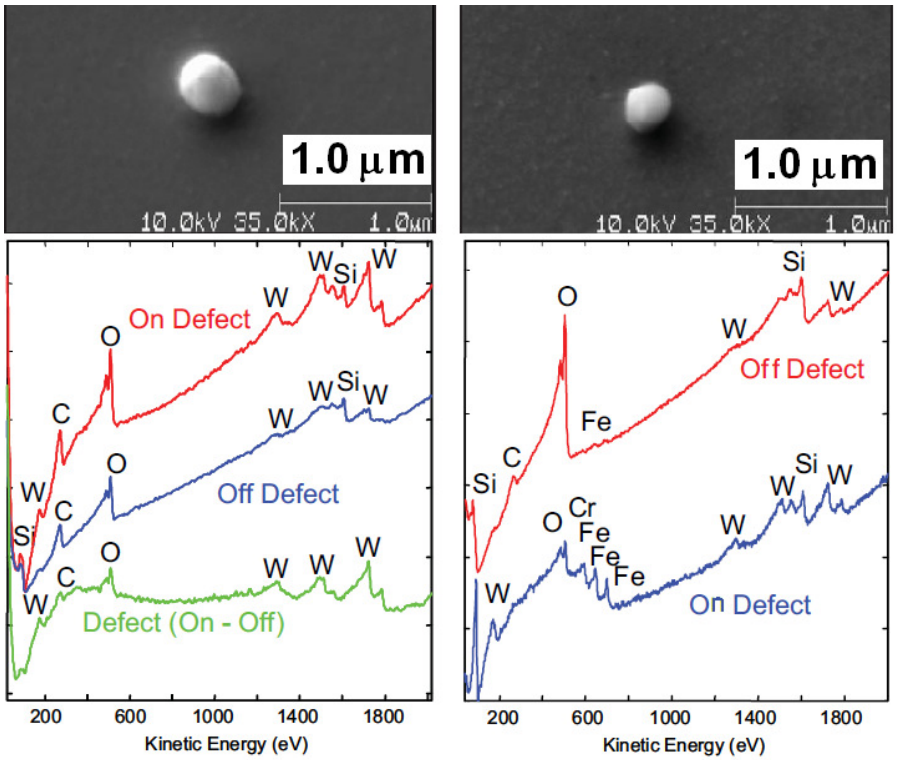
Problem 1. A silicon wafer was treated with a process known as silicide resulting in a uniform layer of WFe_6+$SiCl_2H_2$, except for a couple of defects shown in the SEM figures. AES was used to determine the composition of the defects and produced the graphs shown.

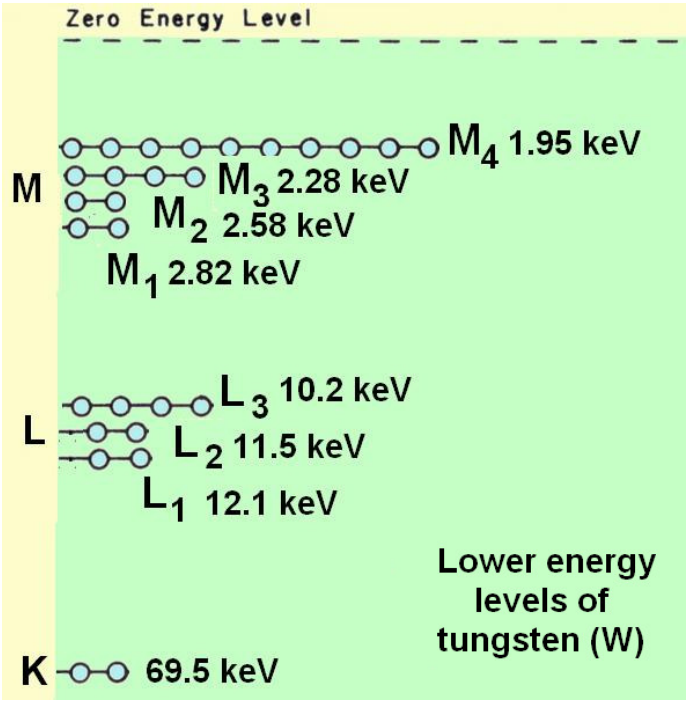


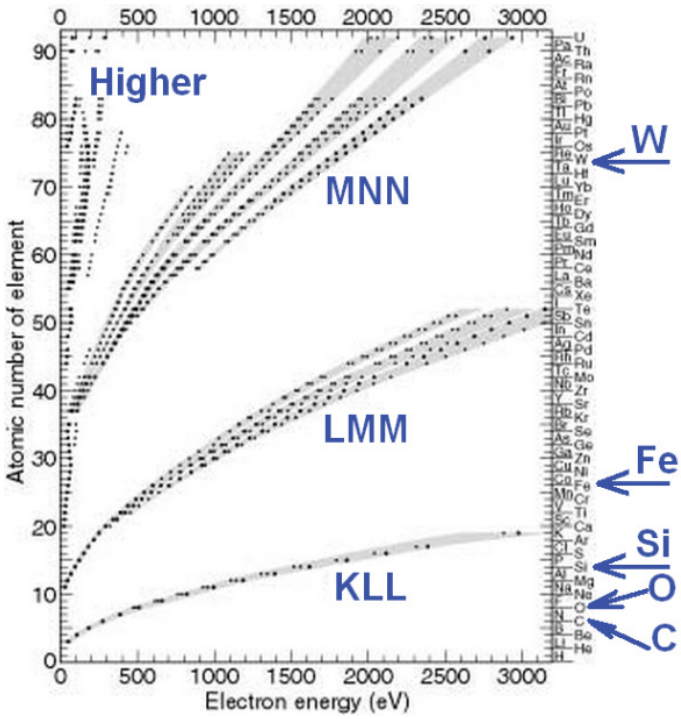
Answer the following questions, if needed you can use the information given in the two charts presented below.

