

# An Extended Application of Quantitative Description Methods for Color Cause of Chrysoberyl

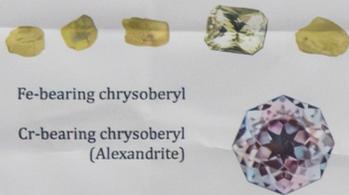
Xinxin Gao, Yimiao Liu, Linling Dong, Ren Lu\*

(gaoxx@idsse.ac.cn; renlu.cc@gmail.com\*)

Deep-sea Science and Engineering, Chinese Academy of Sciences  
University of Chinese Academy of Sciences  
Gemological Institute, China University of Geosciences

## Introduction

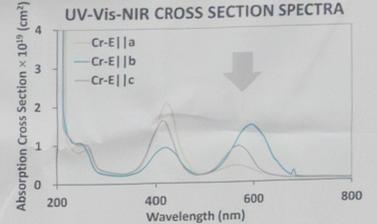
- The development of capability in analyzing color of gemstone is inspiring in years<sup>1,2,3</sup>.
- The quantitative description for chromophores' abilities to color corundum is expected for broader applications.
- Chrysoberyl is a suitable candidate for extended application.



## Results and Discussion

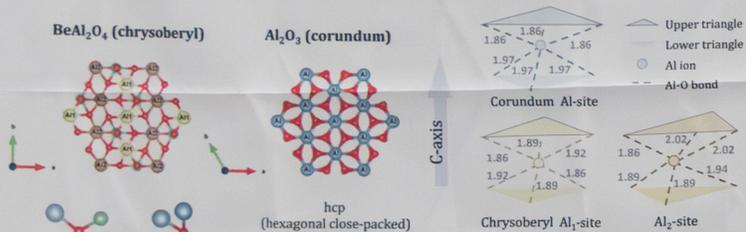
- Corresponding spectral features between two gemstones. In chrysoberyl, absorption peaks of Cr<sup>3+</sup> chromophore show a redshift, while absorption peaks of Fe<sup>3+</sup> chromophores display a blueshift compared with corundum.
- The effectiveness of primary chromophores Cr<sup>3+</sup> and Fe<sup>3+</sup> in chrysoberyl is of the same order of magnitude as in corundum, respectively.

## Color circles of Cr<sup>3+</sup> chromophore



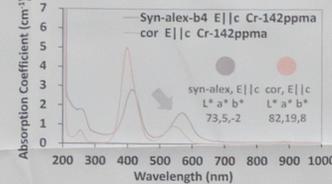
UV-Vis-NIR absorption cross section spectra of Cr<sup>3+</sup> chromophore in chrysoberyl

## The analogy between chrysoberyl and corundum

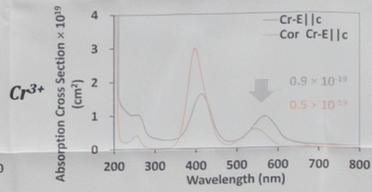


As primary determinants of gemstones' color, chromophores' optical absorption features determined by the physical and chemical conditions of host crystals.

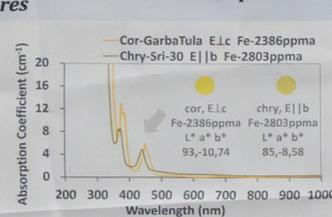
## Absorption coefficient spectra



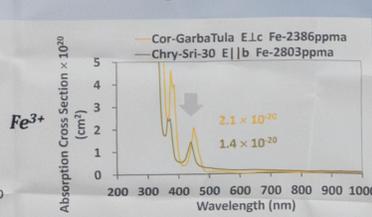
## Absorption cross section spectra Focus on visible range (400-700 nm)



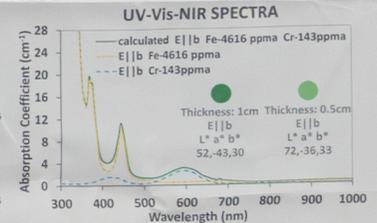
## UV-Vis-NIR Spectra



## Chromophores' effectiveness



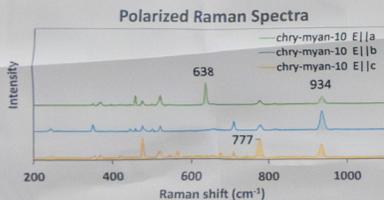
## Color circles of Cr<sup>3+</sup> & Fe<sup>3+</sup> chromophores



UV-Vis-NIR absorption coefficient spectra of Cr<sup>3+</sup> and Fe<sup>3+</sup> chromophores in chrysoberyl

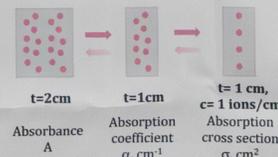
## Materials and Methods

- Double polished wafers
- Polarized Raman spectroscopy
- UV-Vis-NIR spectroscopy
- Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS)
- The Beer-Lambert Law



## The Beer-Lambert Law

Absorption cross section spectra, derived from experimental absorbance spectra, are also fundamental data applied to simulate absorbance spectra via mathematical relationship.



## Conclusion

The analogy between chrysoberyl and corundum is established through their similarities in chemistry, structure and UV-Vis-NIR spectral features. The corundum-based analogy proved a framework to enhance the quantitative understanding of color origin in chrysoberyl—from uniaxial (dichroic) to biaxial (trichroic), from two to three elements, and from single to multiple polyhedron structural units.

References <sup>1</sup>Dubinsky E.V., Stone-Sundberg J., Emmett J.L. (2020) A Quantitative Description of the Causes of Color in Corundum. *Gems & Gemology*, Vol. 56, No. 1, pp. 2–28.  
<sup>2</sup>Shen, C., Palke, A., Sun, Z., & Fairchild, M. D. (2021). How to calculate color from spectra of uniaxial gemstones. *Gems & Gemology*, Vol. 57, No. 1, pp. 36–45.  
<sup>3</sup>Emmett J.L., Atikarinsakul U., Stone-Sundberg J., Sangsawong S. (2023) Yellow Sapphire: Natural, Heat-Treated, Beryllium-Diffused, and Synthetic. *Gems & Gemology*, Vol. 59, No. 3, pp. 268–297.

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