WP 4: Modelling and data analysis

Data analysis of spectral BRDF of coatings with diffraction pigments

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Outline

- Objective
- Description of coatings with diffraction pigments
- Model: determining isochromatic lines
- Multivariate analysis (PCA)
- Results

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Objective

- To determine a procedure for efficient colour characterization of coatings with diffraction pigments.

- How must we select measurement geometries?

Description of coatings with diffraction pigments

Metal substrate with a grating of embossed parallel grooves.

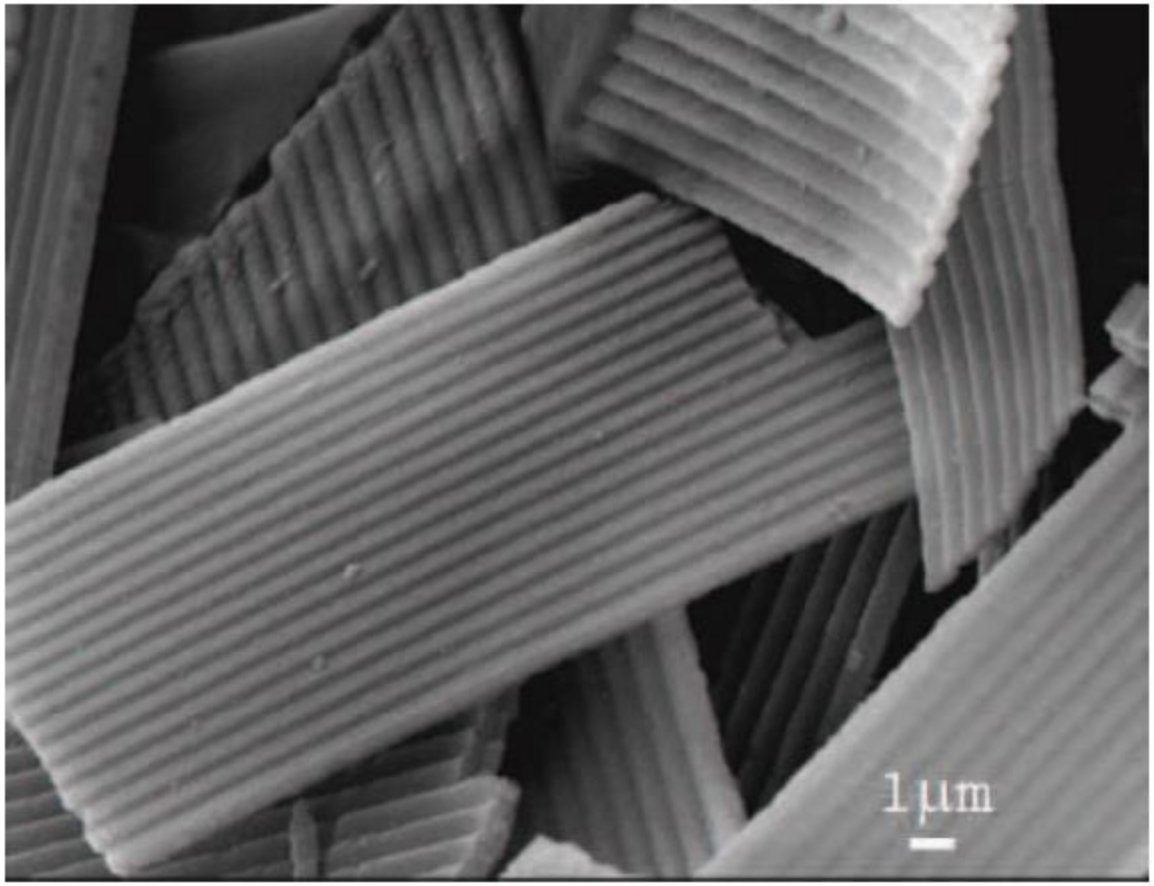

Fig. 1. Picture of a diffraction pigment (source: Viavi Solutions Inc, Milpitas, CA, USA).

