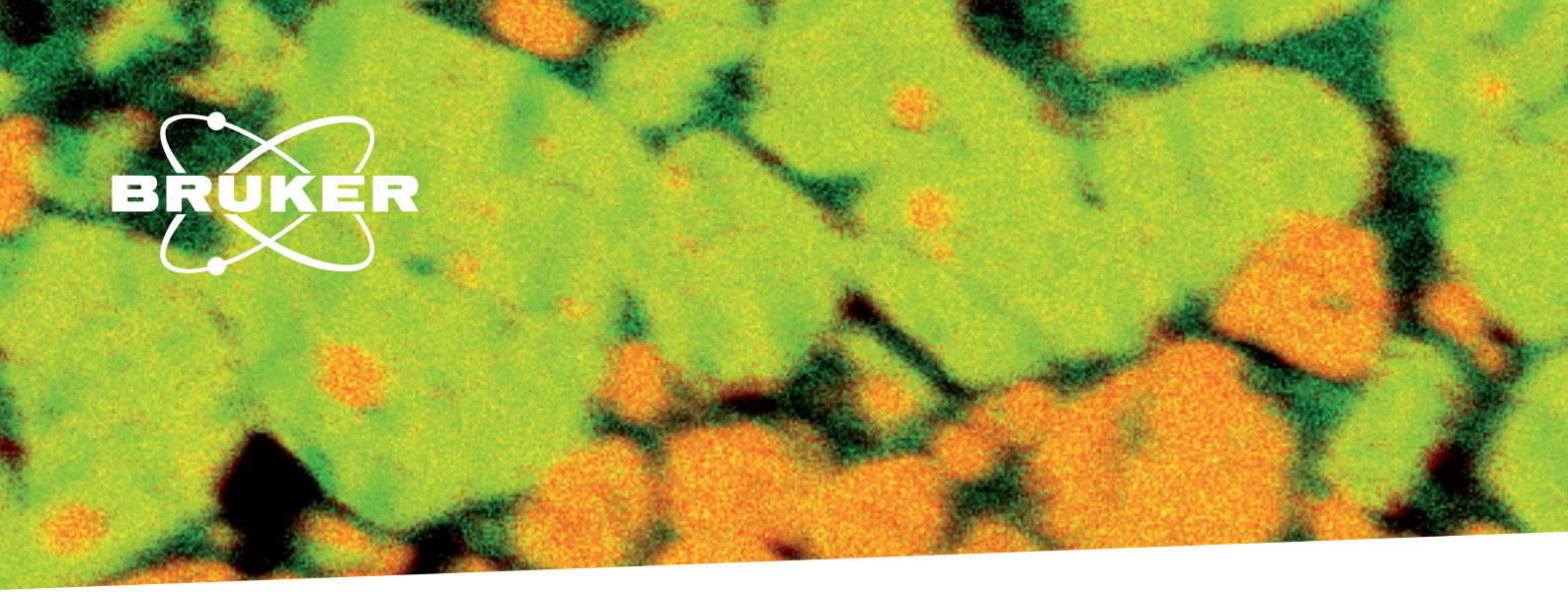


EDS

Determination of the alite to belite ratio in Portland cement clinker using high-speed mapping

Application Note # EDS-06

Introduction

Portland cement is one of the basic materials in the construction industry. The principal component of Portland cement is clinker. According to the cement nomenclature, clinker contains two silicate phases: Ca_3SiO_5 (alite) and Ca_2SiO_4 (belite), as well as aluminate and ferrite. The alite to belite ratio is responsible for the strength of Portland cement in cement clinker. The ability of determining this ratio already during the burning phase is essential for the evaluation of the cement's final strength.

This report shows that high-speed mapping with the XFlash® 5030 detector delivers the necessary information for chemical classification and image interpretation in a very short period of time.

