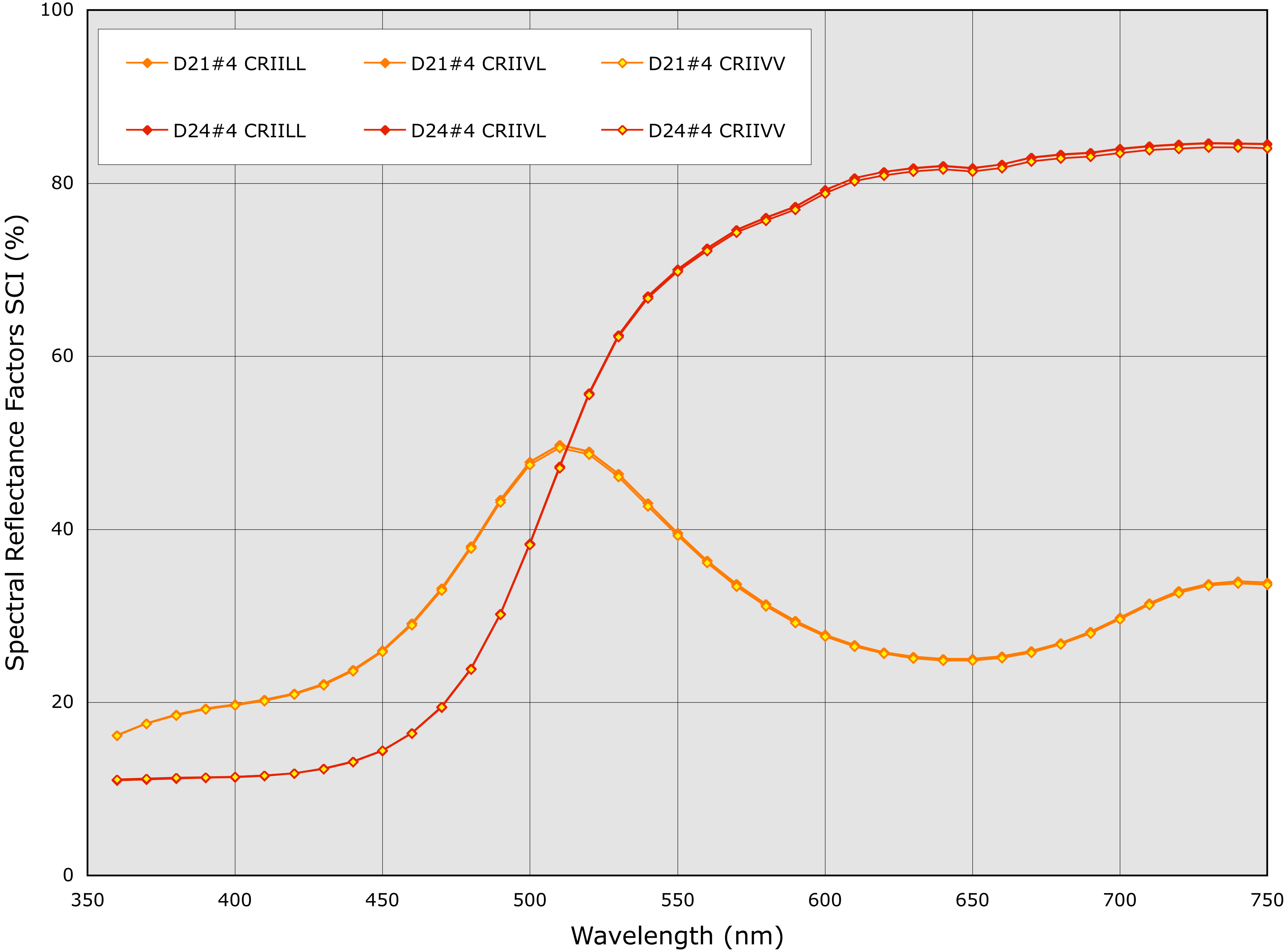


Chart 5. SRF Translucency Screening for Diagnostic Tile Set #4A
D17#4 CRIILL
D17#4 CRIIVL
D17#4 CRIIVV
D20#4 CRIILL
D20#4 CRIIVL
D20#4 CRIIVV
Spectral Reflectance Factors SCI (%)
0
20
40
60
80
100
350
400
450
500
550
600
650
700
750
Wavelength (nm)

Chart 6. SRF Translucency Screening for Diagnostic Tile Set #4A



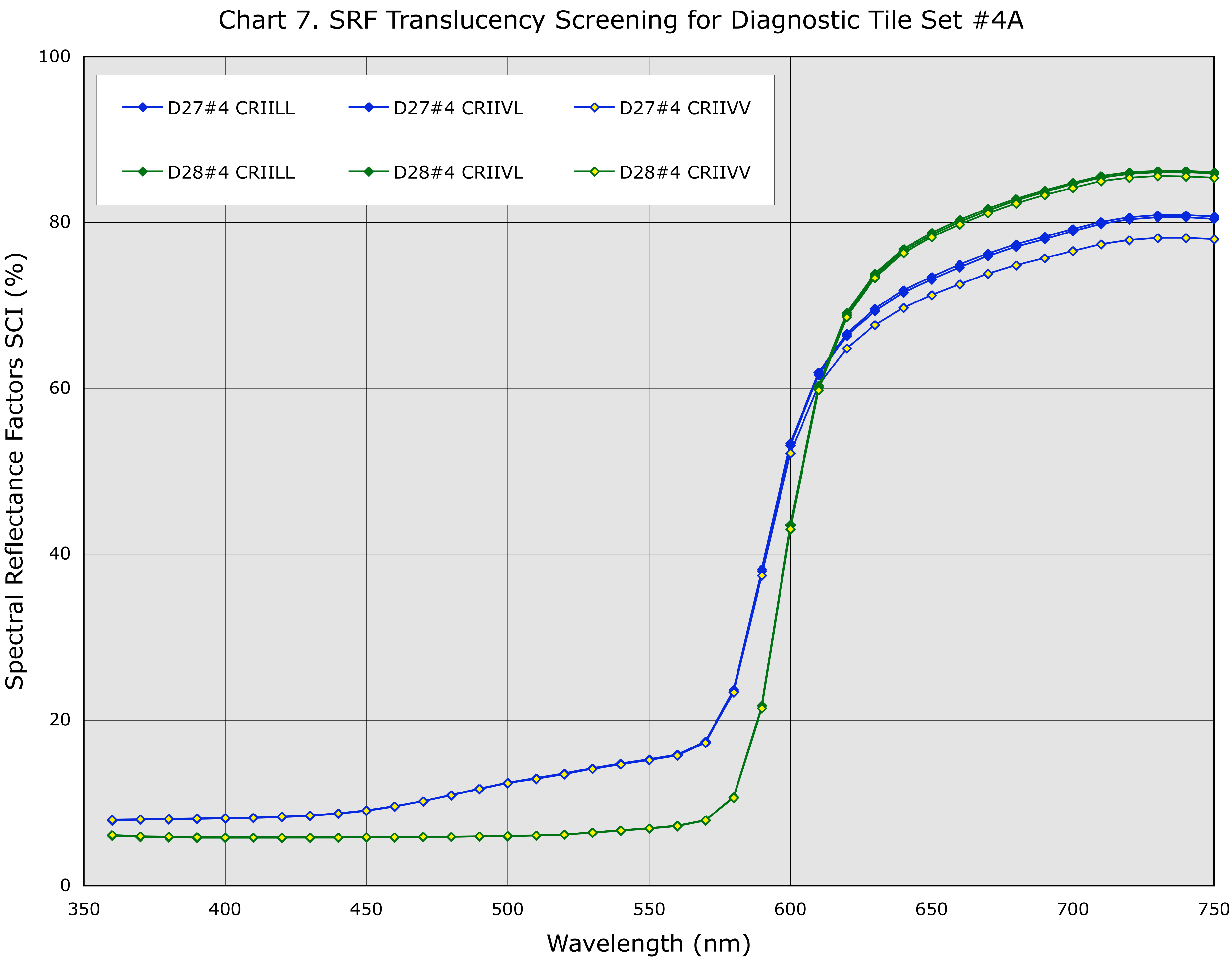
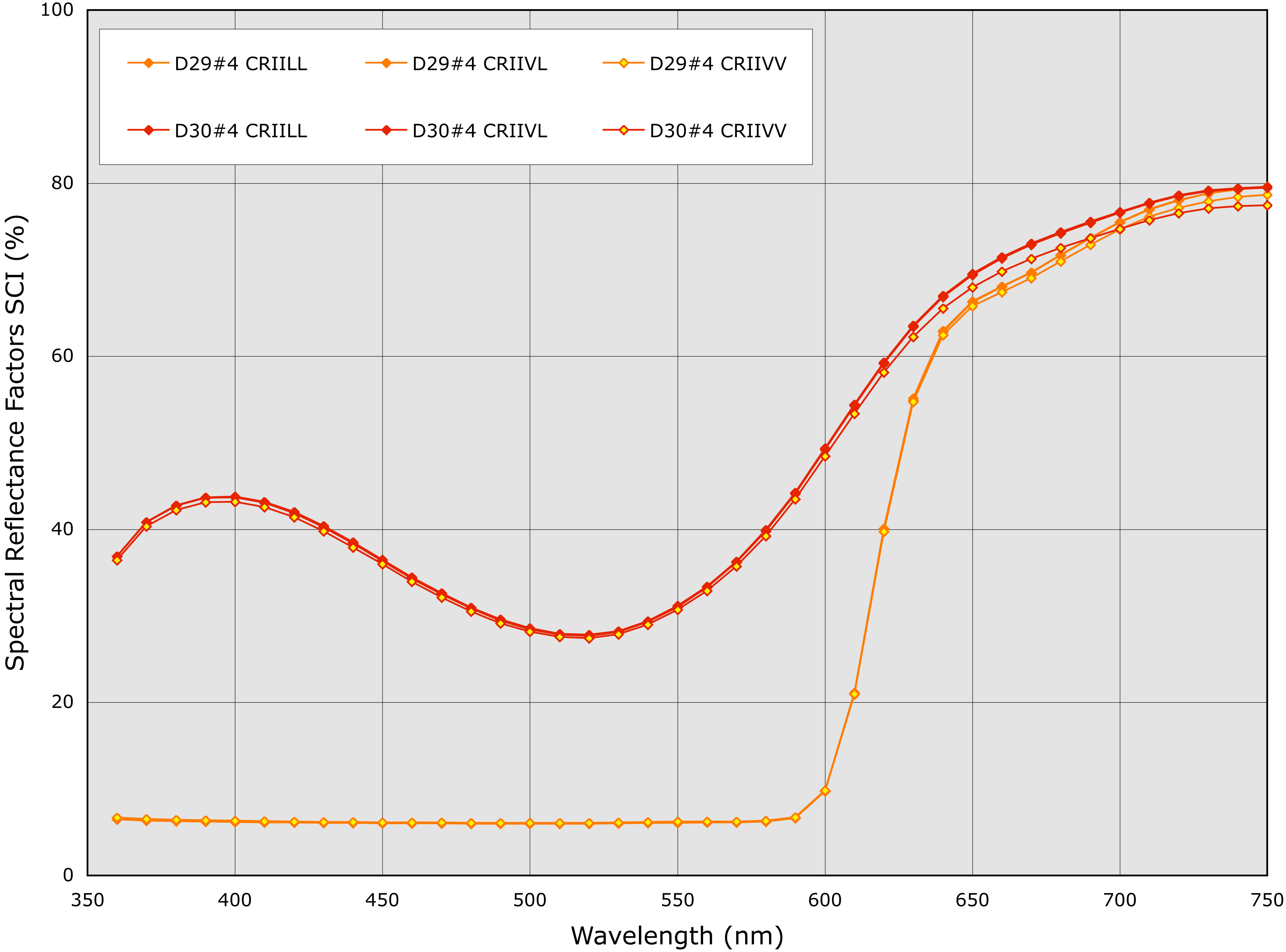