Description of coatings with diffraction pigments

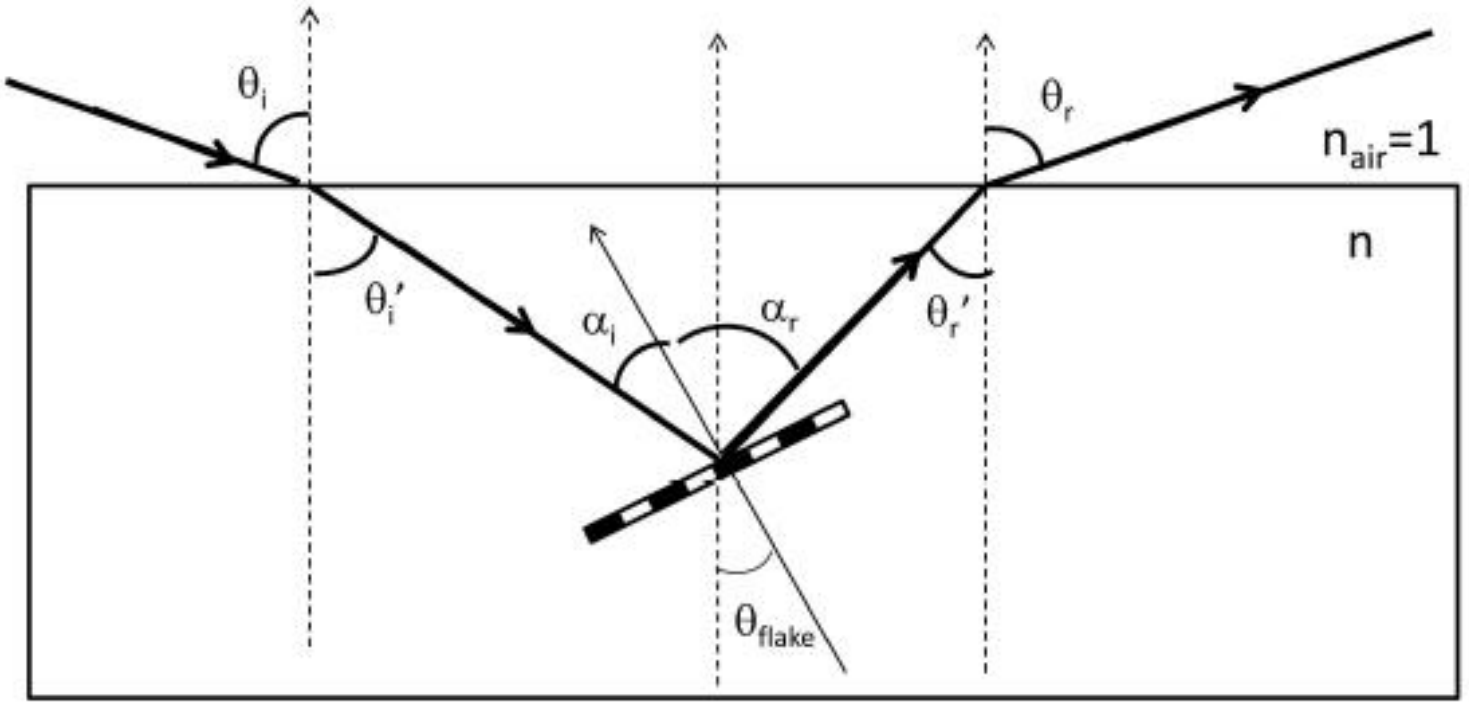

Fig. 2. Geometric scheme for reflection on coatings with diffraction pigments.

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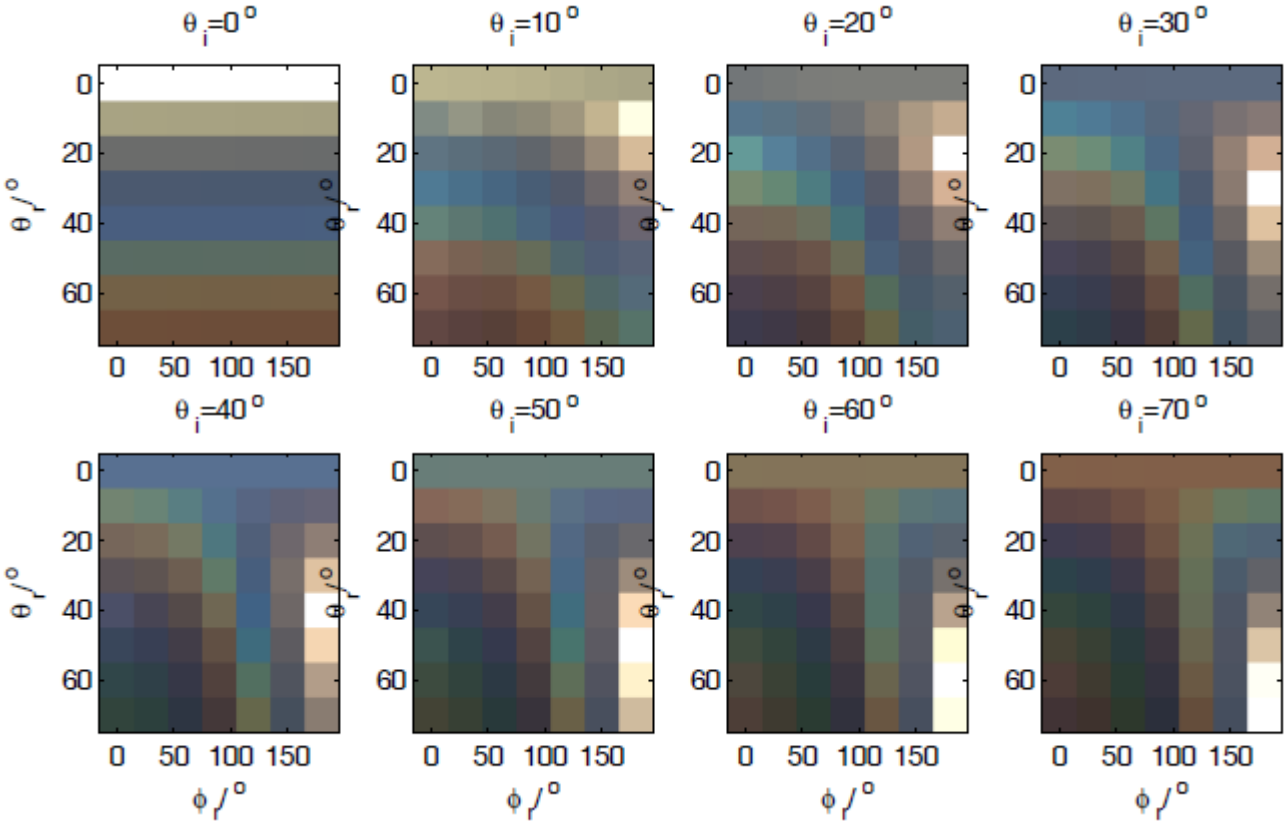
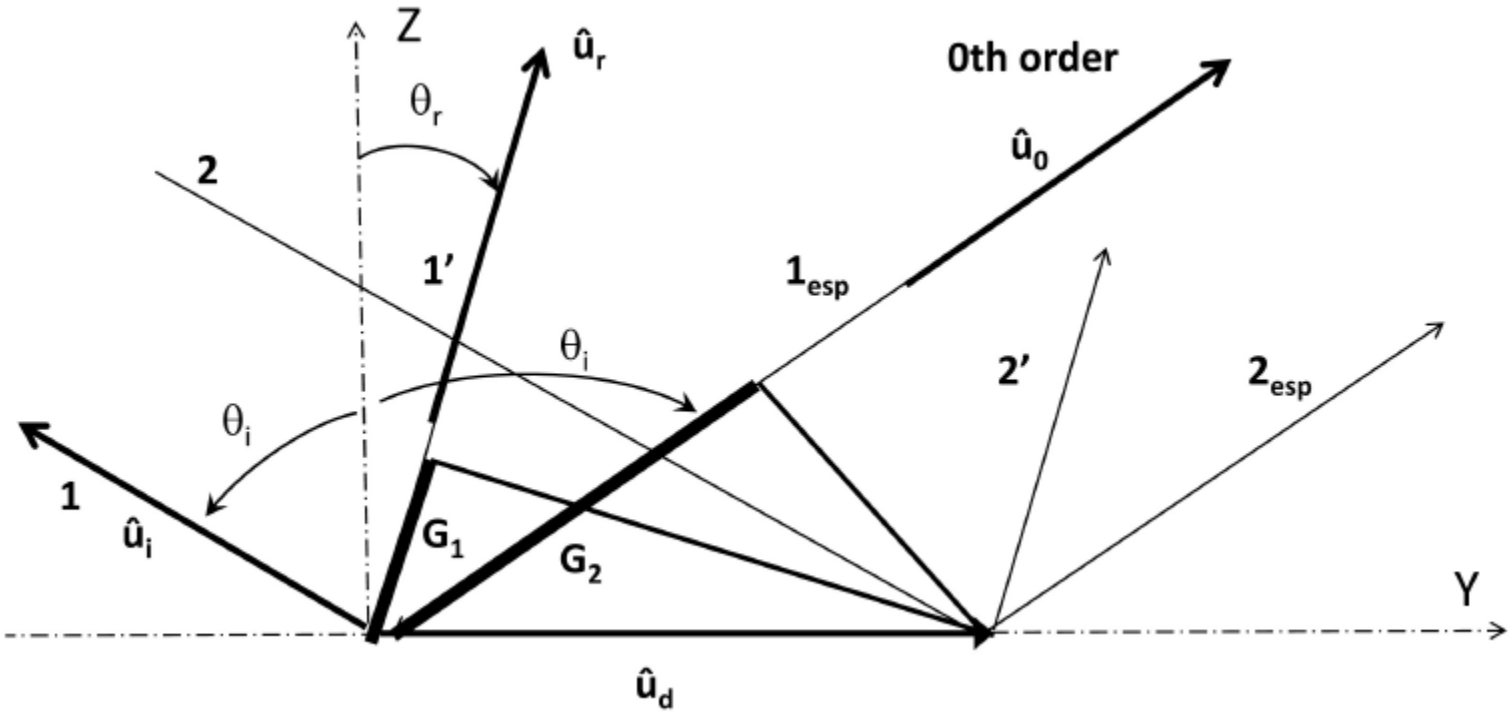
Description of coatings with diffraction pigments



