



# Electronics Failure Analysis

CMC Laboratories, Inc.



# Characterization of Analysis Techniques

Category	Type of information probed	Examples
Bulk property measurement	Overall characterization of a bulk sample	Density, overall chemical composition, mechanical strength, layer adhesion, glass transition temperature, melting temperature
Imaging	Pictures which show morphology or physical structure	Microstructural characterization, interfacial structure, surface morphology, voids, failure interfaces
Elemental Information	Identification of elements	Chemical composition, identification of impurities, chemical depth profiles, elemental mapping of surfaces
Chemical Bonding and Structure	Characterizing chemical bond type and molecular structure	Oxidation state of elements, bond type (ionic, covalent, metallic), crystal structure

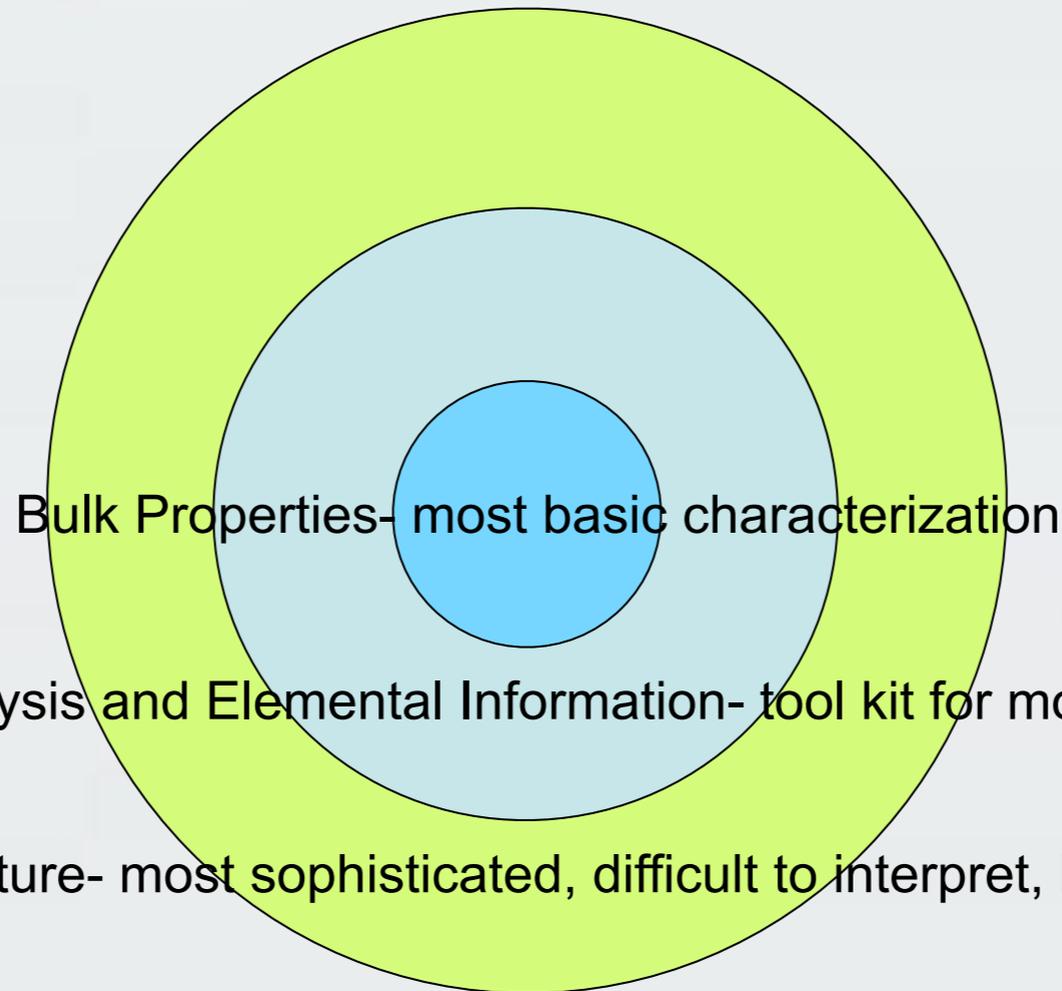


# Where is Analysis Critical

Area	Function	Information Probed	Categories of Analysis Typically Used	Importance
Failure analysis	What was the failure site for a component?	Imaging and elemental composition of failure site. Identification of impurities, defects and foreign material.	Imaging, elemental analysis, chemical bonding and structure	Can determine or infer failure root cause of failure.
Materials and Process Development	How was this component constructed?  What is the result of my fabrication process or process changes?	Interfacial structure, layer thicknesses, layer compositions, diffusion and other dynamic changes as a function of processing conditions (time, temperature...)	Imaging, elemental analysis, chemical bonding and structure, bulk properties	Guidance during process development, documentation of processes for manufacturing, competitive analysis, developing and protecting IP



# Levels of Analysis Capabilities



Chemical Bonding and Structure- most sophisticated, difficult to interpret, but critical for some problems



# Bulk Property Measurements

Analytical Technique	What is Measured	How it works
ICP Inductively Coupled Plasma	Overall bulk chemical composition at ppb level	Sample is chemically dissolved to form liquid. Introduced into a plasma where each element is excited and emits characteristic light. This light spectrum is analyzed with a spectrometer.
TGA/DTA Thermogravimetric Analysis/ Differential Thermal Analysis	Phase changes such as Tg, thermal stability, chemical reactions such as curing	The sample is inserted in a calorimeter and heated/ cooled at a fixed rate. Heat flow is measured as a function of temperature (DTA). Weight change is measured as a function of temperature (TGA)
Density	Material density	Weigh material dry and submersed in a liquid with known specific gravity.
Four Point Bend Test	Flexural Strength (Tensile strength)	Sample is supported on a four point bend test fixture. Force is applied and the stress-strain curve is determined. Force at the breaking point is recorded.
Peel or pull test using a mechanical tester	Layer adhesion strength (indirect)	Test fixture is soldered, wirebonded or epoxy bonded to layer. Layer is pulled (stress uniform under fixture) or peeled (stress is concentrated on edge of fixture) until failure is initiated. Stress/strain curve is monitored.