Chart 7. SRF Translucency Screening for Diagnostic Tile Set #4A
D27#4 CRIILL
D27#4 CRIIVL
D27#4 CRIIVV
D28#4 CRIILL
D28#4 CRIIVL
D28#4 CRIIVV
Spectral Reflectance Factors SCI (%)
0
20
40
60
80
100
350
400
450
500
550
600
650
700
750
Wavelength (nm)

Chart 8. SRF Translucency Screening for Diagnostic Tile Set #4A



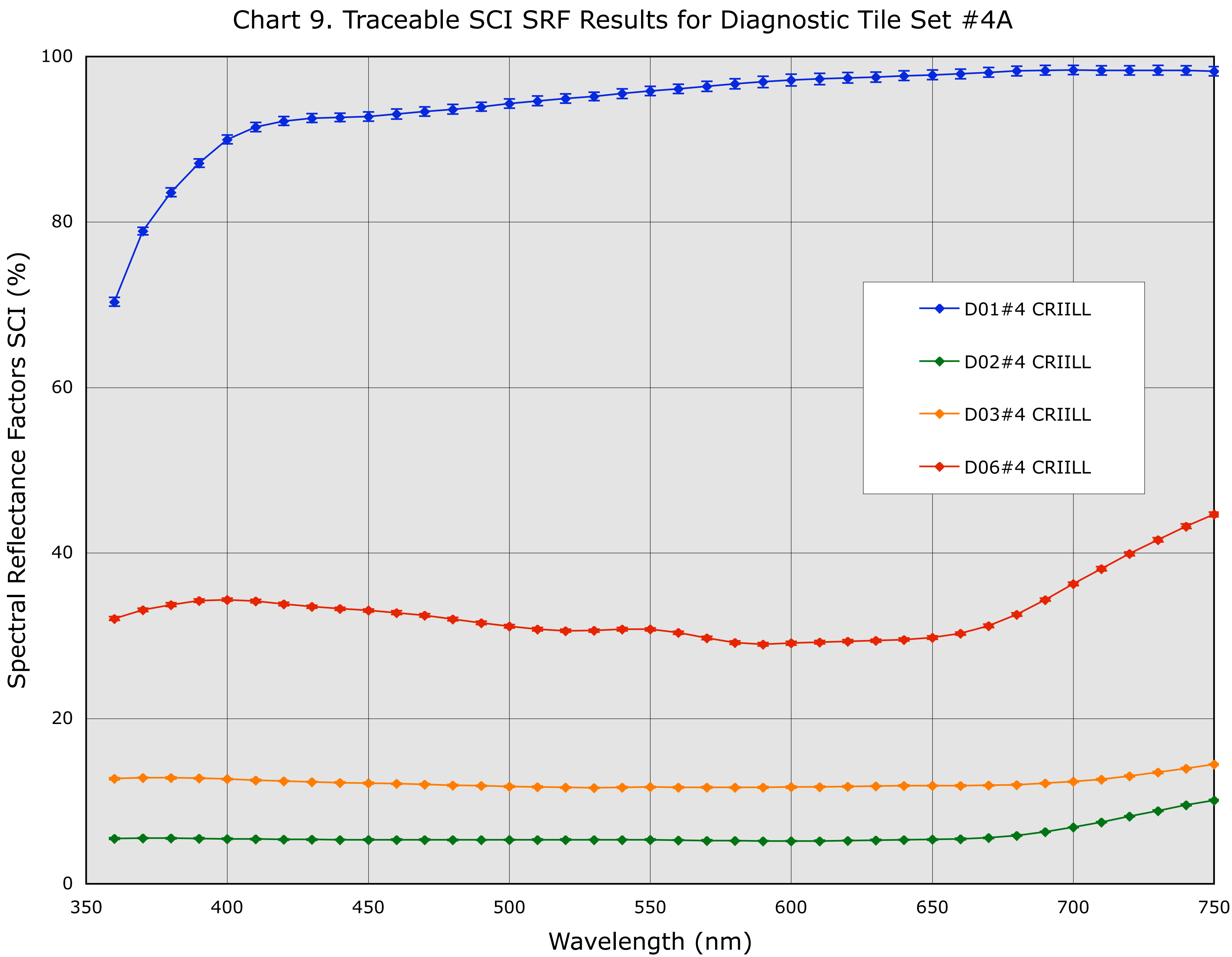


Chart 9. Traceable SCI SRF Results for Diagnostic Tile Set #4A
Spectral Reflectance Factors SCI (%)
Wavelength (nm)
0
20
40
60
80
100
350
400
450
500
550
600
650
700
750
D01#4 CRIILL
D02#4 CRIILL
D03#4 CRIILL
D06#4 CRIILL

