Experiment Brief

Monarc Pro Cathodoluminescence Detector

Title

Observation of crystal structure orientation by cathodoluminescence (CL) polarization-filtered spectrum imaging

Gatan Instrument Used

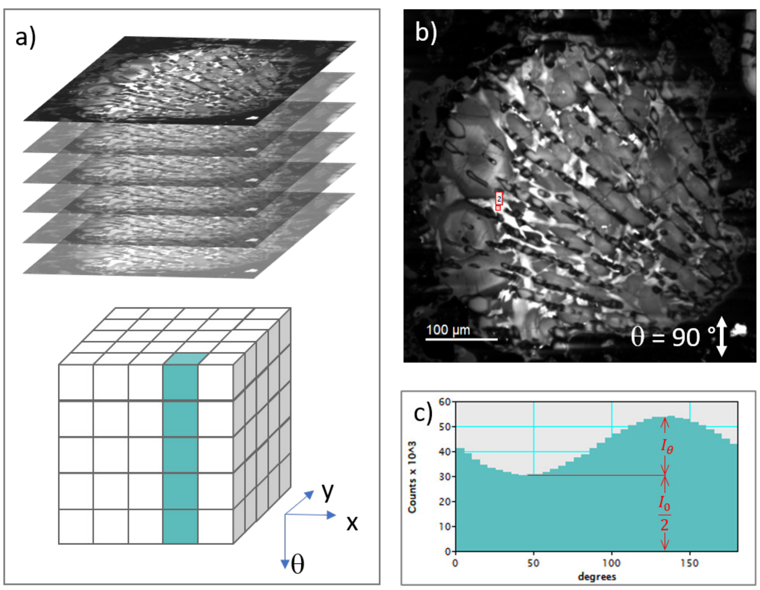
The Monarc® Pro system offers the most complete analysis of CL emissions and empowers all users to capture the highest quality data, whether novice or expert.

Background

The structures, compositions, and history of various geological specimens can be discovered using CL microscopy, where the spatial and/or spectral variation in the luminescence signal of a mineral-thin section reveals the distribution(s) of trace elements reconstruct the geological history. Despite polarization studies forming a key component of optical microscopy analysis of mineral-thin sections, the polarization state of the CL signal has been ignored (presumably) due to the unavailability of appropriate analysis tools.

Materials and Methods

We determine the degree of polarization and its direction in a chondritic meteorite specimen from Miller region 090010 using the Monarc Pro CL system installed on a scanning electron microscope. A polarization spectrum image—an aligned stack of polarization-filtered CL images—was captured using the MultiMap feature of Monarc's DigitalMicrograph® software and an optional rotatable, broadband linear polarization filter (P/N 450.P.U1.3), Figure 1. Maps of the degree of polarization, $D_P = I_P/(I_P + I_0)$, the polarization angle θ_0, and the unpolarized component, I_0, were extracted by fitting using the Law of Malus to each pixel in the data cube; the sample was assumed as the first polarizer, θ_0, and the Monarc's rotatable polarizer angle, θ were extracted from the polarization spectrum image:



$$I(\theta) = I_p \cos^2(\theta - \theta_0) + \frac{I_0}{2}$$

Summary

We demonstrate the collection of the degree of polarization and polarization direction maps from a geological specimen using the Monarc Pro system. The crystals in the sample act as the first polarizer in a polarization analyzer, with the resulting maps likely revealing crystal orientation in the emitting crystal. This experiment serves as a proof of concept for determining crystal orientation using CL in the scanning electron microscope and could be used to determine the birefringence of a specimen.

Figure 1. a) Schematic representations of a polarization-filtered spectrum image, b) polarization-filtered CL intensity map (θ = 90 ± 2.5 °) of a chondritic meteorite meteorite, and c) polarization-filtered CL intensity plot, I_θ, at the indicated location in b).

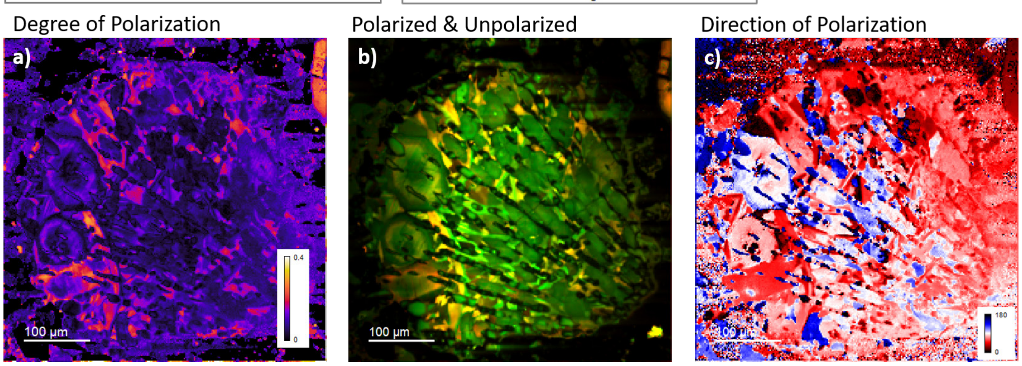


Figure 2. Fit maps extracted from the polarization filtered spectrum image showing a) degree of polarization D_P, b) polarized I_θ (red) and unpolarized I_0 (green) component, and c) polarization angle θ_0.

Gatan, Inc. is the world's leading manufacturer of instrumentation and software used to enhance and extend electron microscopes—from specimen preparation and manipulation to imaging and analysis.

www.gatan.com

EB-Monarc-Polarization-FL1-CA-MAY21