Model: determining isochromatic lines



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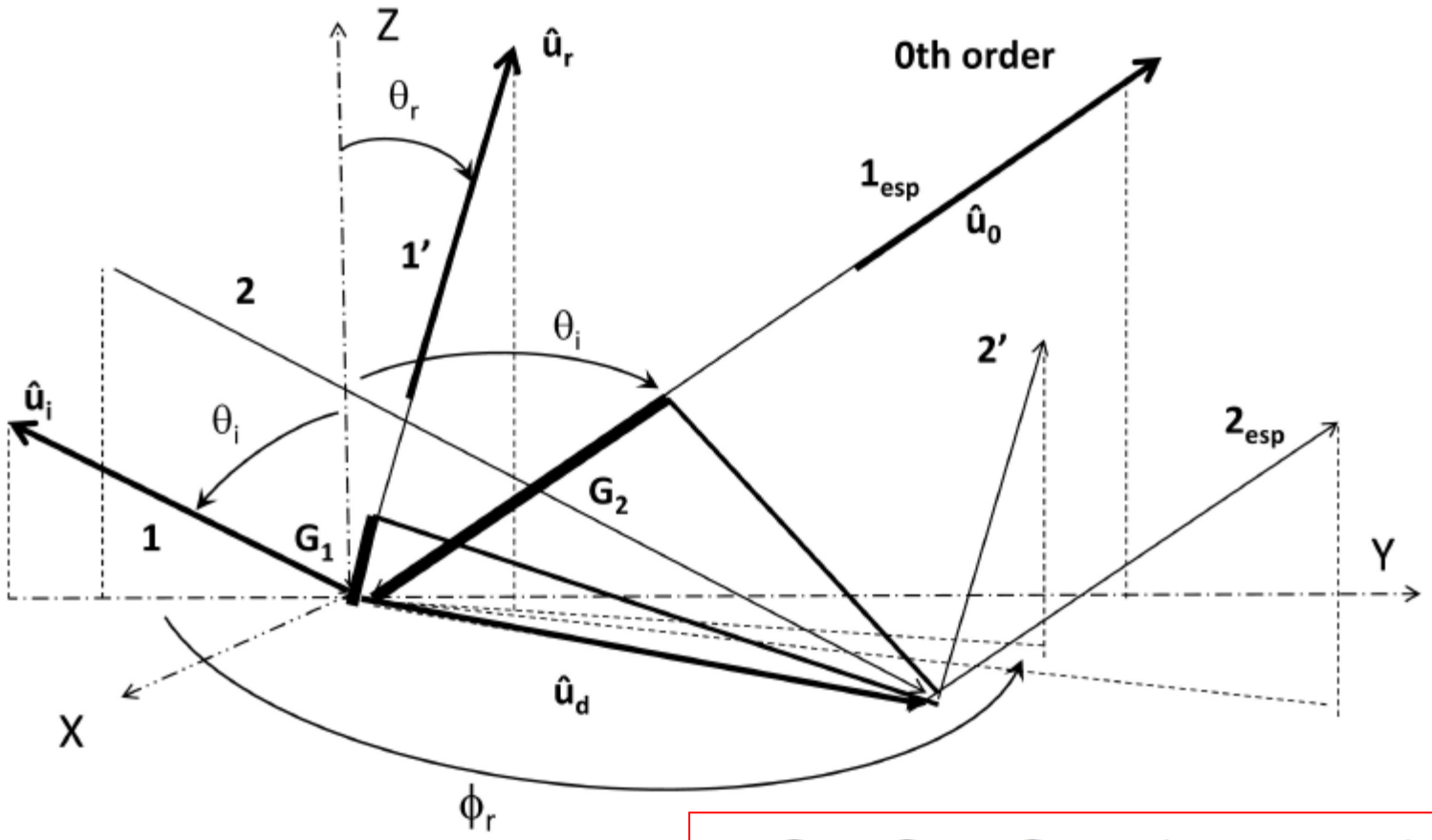
Model: determining isochromatic lines