Chart 10. Traceable SCI SRF Results for Diagnostic Tile Set #4A

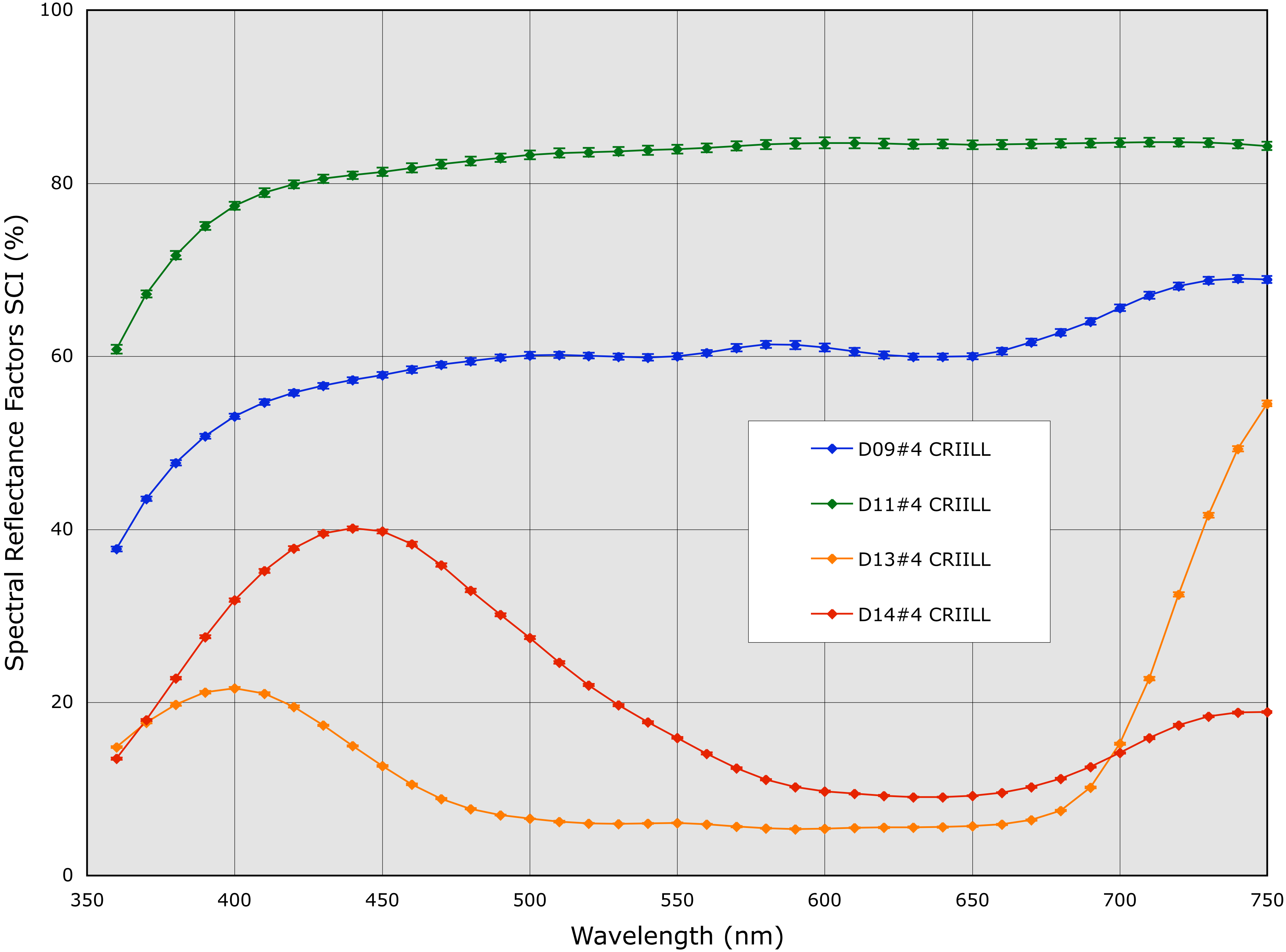
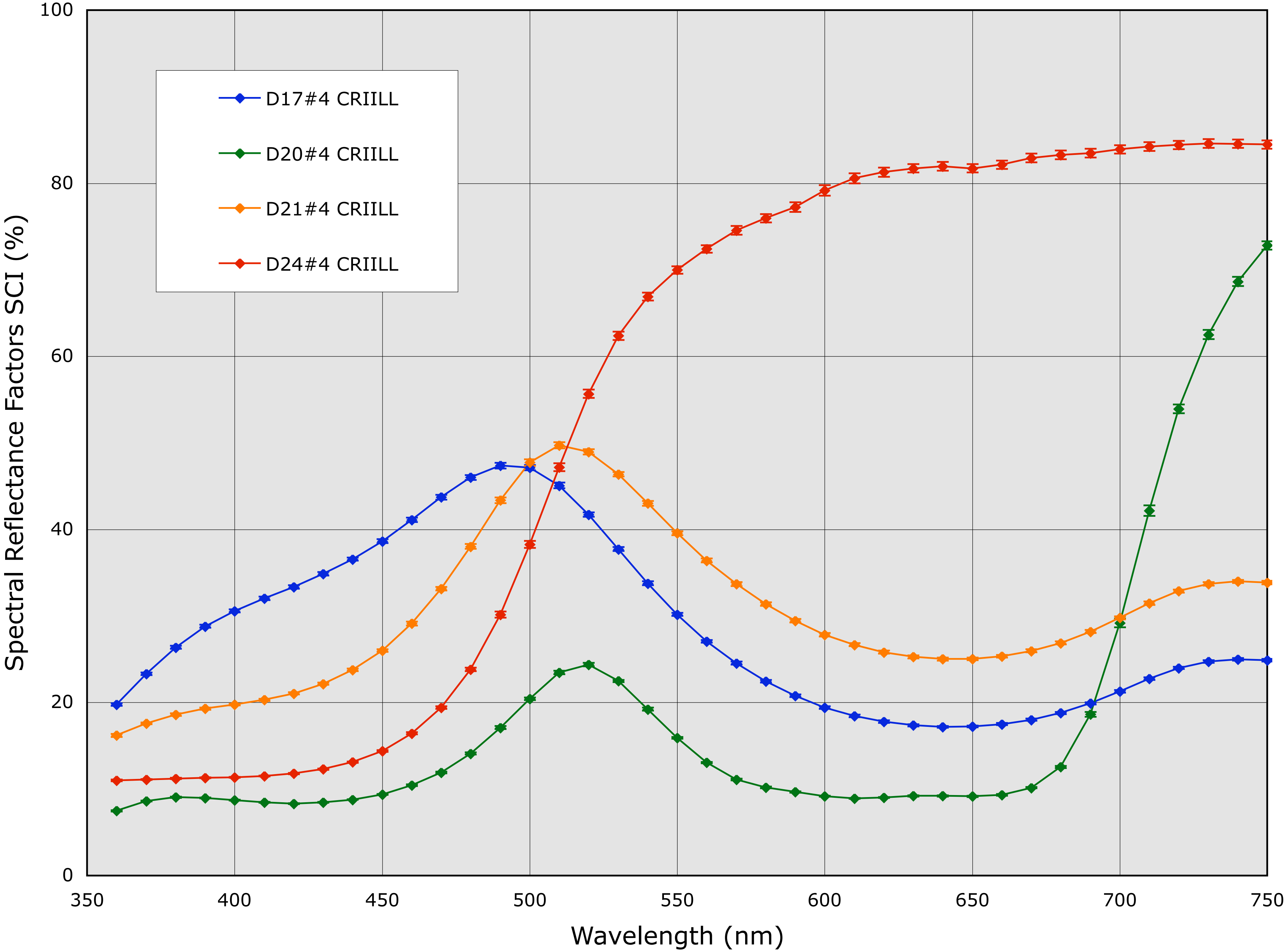


Chart 11. Traceable SCI SRF Results for Diagnostic Tile Set #4A



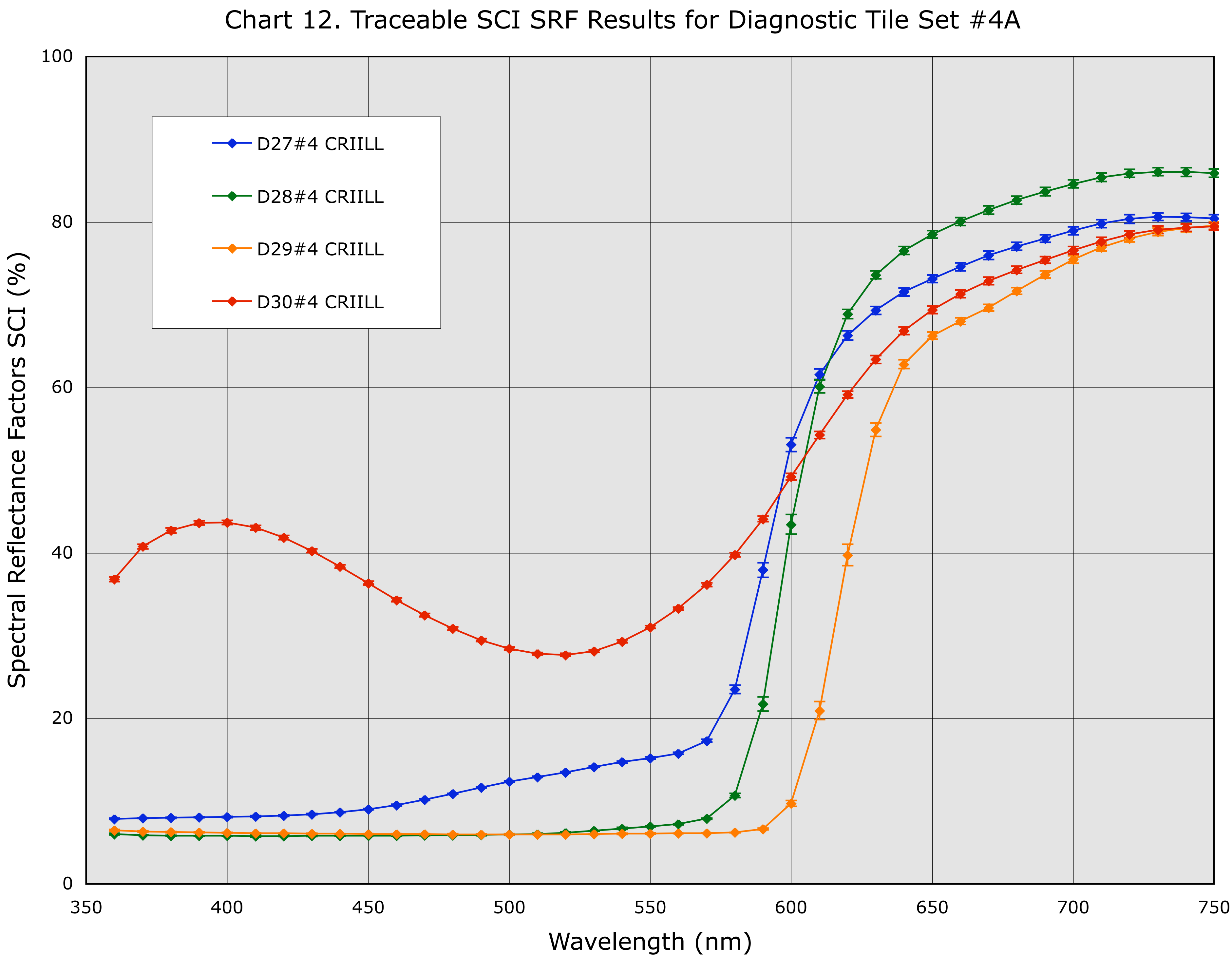


Chart 12. Traceable SCI SRF Results for Diagnostic Tile Set #4A
D27#4 CRIILL
D28#4 CRIILL
D29#4 CRIILL
D30#4 CRIILL
Spectral Reflectance Factors SCI (%)
Wavelength (nm)
0
20
40
60
80
100
350
400
450
500
550
600
650
700
750