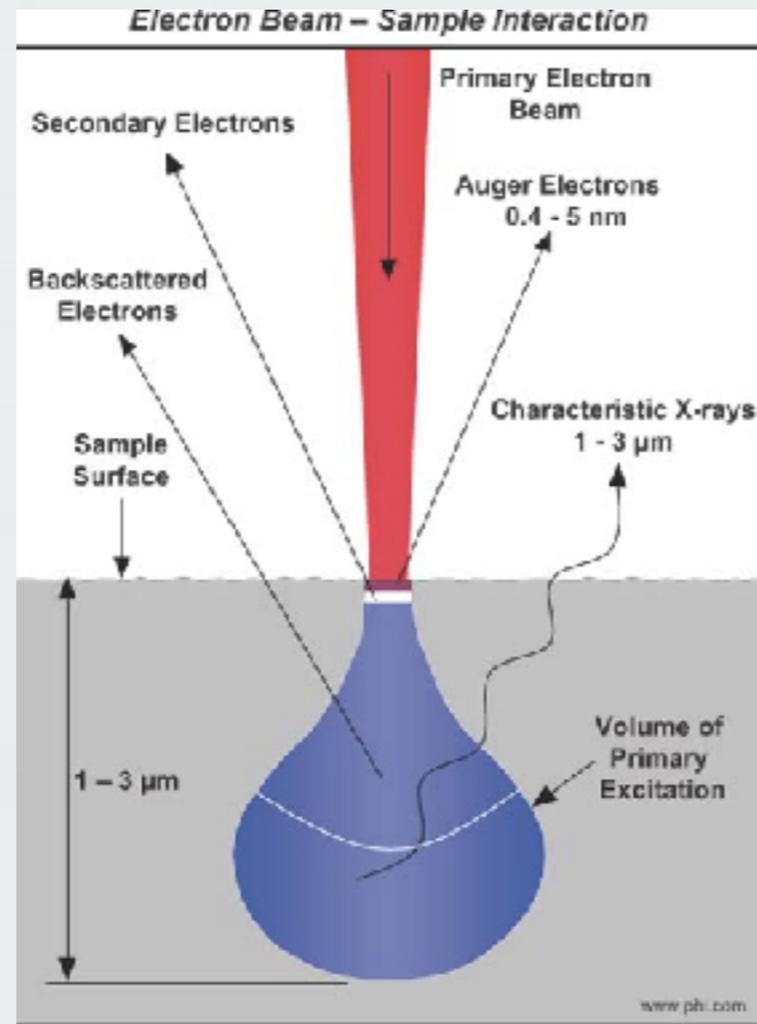


# Imaging Analysis

Analytical Technique	What is Measured	How it works
SEM (Scanning Electron Microscopy)	High resolution and high depth-of-field image of sample surface. Ultimate resolution and image quality a strong function of sample preparation.	A focussed electron beam is scanned across the surface of the sample. Backscattered and secondary electrons are detected as a function of position and mapped to create an electron generated picture of the sample.
FIB (Focussed Ion Beam)	Sample preparation technique to create small length span cross sections of a multilayer sample. Imaging is then done with SEM or TEM. FIB can also be used to create an image. Ideal for analysis of devices with small, difficult to access features such as gates or diffusion layers. Also useful for hard to polish materials.	A focussed ion beam is used to mill through the surface of a material exposing the layers beneath. This milled multilayer structure provides a cross-section view of the sample that can be imaged either with SEM or by imaging electrons emitted when the ion beam itself is scanned across the surface of the cross section.
TEM (Transmission electron microscope)	Extremely high resolution images on the 1-2 angstrom length scale, crystallographic phases and crystallographic orientation can be measured. Very involved and complex sample preparation is required for good TEM images. Use extensively for devices where nanometer size features much be analyzed	A high energy electron beam is transmitted through an extremely thin sample created using ion beam milling or a FIB. The absorption and diffraction of the electrons as they travel through the material is the imaging mechanism. Electron energy and position at the exit side is analyzed.
AFM (Atomic Force Microscopy)	Extremely high resolution three dimensional imaging of surfaces. Non-vacuum technique that can be used in any atmosphere. Used for detecting very small topography changes such as doping profiles versus position in MOSFET devices.	Atomic level interaction between the probe tip of the AFM and atoms on the surface of the sample. Piezoelectric scanner moves probe tip over surface with atomic scale precision. Tiny deflections of probe tip are measured by laser deflection system.
X-ray Radiography	Transmission of an X-ray beam through a sample. Imaging is due to differential X-ray absorption or scattering. Used for imaging defects such as voids in high density materials such as metal solders throughout the bulk of a sample.	X-ray absorption depends on the density of the material the X-ray is traveling through. If voids or delamination is present in high density material such as solders, the X-ray beam is travels through the voided regions without absorption and this results in a higher intensity exiting beam compared to non-voided regions of the sample.
Acoustic Microscopy	Like X-ray radiography, acoustic microscopy is used to detect defects in structures such as voids or delamination throughout the bulk of the sample. Ideal for analyzing low density materials such as polymers (molding compounds, underfill).	Sound waves are absorbed, transmitted or scattered as they move through material. Scattering occurs preferentially at interfaces between materials with different acoustic properties.