$$\Delta G = G_2 - G_1 = d\hat{\mathbf{u}}_\mathrm{d} \cdot \hat{\mathbf{u}}_\mathrm{r} - d\hat{\mathbf{u}}_\mathrm{d} \cdot \hat{\mathbf{u}}_0$$

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Model: determining isochromatic lines

$$\Delta G = d\left[\frac{(\hat{\mathbf{u}}_0 \wedge \hat{\mathbf{u}}_\mathrm{r}) \wedge \mathbf{N}_{XY}}{\|(\hat{\mathbf{u}}_0 \wedge \hat{\mathbf{u}}_\mathrm{r}) \wedge \mathbf{N}_{XY}\|}\right] \cdot (\hat{\mathbf{u}}_\mathrm{r} - \hat{\mathbf{u}}_0)$$

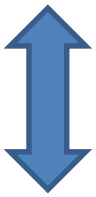
$$\frac{(\sin\theta_\mathrm{i} + \sin\theta_\mathrm{r}\cos\phi_\mathrm{r})\tan\theta_\mathrm{i} + (\sin\theta_\mathrm{i}\cos\phi_\mathrm{r} + \sin\theta_\mathrm{r})\tan\theta_\mathrm{r}}{\sqrt{\tan^2\theta_\mathrm{i} + \tan^2\theta_\mathrm{r} + 2\tan\theta_\mathrm{i}\tan\theta_\mathrm{r}\cos\phi_\mathrm{r}}}$$

$$\Phi(\theta_\mathrm{i}, \theta_\mathrm{r}, \phi_\mathrm{r})$$

Geometric factor

Multivariate analysis (PCA)

$$f_{\mathrm{r,c}}(\theta_{\mathrm{i}}, \theta_{\mathrm{r}}, \phi_{\mathrm{r}}; \lambda) = f_{\mathrm{r},0}(\theta_{\mathrm{i}}, \theta_{\mathrm{r}}, \phi_{\mathrm{r}}; \lambda) + \sum_{k=-|z_{\max}|}^{z_{\max}} \Lambda_{\mathrm{k}}(\lambda)\Theta_{\mathrm{k}}(\Phi)$$