Chart 13. Traceable SCI SRF Results for Diagnostic Tile Set #4A

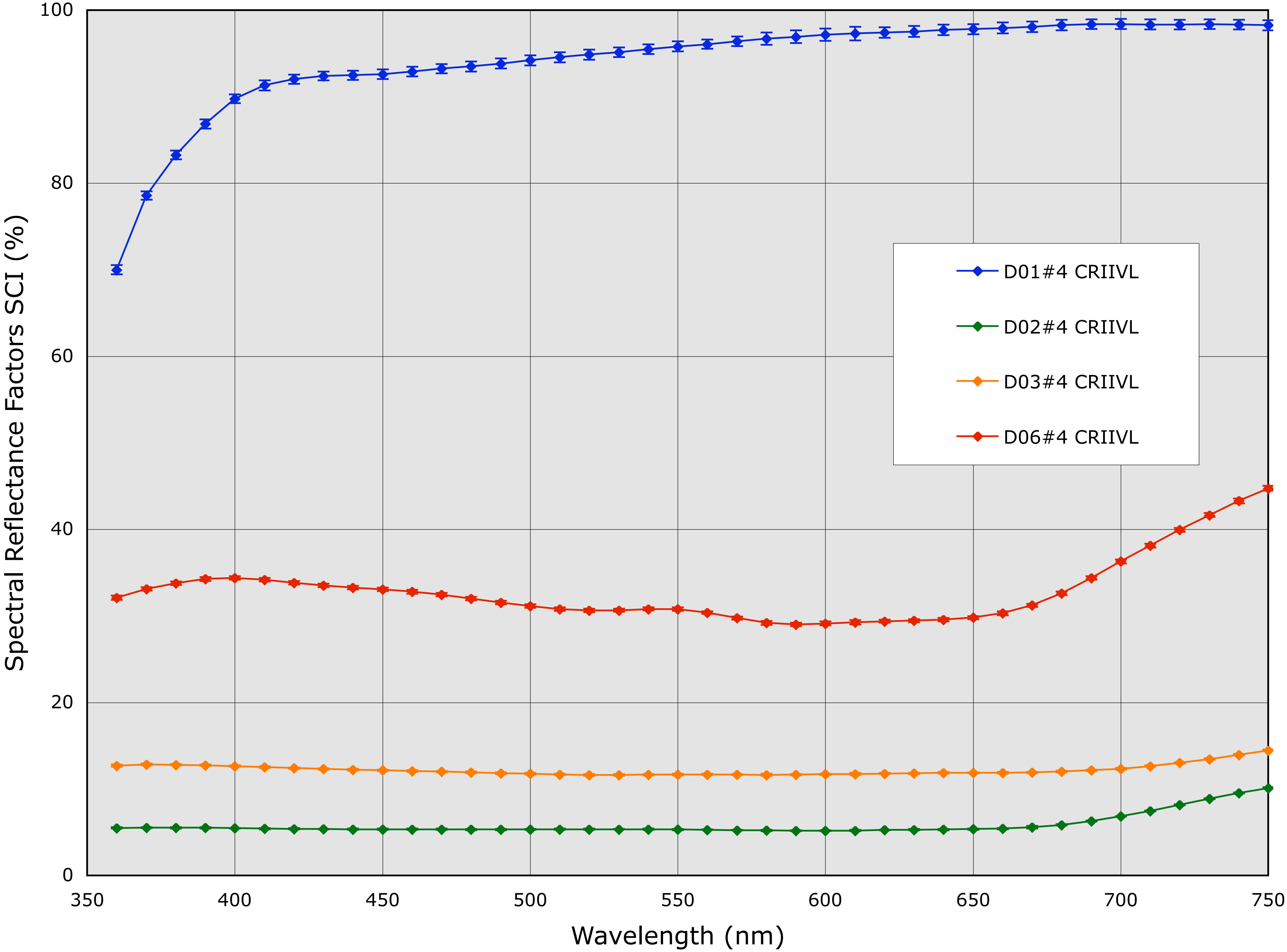


Chart 14. Traceable SCI SRF Results for Diagnostic Tile Set #4A

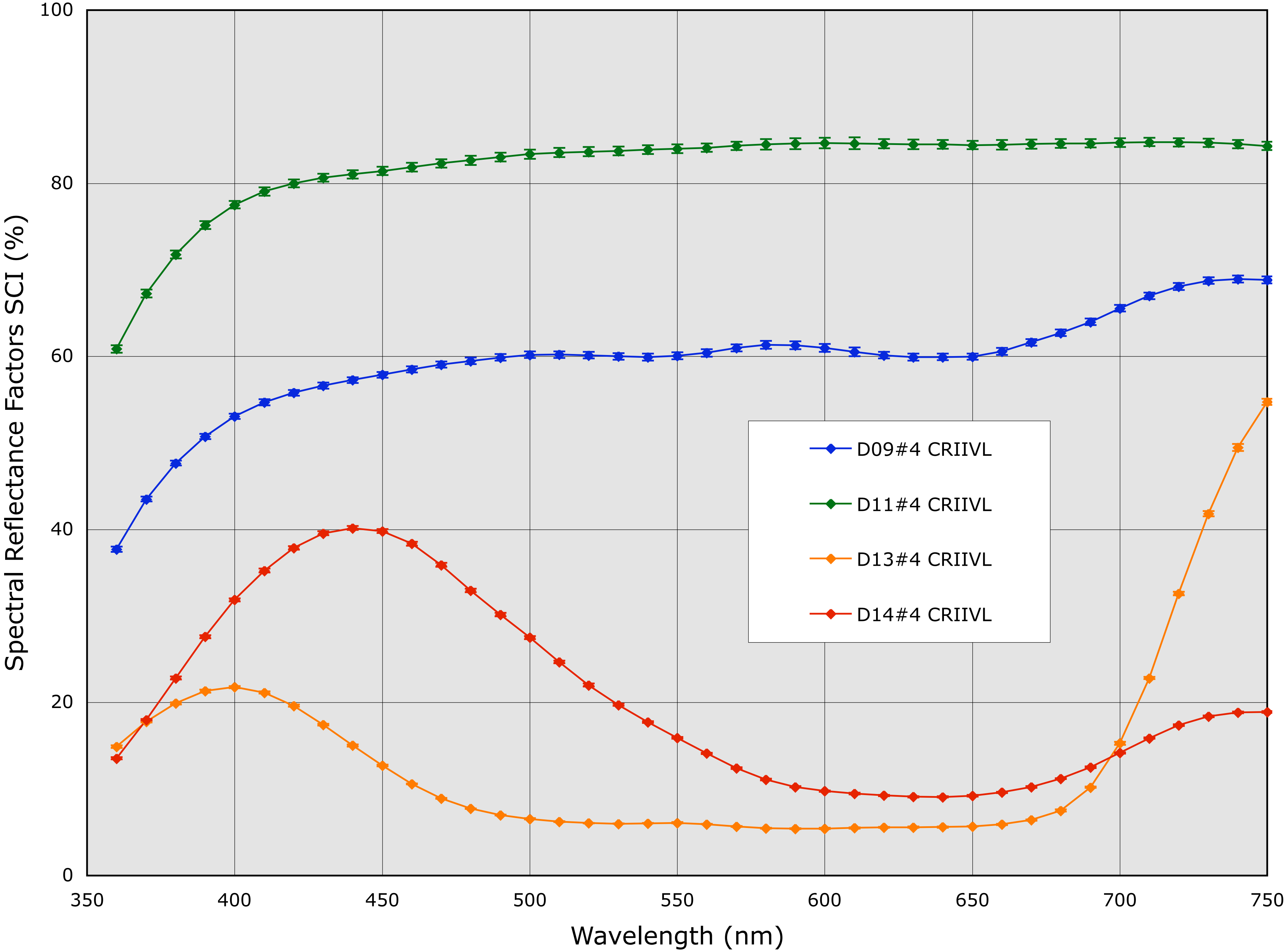
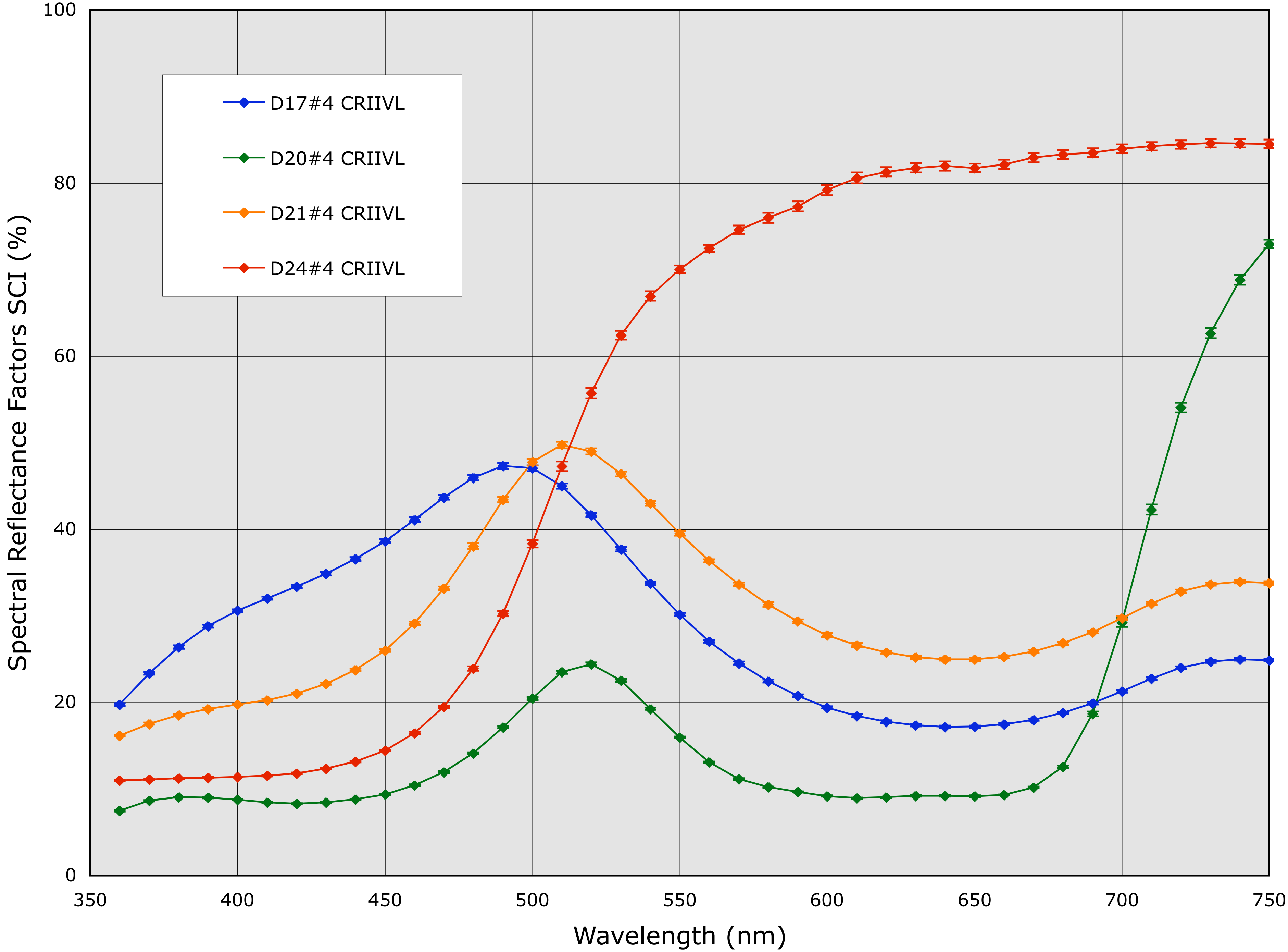


