Multivariate Optical Element Platform
Questions & Answers

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Q: Who is CIRTEMO?

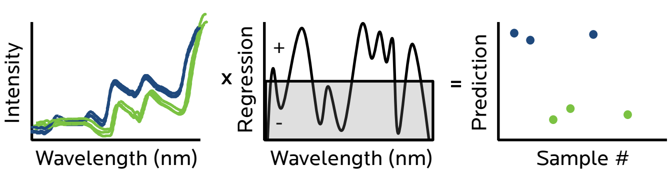
- CIRTEMO designs and manufactures patented optical filters called Multivariate Optical Elements (MOE)
- CIRTEMO is an entrepreneurial group of scientists, application engineers, and business people who know how to get things done
- CIRTEMO was founded in December 2012 and is headquartered in Columbia, South Carolina
- CIRTEMO has 40+ patents granted and perpetually licensed worldwide around MOE technology

Hello. I am MOE.
I am here to help.

Send any additional questions to info@cirtemo.com.

Q: What is Multivariate Optical Computing?

- Chemometrics is a method for modeling multivariate data (eg. optical spectra) where parameters can be applied to data from a spectrometer (or series of bandpass measurements) to estimate the composition of unknowns



MOC can enable a simple optical system to achieve laboratory grade performance!

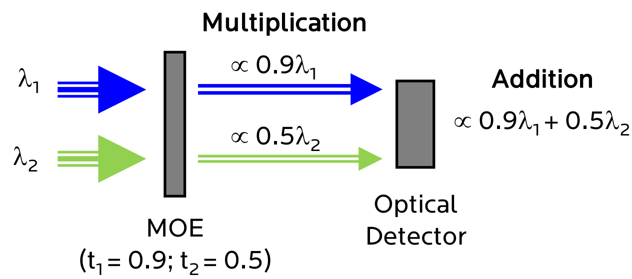
- Multivariate Optical Computing (MOC) is an alternative method for modeling multivariate optical spectra
  - MOC is the optical equivalent of a dot product in which simple optical systems may achieve the sensitivity/specificity of a laboratory grade spectrometer.
  - MOC employs a type of pattern recognition in order to correlate information contained in light with a target analyte attribute

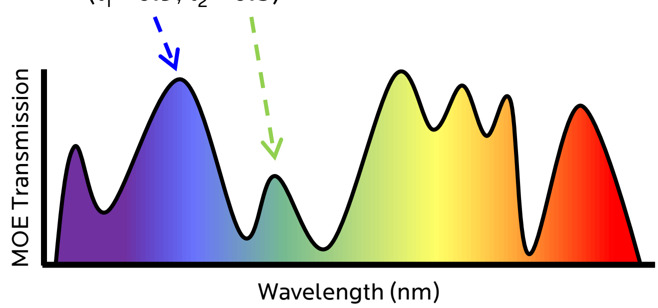
Q: What is a Multivariate Optical Element?

- Multivariate Optical Elements (MOEs) are patented, wide-band, optical interference filters encoded with an application-specific regression (or pattern) to detect/measure complex chemical signatures.
- MOEs enable a filter based instrument to achieve the sensitivity/specificity of a laboratory spectrometer as well as convert a focal plane array into a real-time hyperspectral imager.
- MOEs realize the measurement advantages of Multivariate Optical Computing (MOC) by performing an optical computation:

Q: How Do MOEs Actually Work?

- To apply an optical computation (scalar product), the MOE induces a spectroscopic weighting or multiplication of the incident photons while an addition step occurs at the broadband detection of the MOE-weighted photons.
- MOE based instruments are essentially power meters for a defined target analyte





MOEs enable optical systems to
- **detect and measure specific chemicals or attributes that cannot be achieved with traditional optical filters**
- **achieve better performances from optical components and systems**

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Multivariate Optical Element Platform Questions & Answers

