Improving EDS

Brynjar Morka Mæhlum

November 25, 2022

Contents

Chapter 1

Introduction

The main goal of this project is to improve EDS analysis. There are multiple ways to do this. One way is to make the analysis more transparent, which would make it easier to understand and use. A second option is to improve the input parameters of the analysis by control checking the instrument with a known sample. A third way is to make the quantitative analysis more accurate, which would improve EDS analysis. In this project, the main focus have been trying to improve the transparency of the analysis. Thus, the problem statement was formulated as:

> Problem statement: **How can the transparency of the steps in the EDS analysis be improved, so that the analysis is easier to understand and use?**

With this problem statement, the following sub-problems were formulated:

1. How accurate it the out-of-the-box quantification in AZtec and HyperSpy?
2. What are done with the data at the different steps in the analysis when using HyperSpy?
3. How can the peaks and the background be modelled in a way that is easy to understand?
4. How is the spectrum calibrated, and is AZtec different than HyperSpy?
5. How does different background models affect the quantitative analysis done in HyperSpy?
6. When does the analysis fail, both in AZtec and HyperSpy?

(Question for Ton: Should I have a short paragraph here about the status of EDS analysis today?)

One of the main problems with the existing software for EDS analysis is that they are like black boxes. The manufacturer of EDS sensors, like EDAX, Hitatchi, Thermo Fisher Scientific, and Oxford Instruments **(Question for Ton: Cite this?)**, provide their own software for analyzing EDS data. These software packages are black boxes, because the code is hidden, and the users does not know what is happening inside the software. In other words, the user pushes some buttons to start the analysis of their sample, and then the software does some "magic" to analyze the data and produce some results. The user has few options to change the analysis to fit their needs. Many users tend to accept the results **(Question for Ton: Need to cite something here?)** from the software without questioning them, even though the analyzation "magic" differs between software packages and might be unreliable. The manufacturer Hitachi have trouble with separating Cs from ??, and their solution is to neglect the existence of Cs **(Brynjar: Find citation)**. The manufacturer Oxford Instruments provides the software AZtec which have trouble with ??, and their solution is ?? **(Brynjar: Find something, eg. zero peak)**. Even if the software is not wrong, the user might not understand the results, and the user have no way to change the analysis to fit their needs. Some might say that using e.g. AZtec is EDS analysis for dummies. One could solve this problem with an increase in transparency, because that would make it easier to understand EDS analysis and easier for users to adapt the analysis to their own needs.

(Brynjar: Paragraph about Dispersion, offset, energy resolution?)

(Brynjar: Paragraph about Other parameters of EDS analysis?)

(Brynjar: Paragraph about Improving quantitative EDS analysis?)

Chapter 2

Results

2.1 Introduction

The results are presented in this chapter. First qualitative then quantitative results are presented.

2.2 Qualitative results

2.2.1 Calibration

Table 2.1: Different calibration values. The AZtec calibration is reffered to as the uncalibrated value. The dispersion is calculated with **??**. The offset is calculated with **??**. The own calibration was done on Ga L_α and As K_α from the 30 kV measurement on the GaAs wafer. The HyperSpy cailbration was done by making a model and fitting it to the data on the 30 kV GaAs spectrum.

Calibration method	Dispersion, [keV/channel]	Zero offset [channels]
AZtec	0.01	20
HyperSpy	0.010028	21.0787
Own calibration	0.010030	21.127

2.3 Quantitative results

2.3.1 Initial quantification

The initial quantification was done on the data from the GaAs wafer in AZtec and in HyperSpy as out-of-the-box as possible. The results are presented in Table 2.3. The wafer is a 1:1 alloy of gallium and arsenic, so the atomic percent of

Table 2.2: Peak accuracy of the different calibration methods. The accuracy here is the deviation from the theoretical peak to the measured peak. The measured peak is the Gaussian fitted center of the peak. All results are from the 30 kV measurements. The own calibration was done on Ga L_α and As K_α from the 30 kV measurement on the GaAs wafer. The HyperSpy cailbration was done by making a model and fitting it to the data on the 30 kV GaAs spectrum. AZ is short for AZtec. HS is short for HyperSpy. All deviations are in percentage difference from the theoretical peak value.

Peak and line	Theoretical [keV]	AZ deviation [%]	HS deviation [%]	Own deviation [%]
As Lα	1.2819	1.000	0.439	0.422
As Kα	10.5436	-0.202	-0.025	-0.010
Ga Lα	1.098	1.044	0.342	0.318
Ga Kα	9.2517	-0.153	0.009	0.024
Cu Lα	0.9295	1.767	0.888	0.857
Cu Kα	8.0478	-0.114	0.031	0.045
Mo Kα	17.4793	-0.325	-0.108	-0.090
Mo Lα	2.2932	1.047	0.859	0.858
Si Kα	1.7397	0.167	-0.175	-0.182
Al Kα	1.4865	0.200	-0.247	-0.259
Cu Kα	8.0478	-0.116	0.029	0.043
C Kα	0.2774	-2.955	-6.583	-6.738

Ga and As should be 50% and 50% respectively.

Table 2.3: Initial quantification of the GaAs wafer. The ratio in the wafer is 1:1, so the correct ratio is 50% and 50%, because the results are in atomic percent. **(Brynjar: Put in the actual results here. Use both HyperSpy linear and model fitted results?)**

V_{acc}	AZtec		HyperSpy	
	Ga	As	Ga	As
5 kV	50 %	50 %	50 %	50 %
10 kV	50 %	50 %	50 %	50 %
15 kV	50 %	50 %	50 %	50 %
30 kV	50 %	50 %	50 %	50 %

Bibliography