Chart 15. Traceable SCI SRF Results for Diagnostic Tile Set #4A



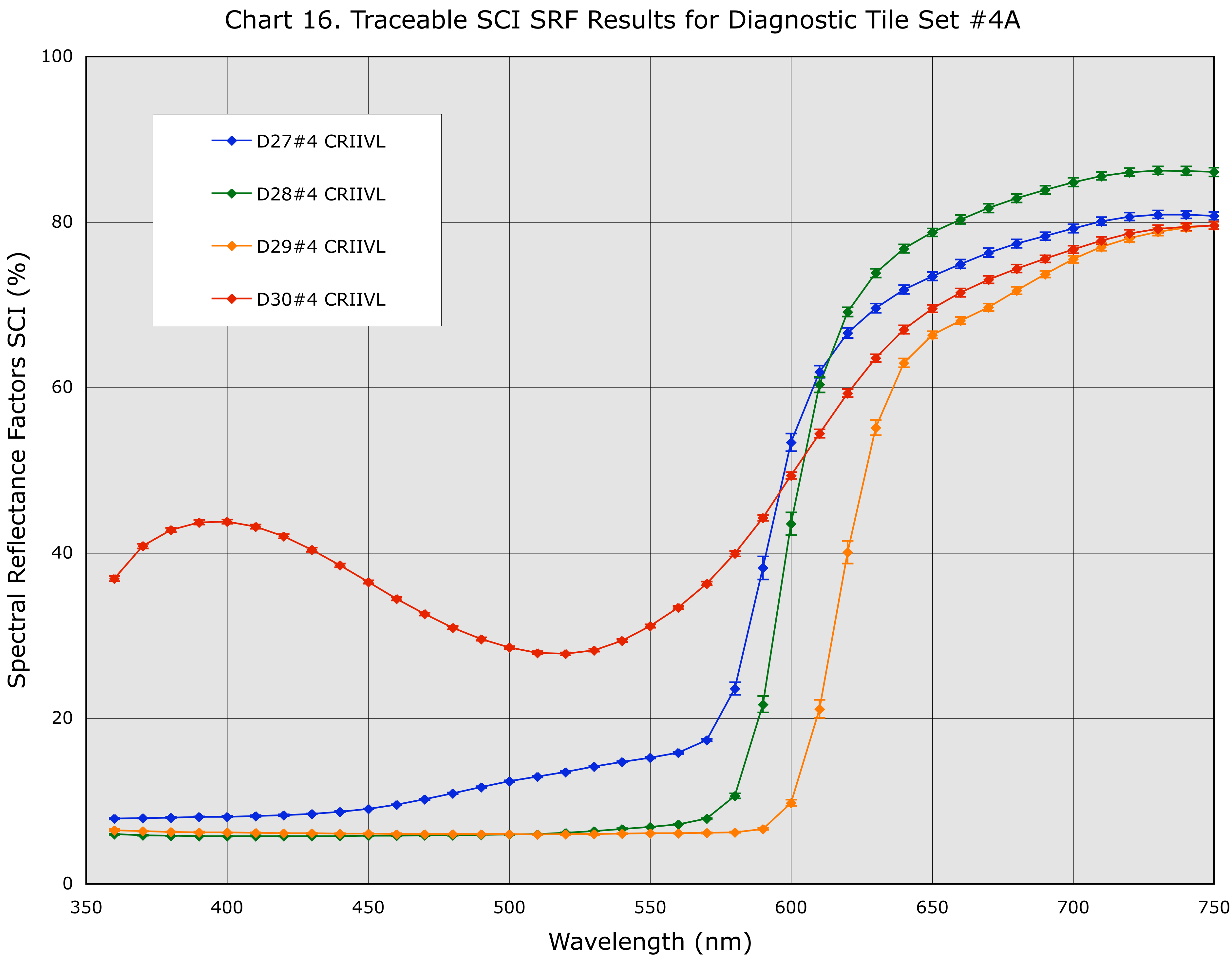


Chart 16. Traceable SCI SRF Results for Diagnostic Tile Set #4A
D27#4 CRIIVL
D28#4 CRIIVL
D29#4 CRIIVL
D30#4 CRIIVL
Spectral Reflectance Factors SCI (%)
Wavelength (nm)
0
20
40
60
80
100
350
400
450
500
550
600
650
700
750

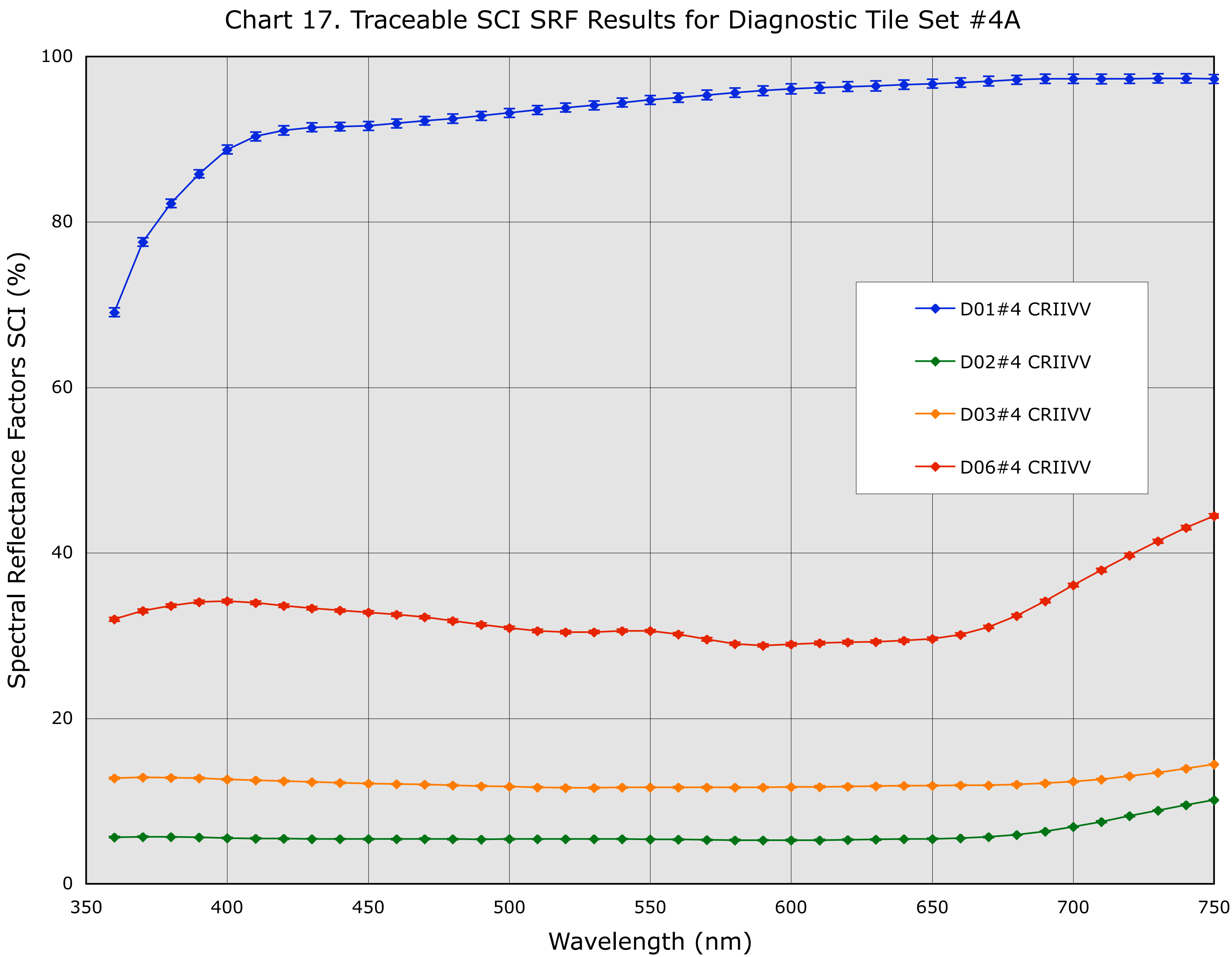


Chart 17. Traceable SCI SRF Results for Diagnostic Tile Set #4A
Spectral Reflectance Factors SCI (%)
100
80
60
40
20
0
350
400
450
500
550
600
650
700
750
Wavelength (nm)
D01#4 CRIIVV
D02#4 CRIIVV
D03#4 CRIIVV
D06#4 CRIIVV