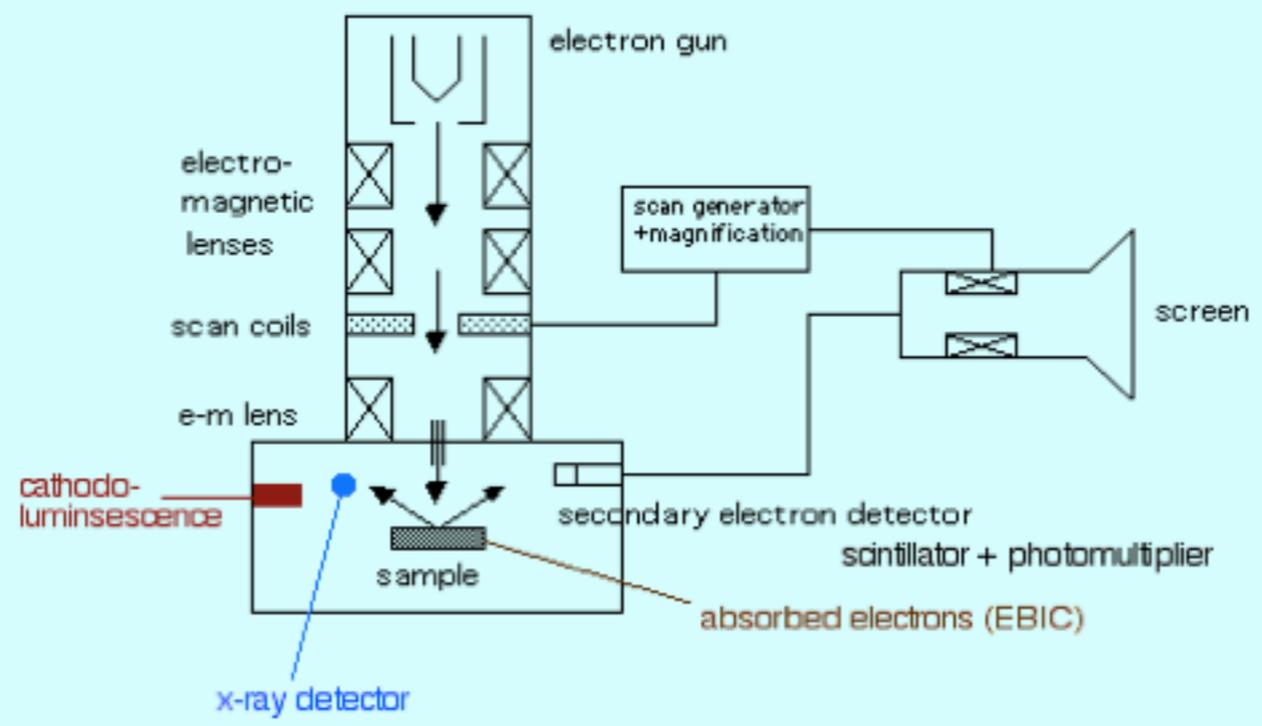
# Many Analysis Techniques Utilize Electron Interaction with Samples