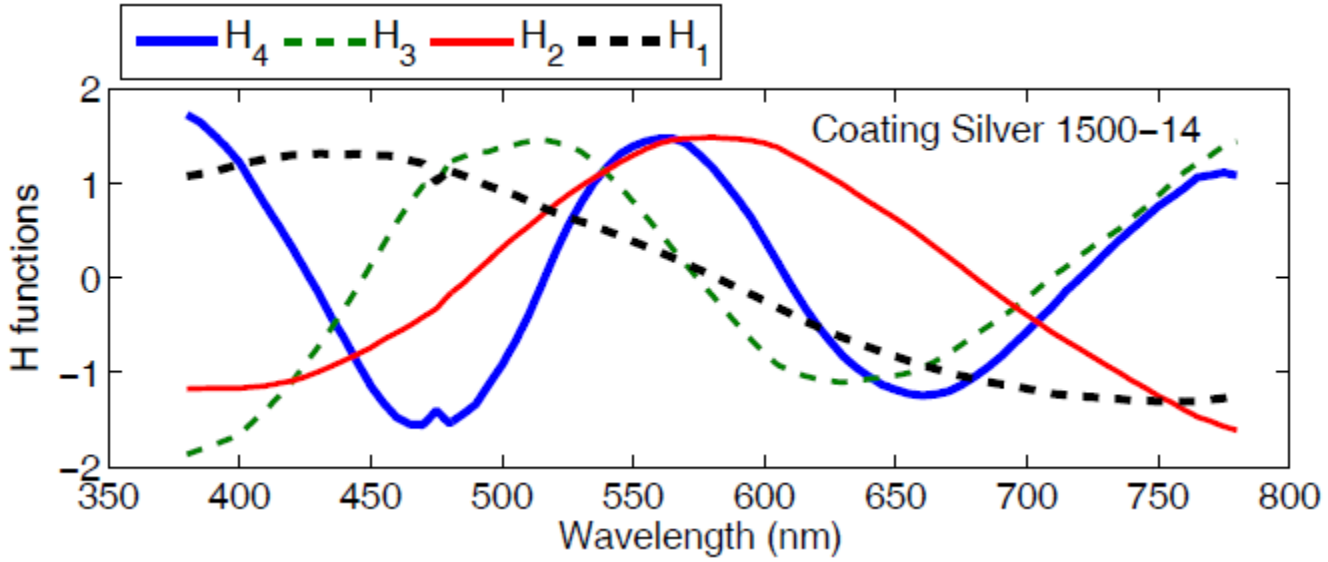


Model

PCA

$$f_{\mathrm{r}}(\theta_{\mathrm{i}}, \theta_{\mathrm{s}}, \phi_{\mathrm{s}}; \lambda) = \langle f_{\mathrm{r}}(\theta_{\mathrm{i}}, \theta_{\mathrm{s}}, \phi_{\mathrm{s}}) \rangle_{\lambda} \left[1 + \Sigma_{j=1}^{S} c_j(\theta_{\mathrm{i}}, \theta_{\mathrm{s}}, \phi_{\mathrm{s}}) H_j(\lambda)\right]$$

Results



$$f_{\mathrm{r}}(\theta_{\mathrm{i}}, \theta_{\mathrm{s}}, \phi_{\mathrm{s}}; \lambda) = \langle f_{\mathrm{r}}(\theta_{\mathrm{i}}, \theta_{\mathrm{s}}, \phi_{\mathrm{s}}) \rangle_{\lambda} \left[1 + \Sigma_{j=1}^{S} c_j(\theta_{\mathrm{i}}, \theta_{\mathrm{s}}, \phi_{\mathrm{s}}) H_j(\lambda)\right]$$

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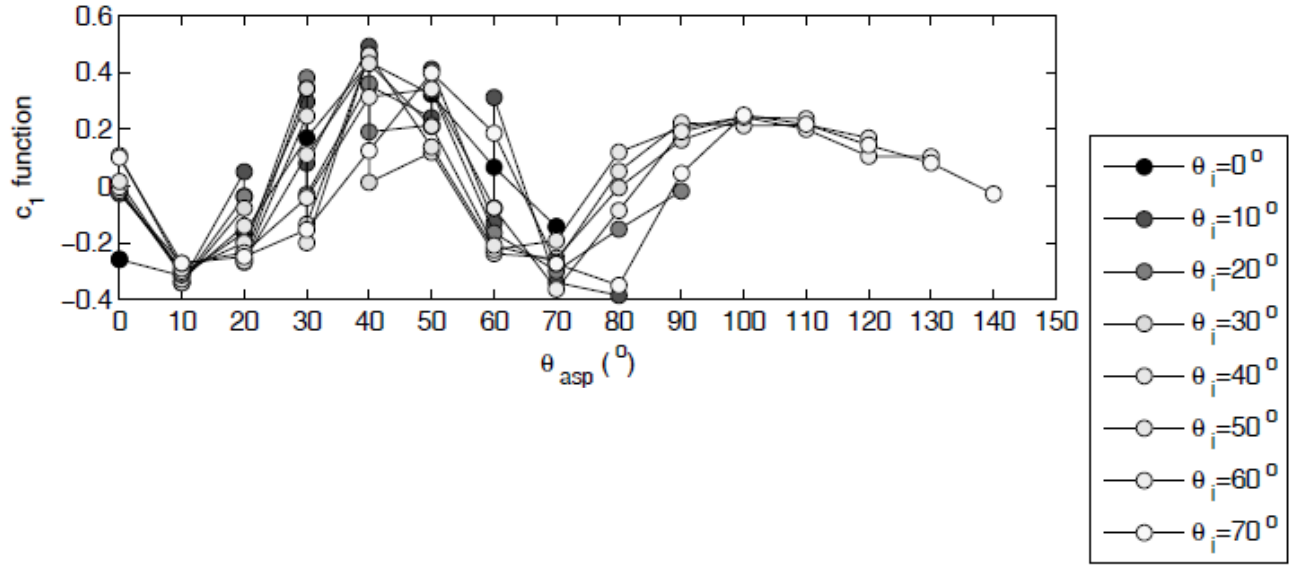
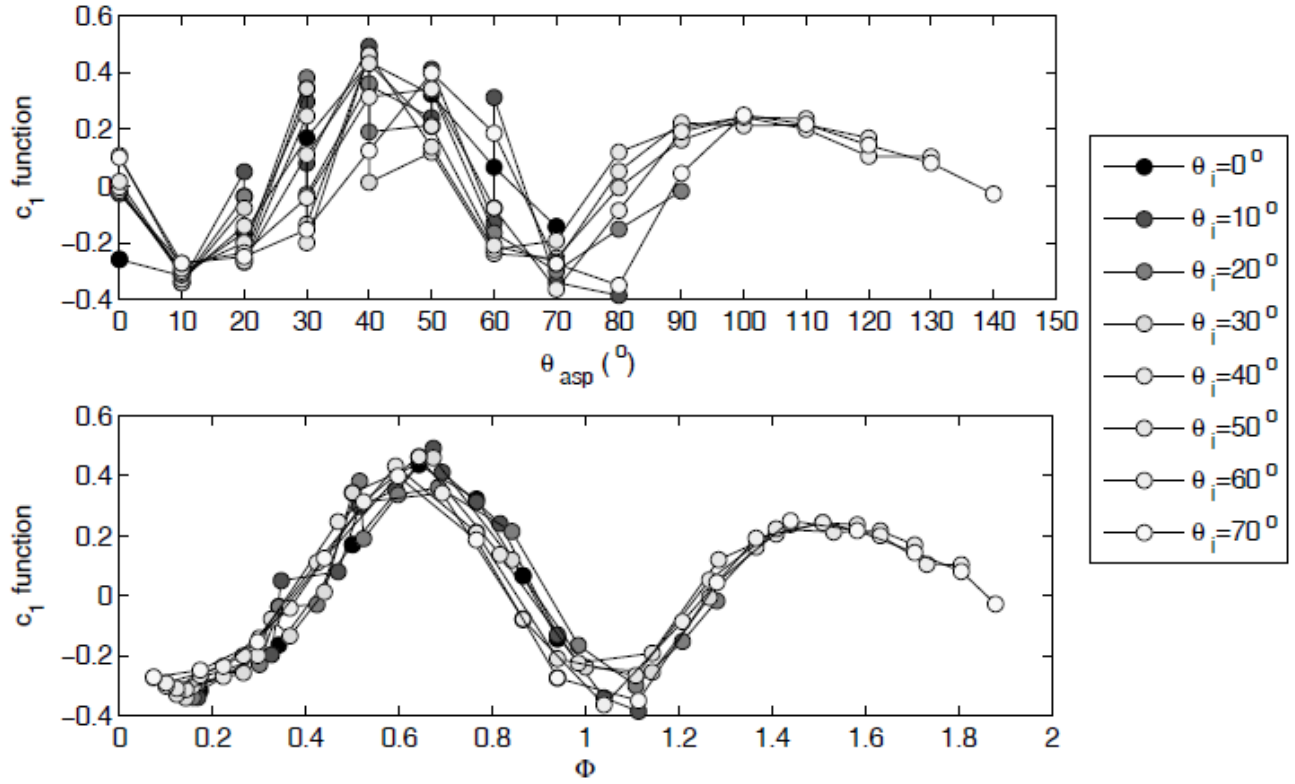
Results