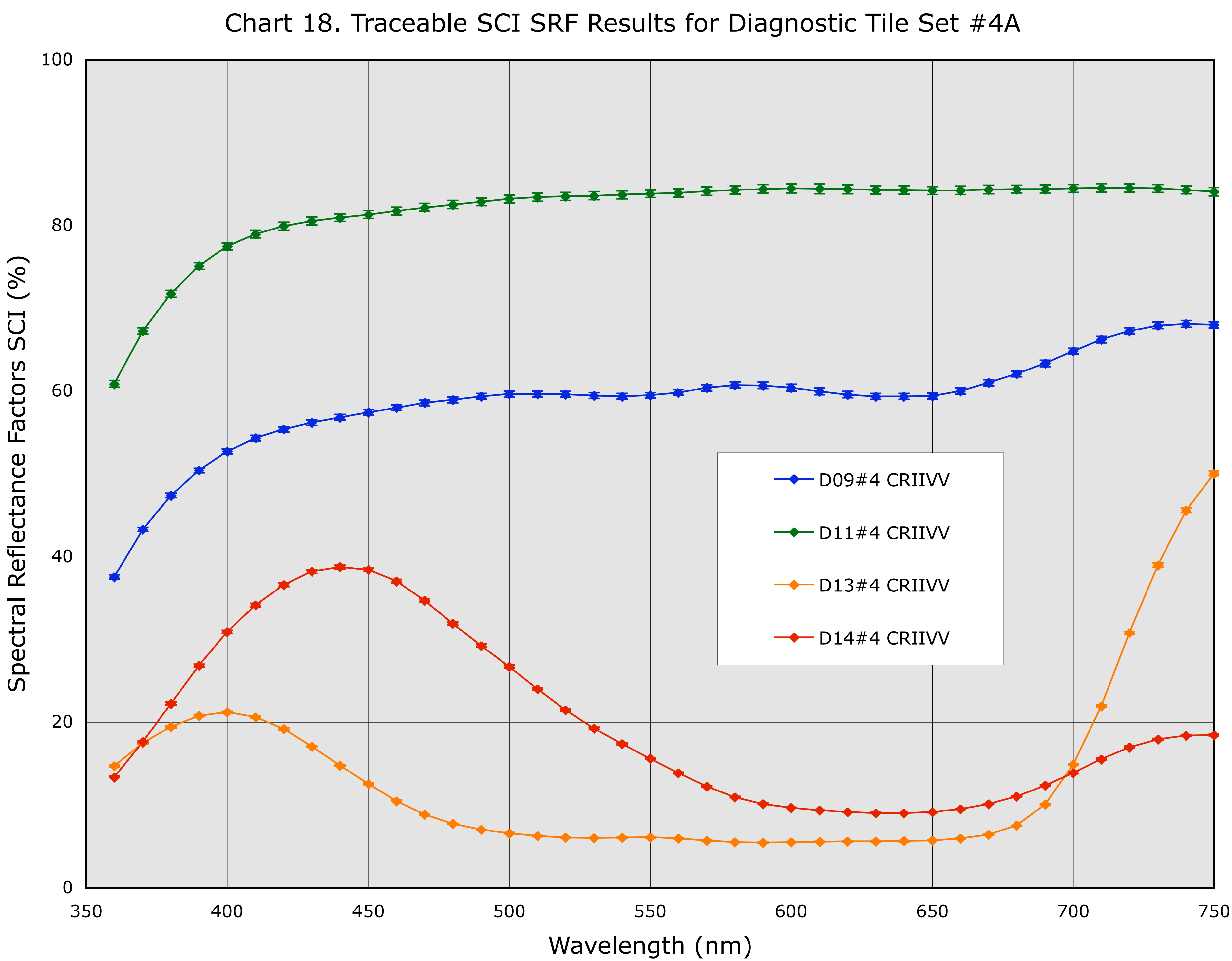


Chart 18. Traceable SCI SRF Results for Diagnostic Tile Set #4A
Spectral Reflectance Factors SCI (%)
Wavelength (nm)
D09#4 CRIIVV
D11#4 CRIIVV
D13#4 CRIIVV
D14#4 CRIIVV
0
20
40
60
80
100
350
400
450
500
550
600
650
700
750

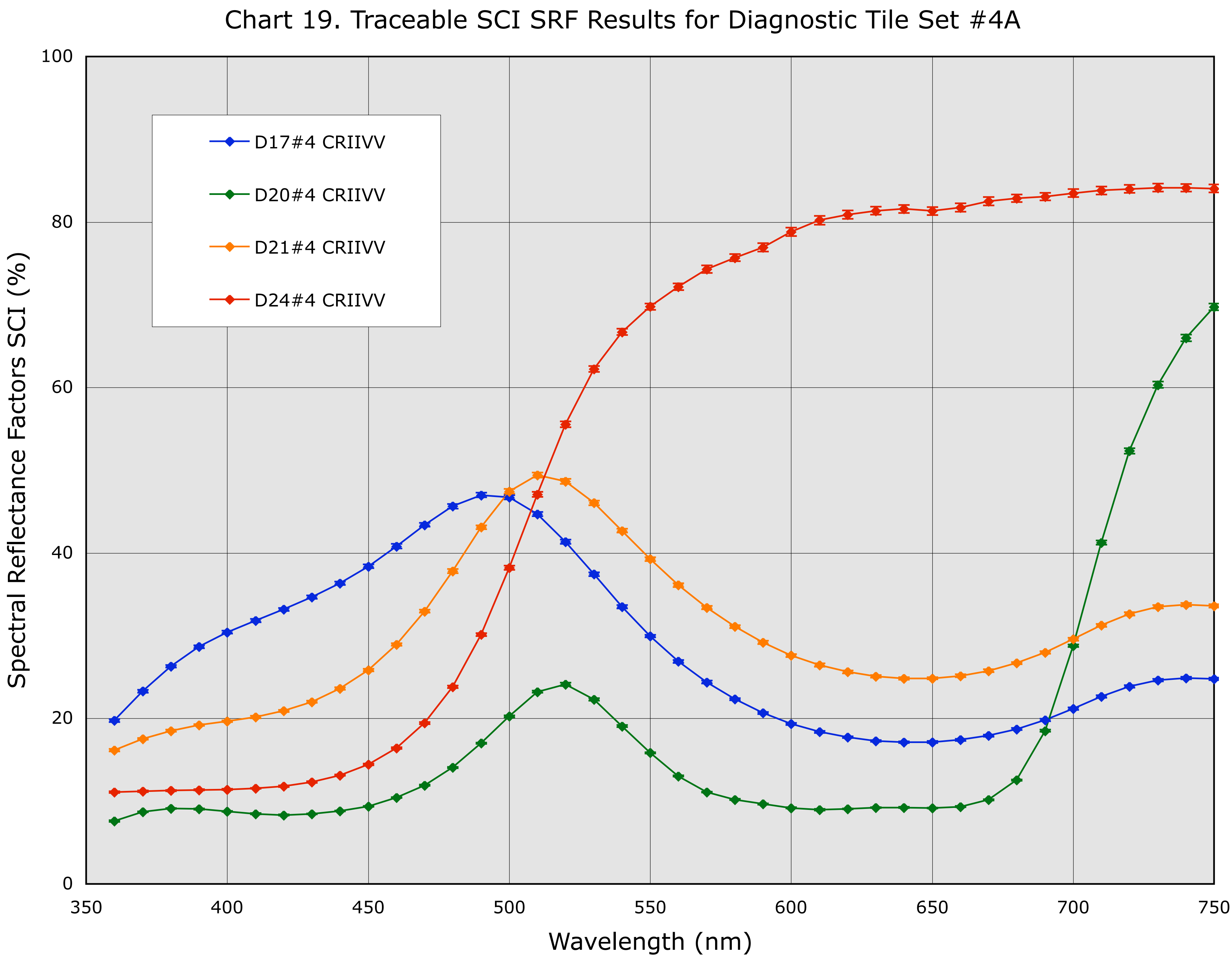


Chart 19. Traceable SCI SRF Results for Diagnostic Tile Set #4A
D17#4 CRIIVV
D20#4 CRIIVV
D21#4 CRIIVV
D24#4 CRIIVV
Spectral Reflectance Factors SCI (%)
Wavelength (nm)
0
20
40
60
80
100
350
400
450
500
550
600
650
700
750