A) Why do you think AES was preferred over other techniques to analyze the defects?

Answer.

XPS uses an x-ray beam of >20 µm of diameter while AES uses an x-ray beam of ~0.3 µm. XPS would illuminate a region at least 20 times larger than the defect while AES can illuminate parts of the defect without exciting the uniform layer.





B) What is the probable composition of the defect on the left picture?

Answer.

By looking at the "On – Off" curve, we see that the left defect is basically made of tungsten (W), probably unreacted from the silicide process.

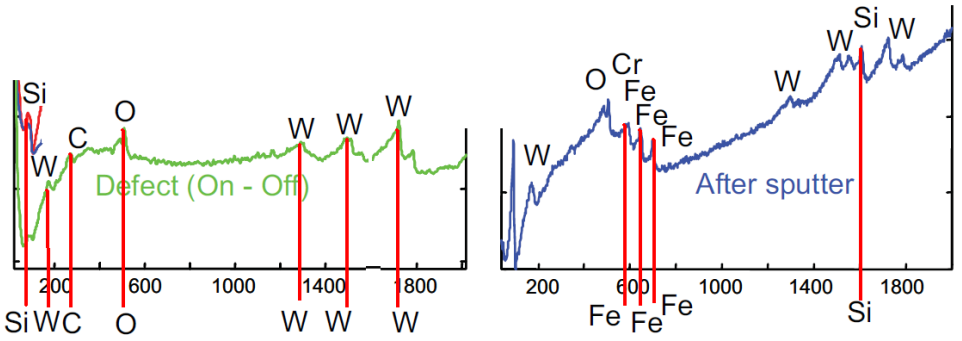
C) What is the probable composition of the defect on the right picture?

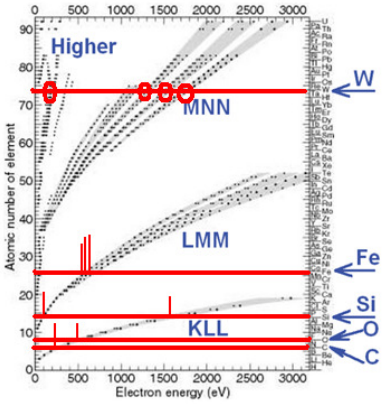
Answer.

By looking at the "On defect" curve we see an excess of Fe and Cr not existent on the uniform layer (Off defect), thus the defect is probably unreacted Fe, the presence of Cr suggests that iron was added from steel and not from pure iron.

D) Label all of the AES peaks of Si, W, C, O and Fe according to the transitions (eg. LMM, etc.). Please identify the peaks by element and energy.

Answer.





The peaks are shown on the previous graphs. Looking at their energies and comparing to the nomenclature chart on the right, one can make the following assignments:

Element	Energy (keV)	Nomenclature	Element	Energy (keV)	Nomenclature
Si	~ 70	LMM	Fe	~ 590	LMM
W	~ 180	Higher	Fe	~ 650	LMM
C	~ 280	KLL	Fe	~ 720	LMM
O	~ 520	KLL	Si	~ 1600	KLL
W	~ 1280	MNN			
W	~1450	MNN			
W	~1700	MNN			

E) If XRF with hard x-ray photons of 15 keV are used to examine the left defect, what would be the energy of some of the x rays emitted by tungsten? Label the x rays according to the proper nomenclature (eg. $K_{\alpha 1}$, etc.).

Answer.

The incident x ray is not energetic enough as to produce K x rays, but it can produce L x rays:

- $L_{\alpha 1}$: L_3 - M_5 ≈ 10.2 – 1.8 = 8.4 keV
- $L_{\alpha 2}$: L_3 - M_4 = 10.2 – 1.95 = 8.25 keV
- $L_{\beta 1}$: L_2 - M_4 = 11.5 – 1.95 = 9.55 keV
- Etc.

The actual values (from the LBL data booklet: http://xdb.lbl.gov/Section1/Sec_1-2.html) are:

Element	$K\alpha_1$	$K\alpha_2$	$K\beta_1$	$L\alpha_1$	$L\alpha_2$	$L\beta_1$	$L\beta_2$	$L\gamma_1$	$M\alpha_1$
74 W	59,318.24	57,981.7	67,244.3	8,397.6	8,335.2	9,672.35	9,961.5	11,285.9	1,775.4