$$f_{\mathrm{r}}(\theta_{\mathrm{i}}, \theta_{\mathrm{s}}, \phi_{\mathrm{s}}; \lambda) = \langle f_{\mathrm{r}}(\theta_{\mathrm{i}}, \theta_{\mathrm{s}}, \phi_{\mathrm{s}}) \rangle_{\lambda} \left[1 + \Sigma_{j=1}^{S} c_j(\theta_{\mathrm{i}}, \theta_{\mathrm{s}}, \phi_{\mathrm{s}}) H_j(\lambda)\right]$$

Results



$$f_r(\theta_i, \theta_s, \phi_s; \lambda) = \langle f_r(\theta_i, \theta_s, \phi_s) \rangle_\lambda \left[1 + \Sigma_{j=1}^{S} c_j(\theta_i, \theta_s, \phi_s) H_j(\lambda)\right]$$

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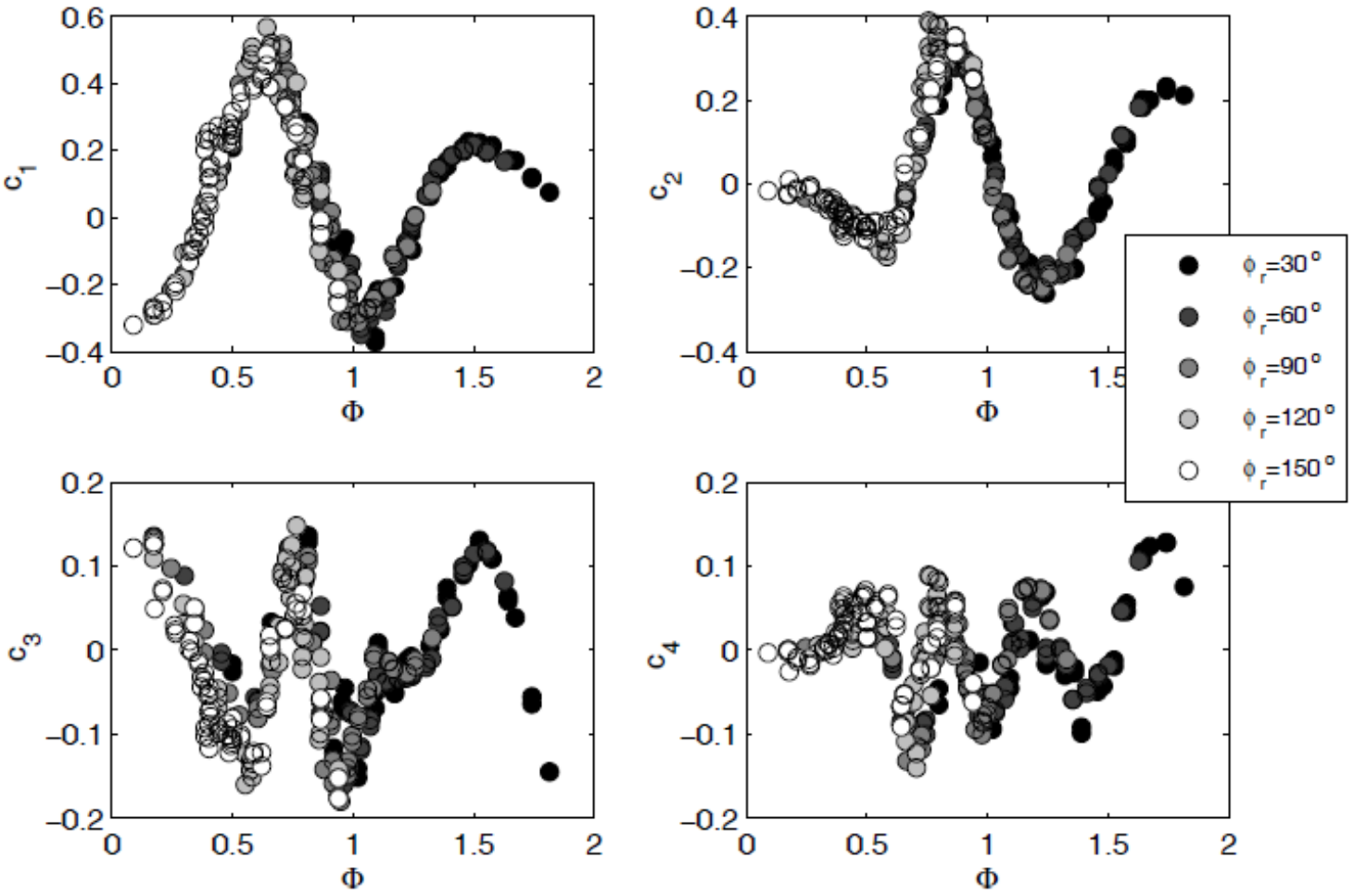
Results