# SEM Review

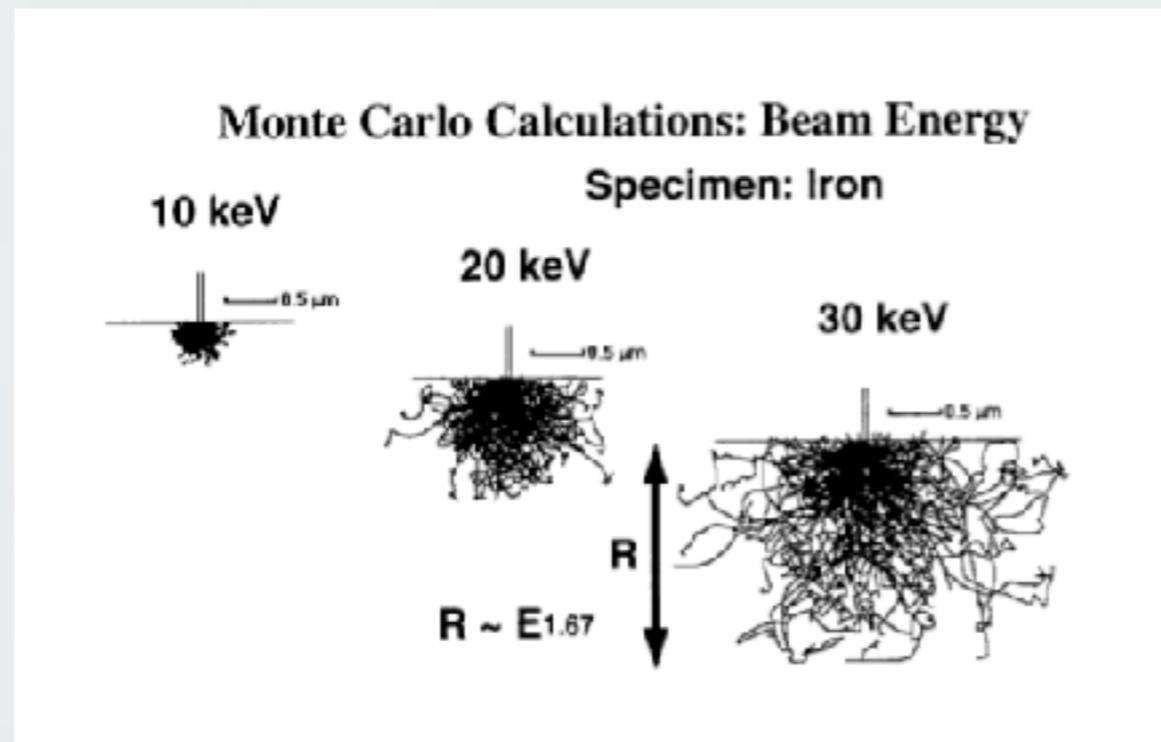
**Schematic diagram of typical SEM:**





# Interaction Shape versus