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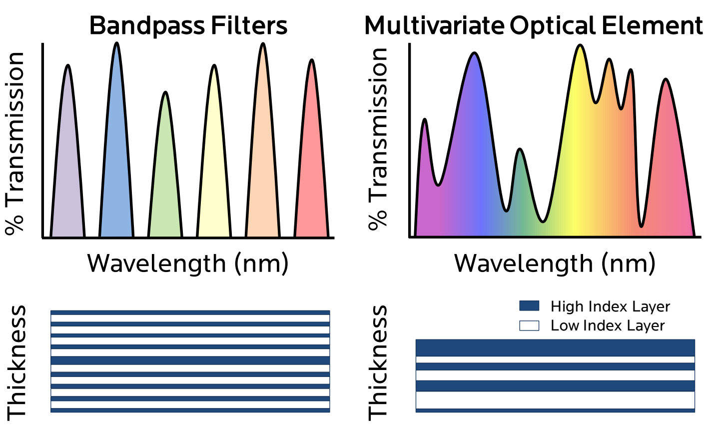
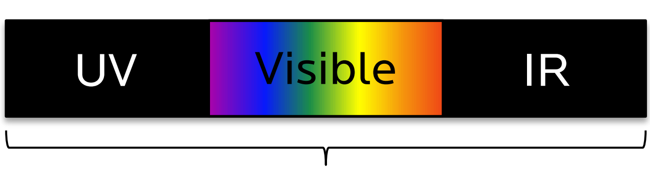
Q: How do MOEs differ from optical band pass filters?

- Multivariate Optical Elements (MOE) are not band pass (BP) filters
  - MOEs possess a higher overall throughput than individual BP filters yielding a higher analyte sensitivity baseg
  - MOEs sample more spectral wavelengths than discrete BP filters yielding a higher analyte specificity
- MOEs tend to exhibit fewer layers and lower overall filter thicknesses than traditional band pass filters.
  - Unlike well defined quarter wave optical thickness (QWOT) deposition recipes used for BP filter fabrication, there are multiple MOE solutions possible for any application
  - Optimal MOE designs are selected based on a set of analyte performance criteria in addition to overall physical thickness and number of layers
- MOEs are fabricated via the same methods as traditional BP filters



Q: Where in the Electromagnetic Spectrum May MOEs be Utilized?

- Multivariate Optical Elements (MOEs)may be utilized:
  - from the ultraviolet (UV) to the infrared (IR)
  - in a vast array of spectroscopic modalities like fluorescence, colorimetric, near infrared (NIR), MIR and Raman
  - for the detection of powders, liquids, slurries and gases.



MOEs may be utilized from the UV to the IR

Q: What types of systems utilize MOEs?

- Multivariate Optical Elements (MOEs):
  - enable a filter photometer to achieve the sensitivity/specificity of a laboratory spectrometer
  - Convert a focal plane array into a real-time hyperspectral imager
- Wherever an optical filter is employed, a MOE may be able to provide additional value.
- MOEs have been previously demonstrated in applications ranging from process control (pharmaceutical, food & beverage, industrial, etc.) to oceanic monitoring. More recent interest in the MOE platform spans both the life science and medical device communities.

Q: How do you design an MOE?

- Traditional chemometric modeling
  - identifies and exploits the variance within spectral (and reference) data to correlate with a feature/analyte of interest
  - most often deconvolves spectroscopic data into a projection in N-dimensional space (i.e. score)
- An MOE is designed through an iterative, non-linear optimization routine where
  - the physical layer thicknesses of an interference filter are varied in order to achieve a desired transmission or reflection response
  - spectroscopic calibration data as well as sensor/instrument radiometric data are evaluated in order to determine a performance metric

Q: How sharp of a spectral feature can an MOE resolve?

- Although spectral resolution is a typical specification for defining optical filters, Multivariate Optical Elements (MOEs) are designed with specifications tied to an application attribute or feature (i.e. figure of merit).

Q: Can MOEs be designed to minimize or eliminate non-chemical interferants like pH or angle of Incidence?

- Yes. Unlike single bandpass filters, Multivariate Optical Elements (MOEs) can be designed with environmental conditions in mind.

Interested in more information about the MOE Platform?

Drop me a line at info@cirtemo.com.

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