$$f_{\mathrm{r}}(\theta_{\mathrm{i}}, \theta_{\mathrm{s}}, \phi_{\mathrm{s}}; \lambda) = \langle f_{\mathrm{r}}(\theta_{\mathrm{i}}, \theta_{\mathrm{s}}, \phi_{\mathrm{s}}) \rangle_{\lambda} \left[1 + \Sigma_{j=1}^{S} c_j(\theta_{\mathrm{i}}, \theta_{\mathrm{s}}, \phi_{\mathrm{s}}) H_j(\lambda)\right]$$

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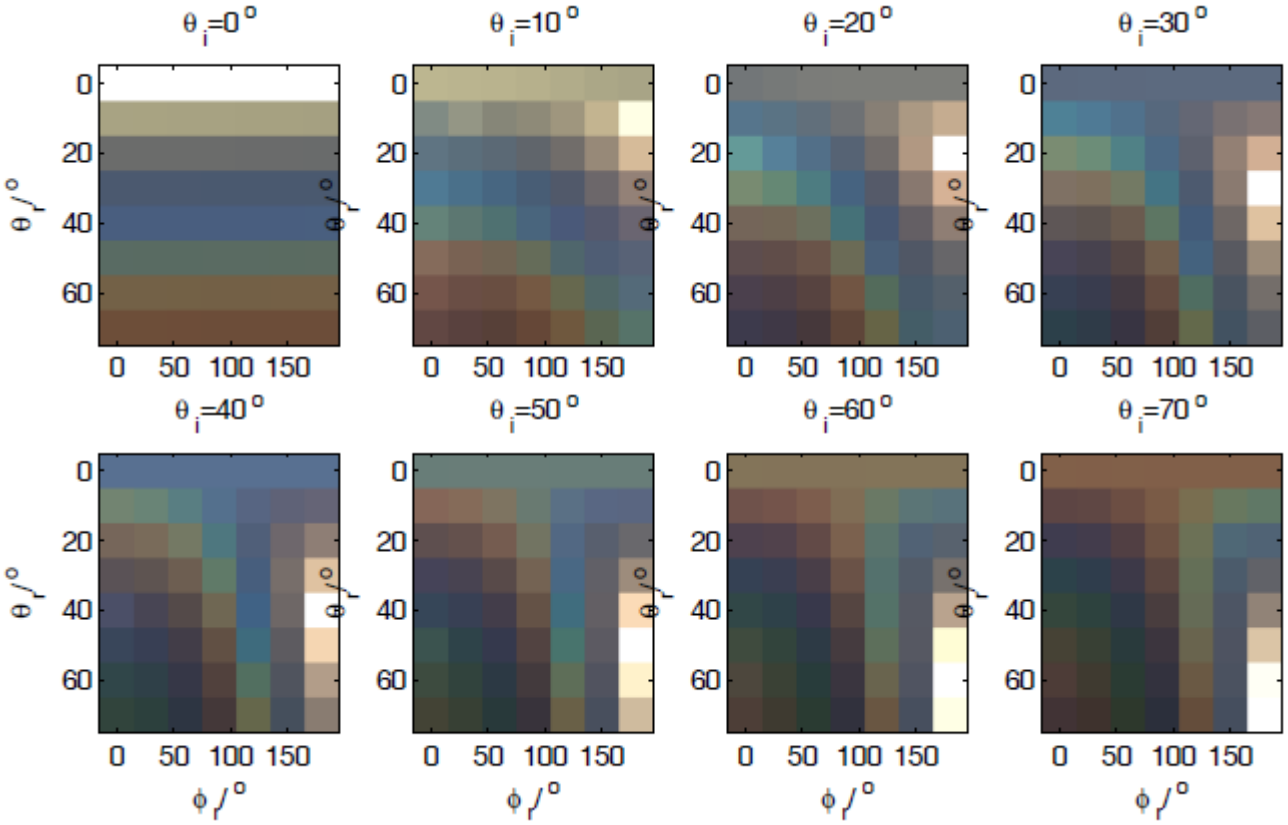
Results