Beam Energy

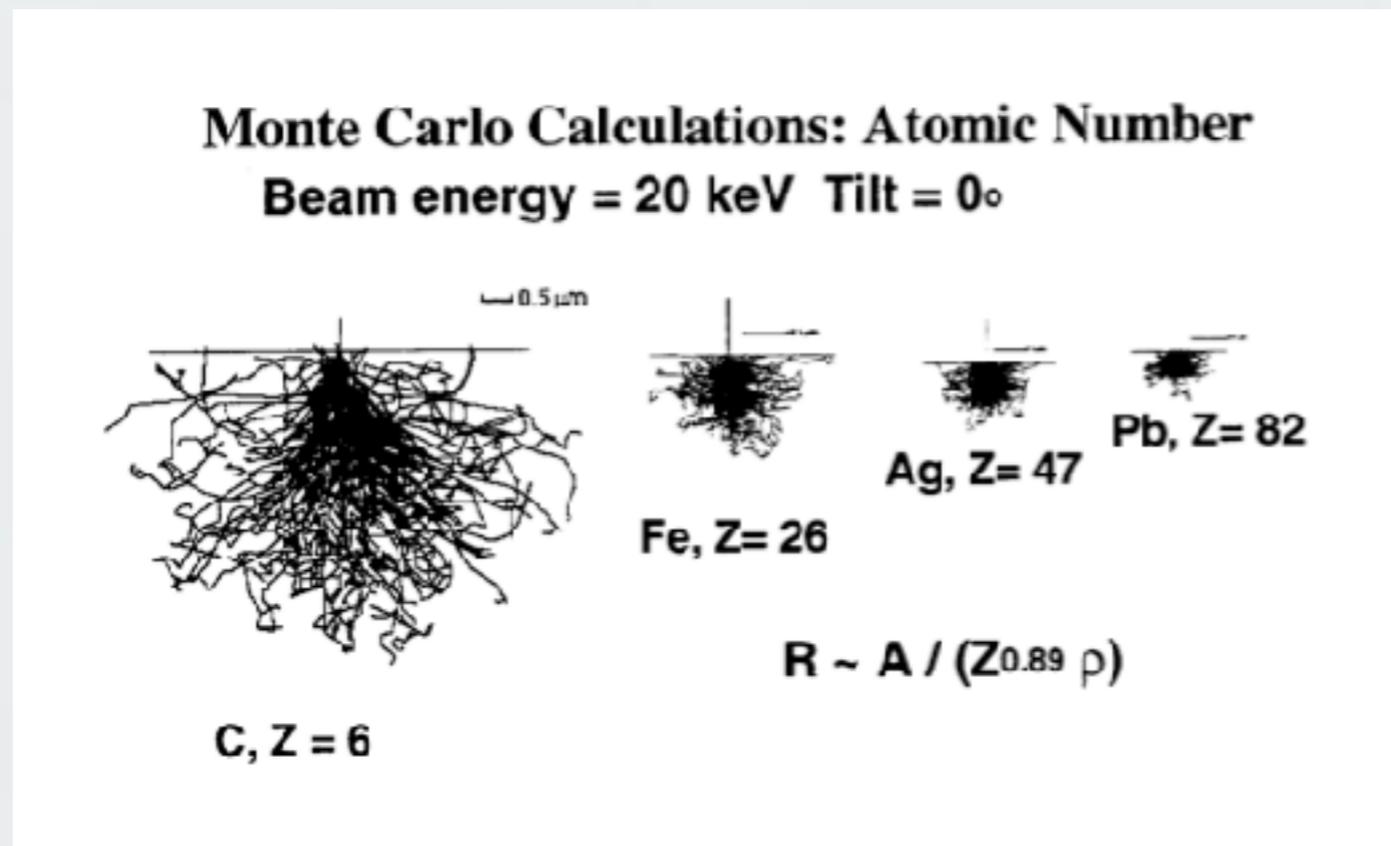
Penetration depth of electron beam increases with electron beam energy