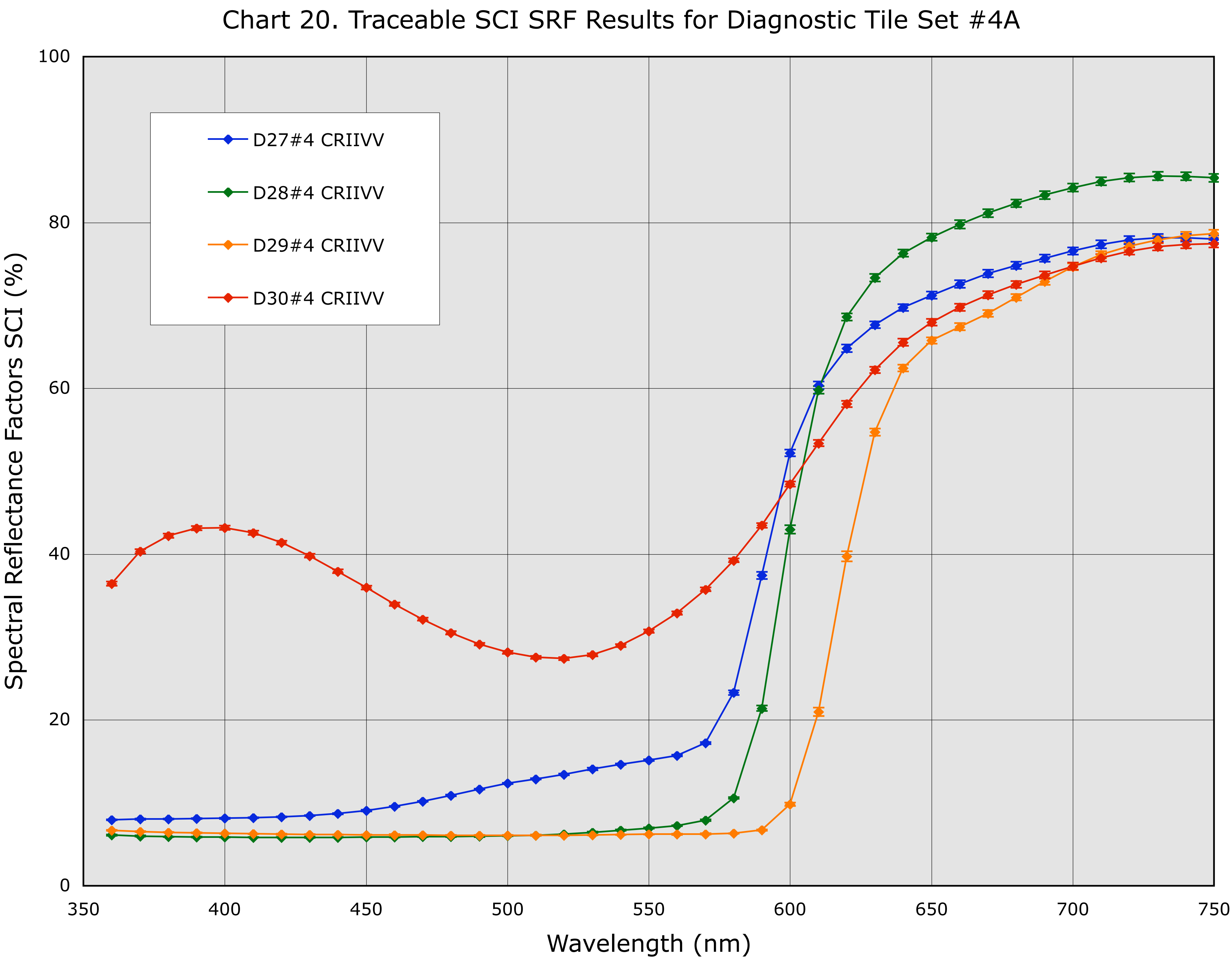


Chart 20. Traceable SCI SRF Results for Diagnostic Tile Set #4A
D27#4 CRIIVV
D28#4 CRIIVV
D29#4 CRIIVV
D30#4 CRIIVV
Spectral Reflectance Factors SCI (%)
Wavelength (nm)
0
20
40
60
80
100
350
400
450
500
550
600
650
700
750

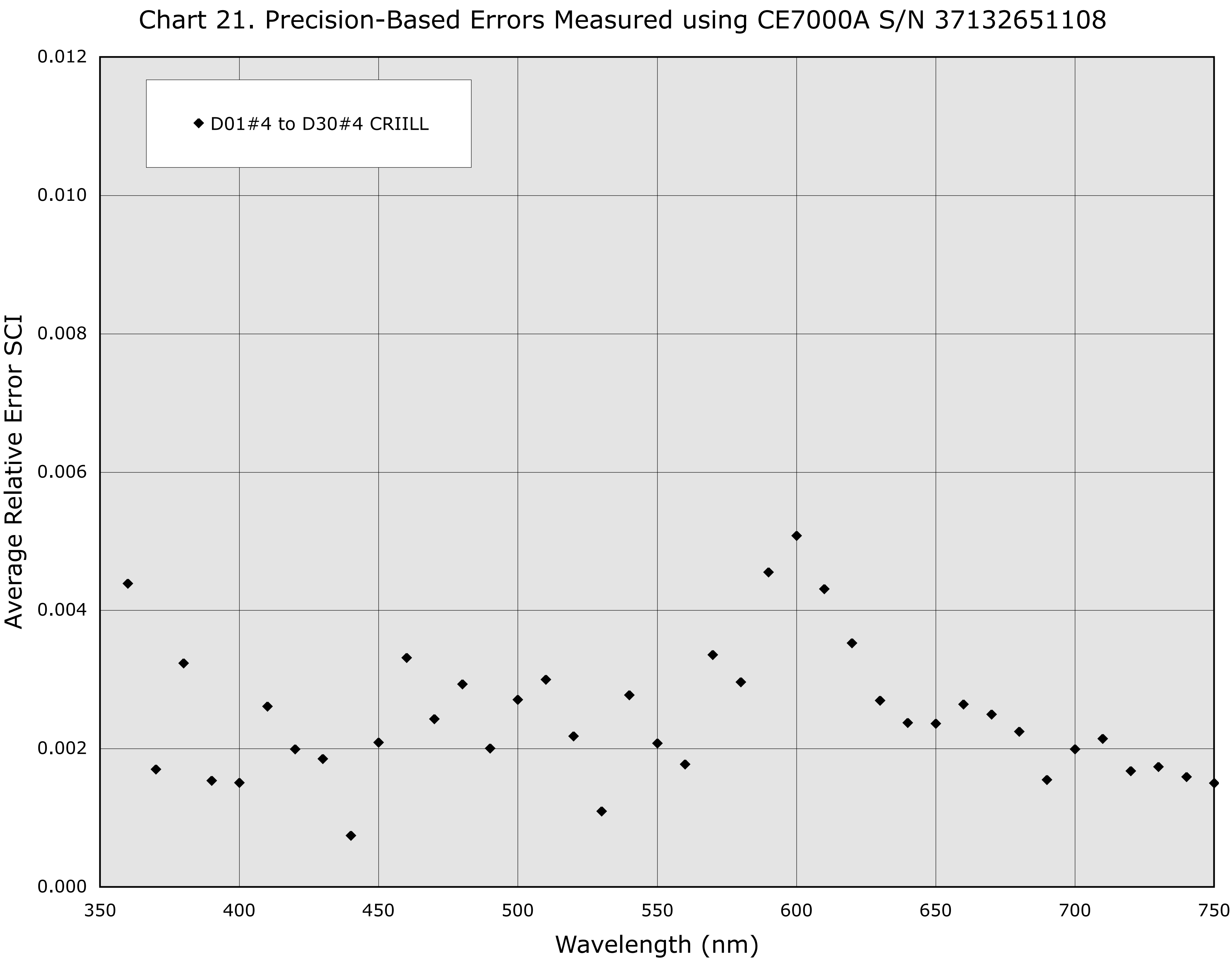
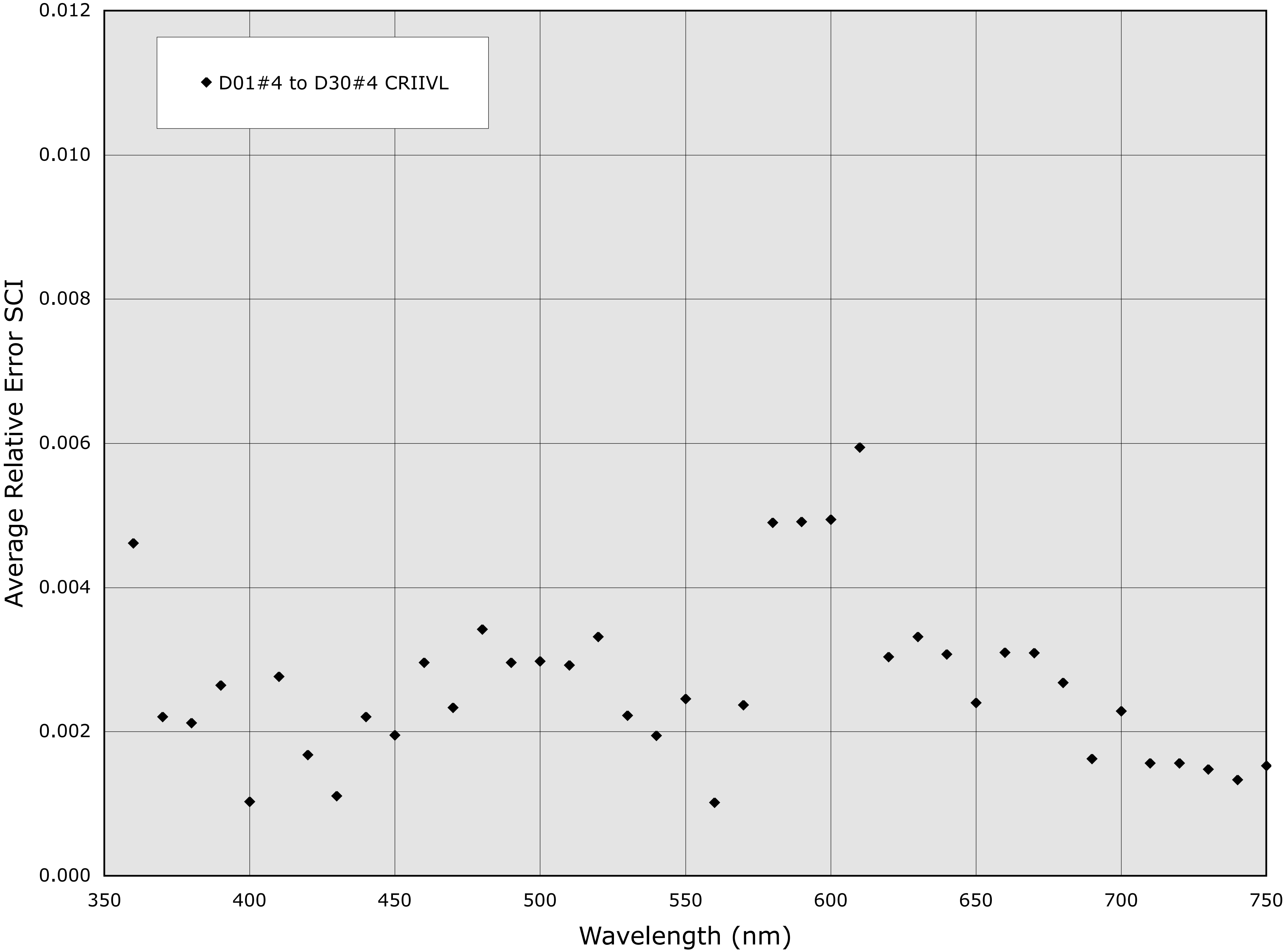