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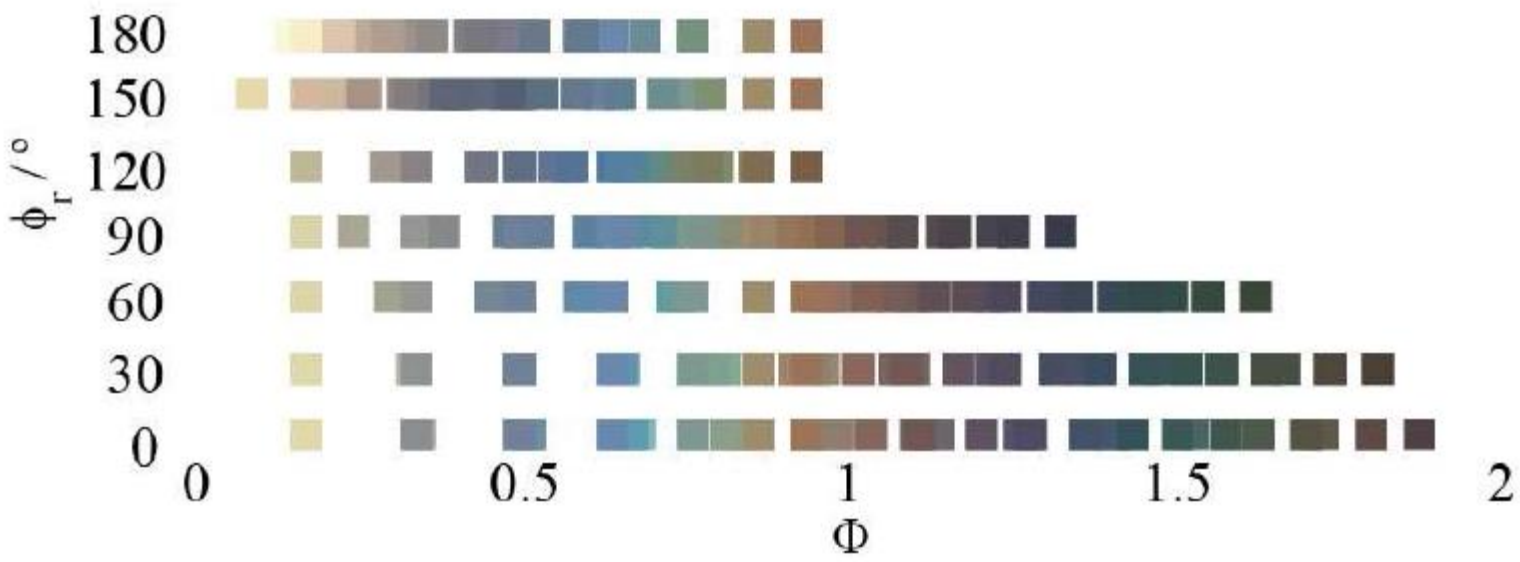
Results



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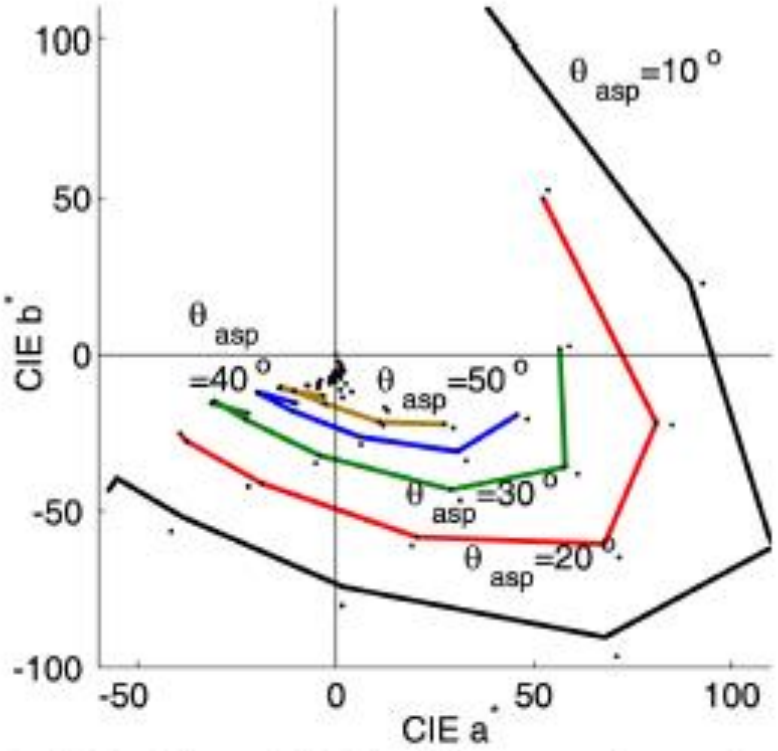
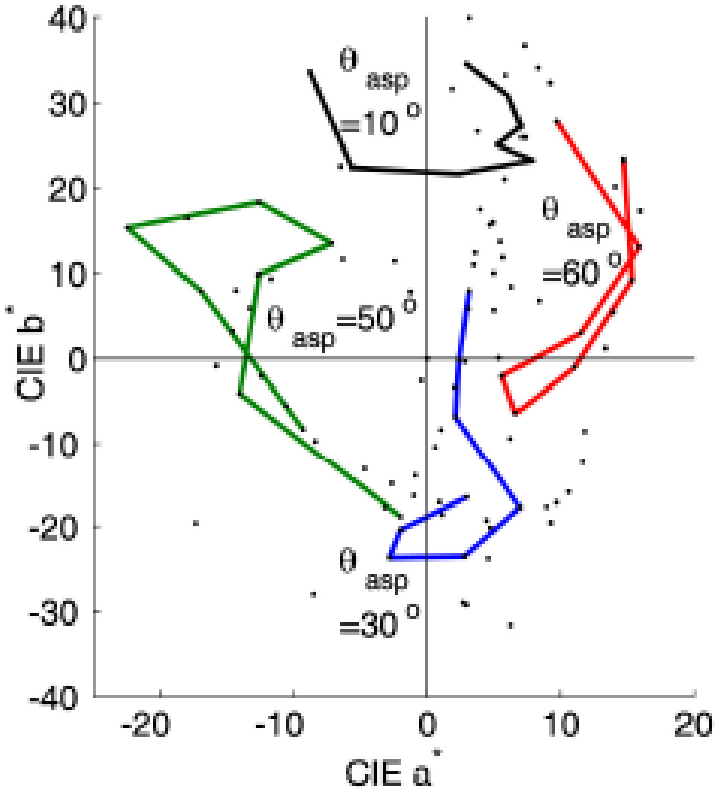
Results



(a) Coating with interference pigments: Cyan Purple 230 L



(b) Coating with diffraction pigments: Sprectraflair Silver 1500-14.

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