# Interaction Shape versus Atomic Number of Sample Atoms

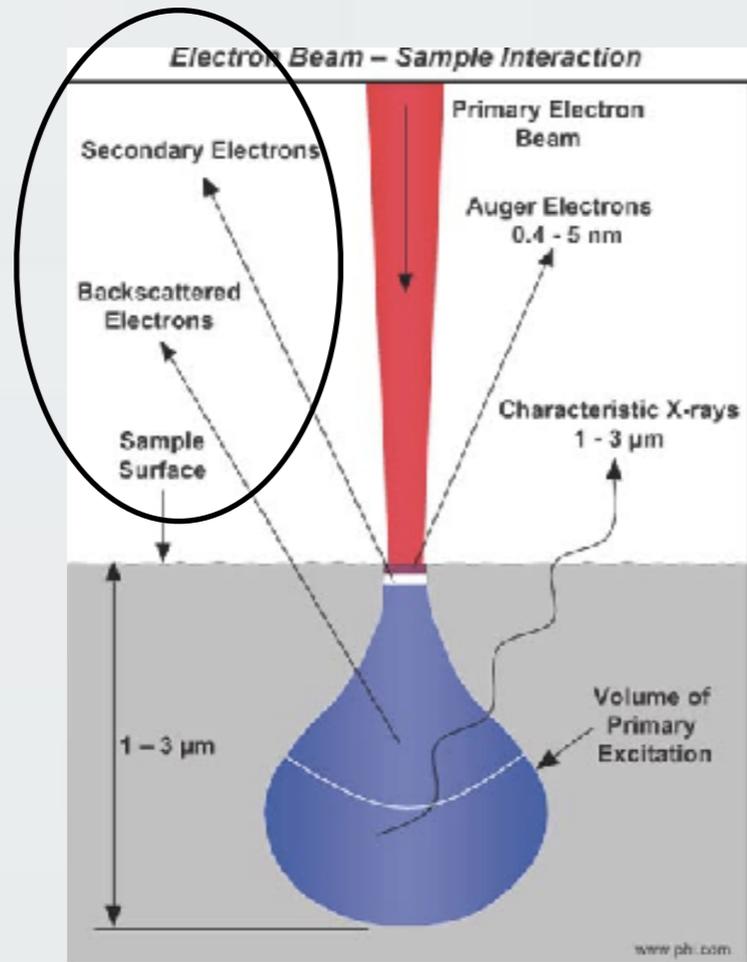
Penetration depth of electron beam decreases with increasing atomic number of host