Chart 21. Precision-Based Errors Measured using CE7000A S/N 37132651108
D01#4 to D30#4 CRIILL
Average Relative Error SCI
Wavelength (nm)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
350
400
450
500
550
600
650
700
750

Chart 22. Precision-Based Errors Measured using CE7000A S/N 37132651108



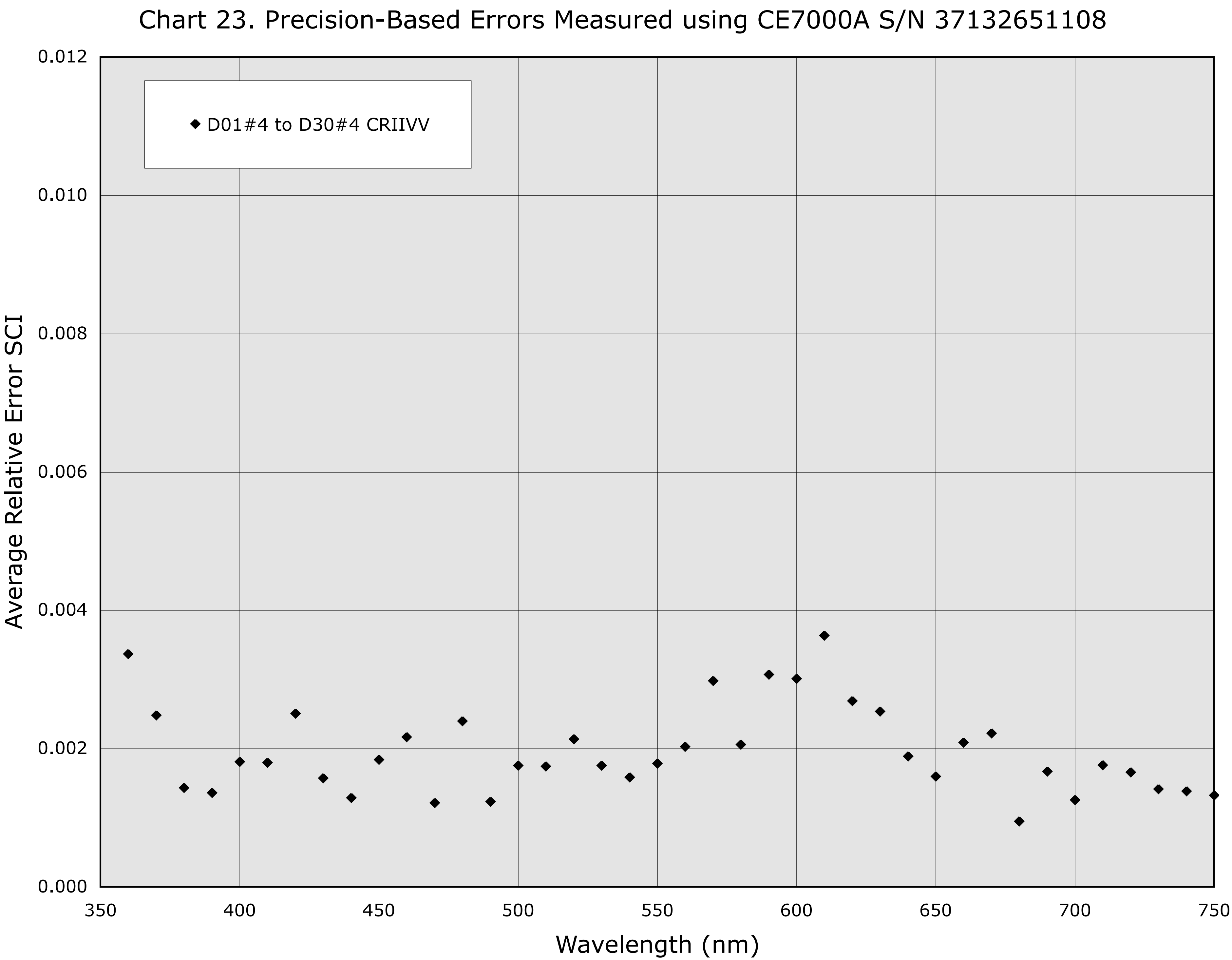


Chart 23. Precision-Based Errors Measured using CE7000A S/N 37132651108
D01#4 to D30#4 CRIIVV
Average Relative Error SCI
0.000
0.002
0.004
0.006
0.008
0.010
0.012
Wavelength (nm)
350
400
450
500
550
600
650
700
750

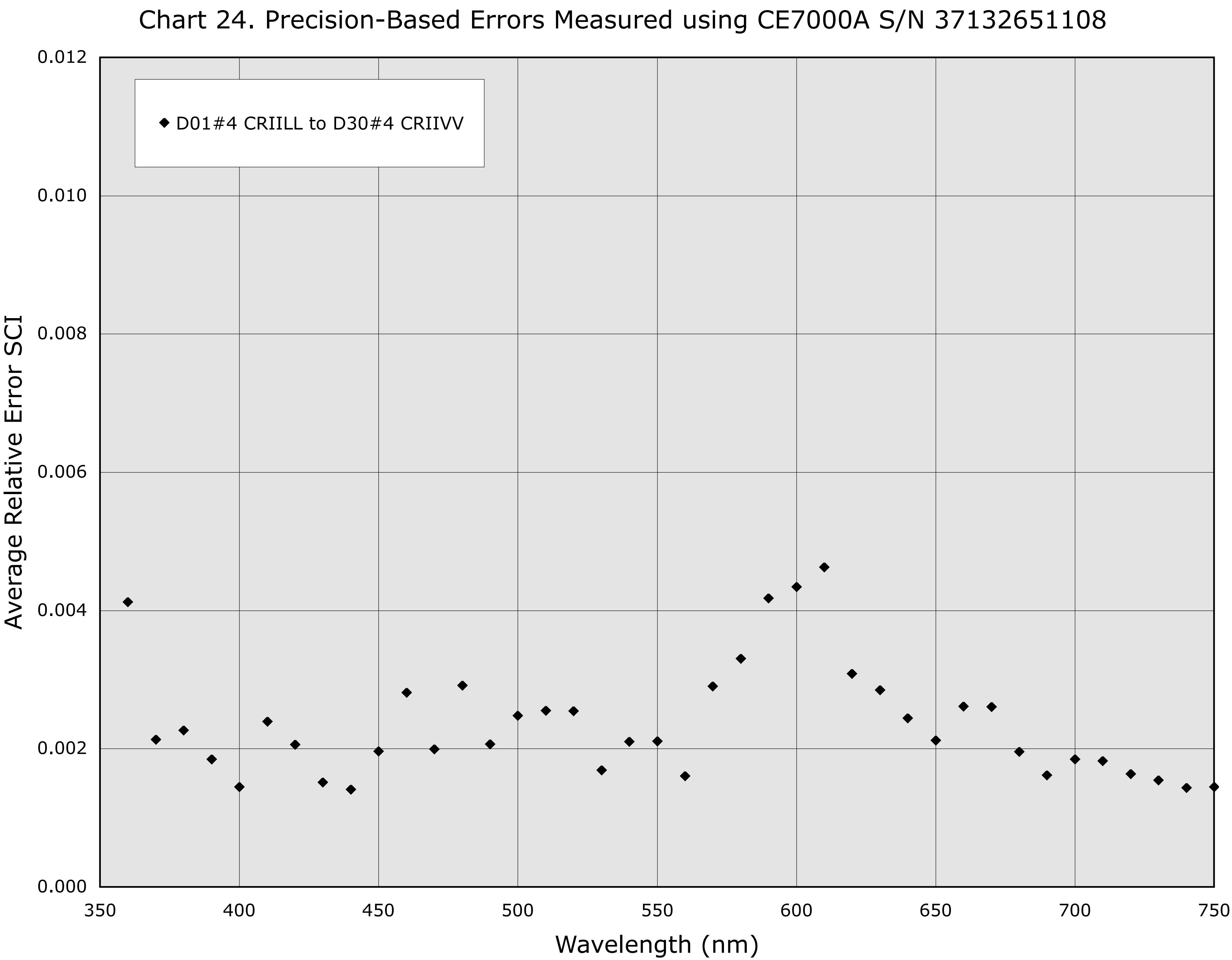


Chart 24. Precision-Based Errors Measured using CE7000A S/N 37132651108
D01#4 CRIILL to D30#4 CRIIVV
Average Relative Error SCI
Wavelength (nm)
0.012
0.010
0.008
0.006
0.004
0.002
0.000
350
400
450
500
550
600
650
700
750

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