Methods

The analysis was performed on a polished cement clinker sample embedded in a conductive matrix. The sample was analyzed with a Bruker QUANTAX system equipped with a liquid nitrogen free XFlash® detector (energy resolution of 127 eV for Mn Kα). The element mappings were carried out under the following measurement conditions:

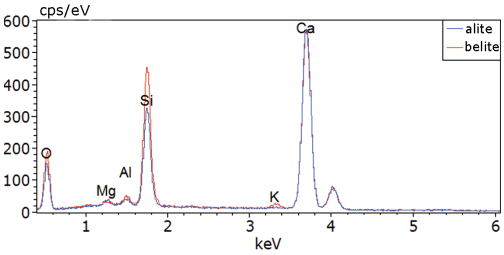
- Accelerating voltage: 15 kV
- Beam current: 20 nA
- Input count rate: 150 000 cps
- Acquisition time: 5 min
- Mapping resolution: 600 x 450 pixels

Table 1
Alite and belite percentage composition (wt.%) and average atomic number

	Ca	Si	O	av. atomic number
Alite	52.76	12.129	35.04	14.56
Belite	46.54	16.3	37.16	15.06

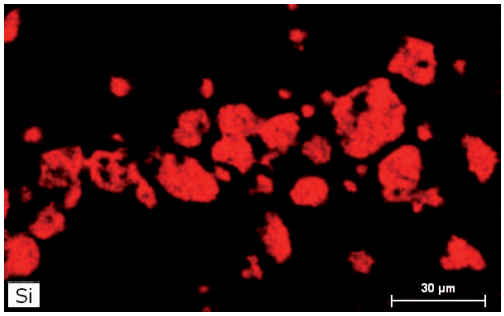
Results

Alite and belite consist of silicon, calcium and oxygen. The corresponding concentrations are shown in Table 1. The similarity of the average atomic number of both phases (see Table 1) anticipates that the BSE image (Figure 2) will not deliver enough contrast to identify the phases to be analyzed.



The difference between phases can be easily displayed with high-speed mapping. With it, the difference in silicon and calcium concentrations can be quickly made visible even at a high image resolution (Figure 3).

Threshold adjustments and the selection of the appropriate filter in ESPRIT Feature, Bruker's particle analysis solution, allow to distinguish the phase with higher silicon content (belite) and the phase with higher calcium content (alite) and determine the total area percentage of each of them.



The phase percentages for alite and belite in this example are shown in Table 2. Consequently, the alite to belite ratio is 2.2.

Conclusions

This analysis shows that high-speed mapping with the XFlash® detector is an excellent solution for a fast characterization of cement clinker samples regarding their alite to belite ratio.

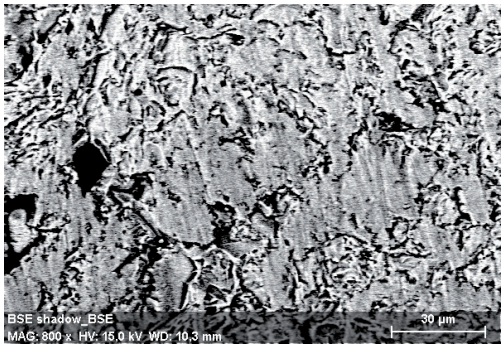


Figure 1
Spectra of both calcium silicate phases

Figure 2
BSE image of the sample section

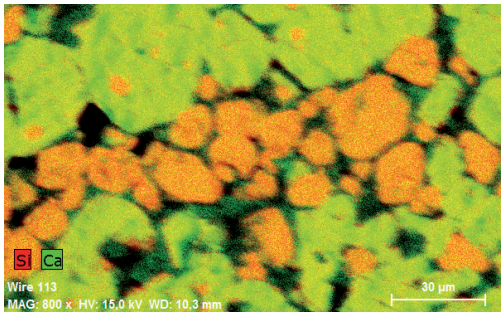


Figure 3
Overlay of Si and Ca element maps (belite: orange, alite: yellowish green)

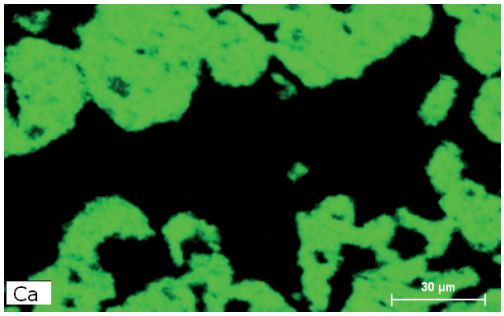


Figure 4
Binarized element distribution of silicon and calcium

Phase	Area
Alite	55.7 %
Belite	25.3 %
Unassigned	19.0 %

Table 2
Phase percentage of alite and belite

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All configurations and specifications are subject to change without notice.
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