# Electron Interaction with Sample

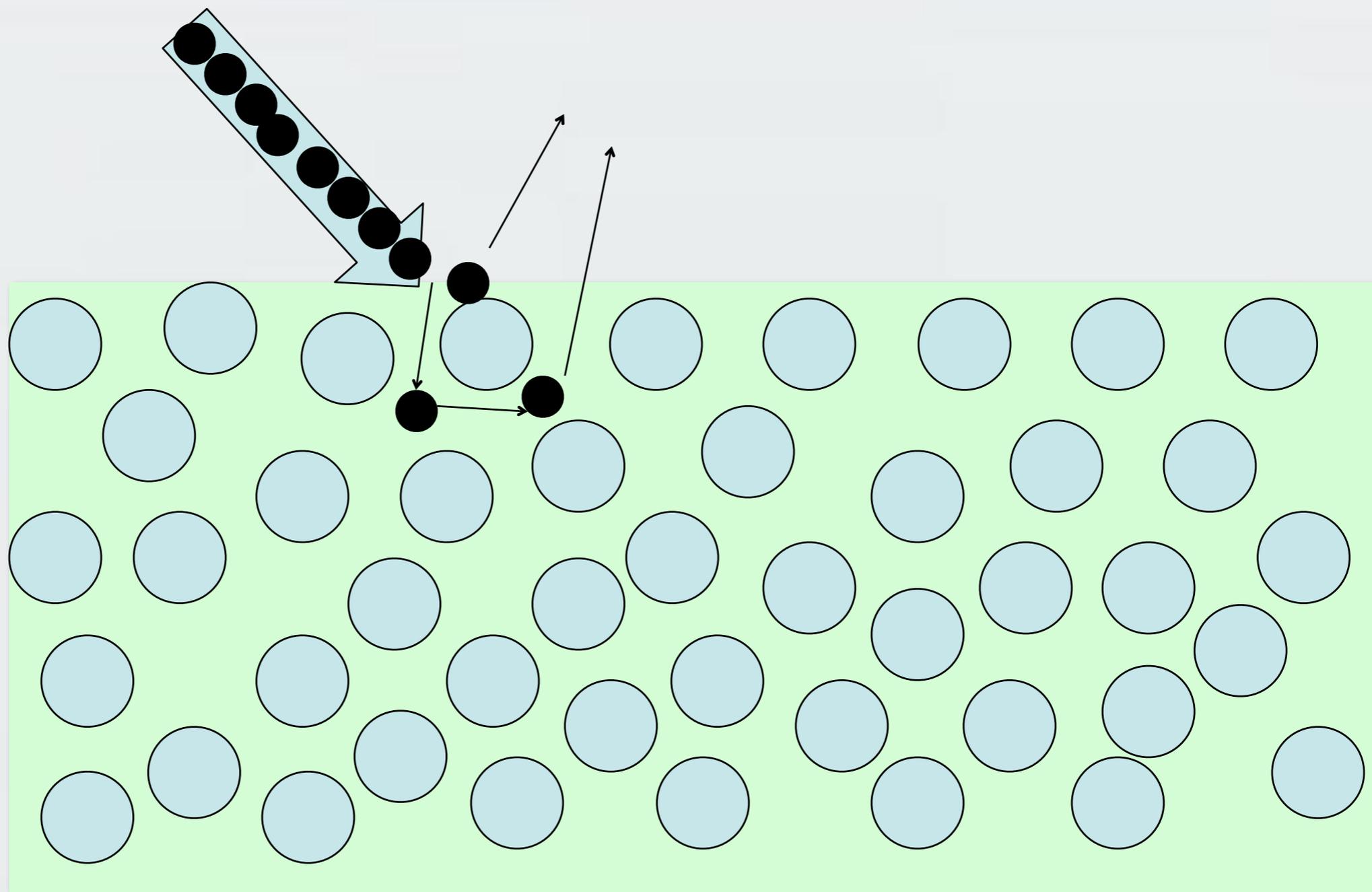
SEM Imaging



- Backscattered Electrons elastic collision with sample atoms
- Secondary Electrons- electrons knocked out of sample when incident electrons collide inelastically with sample atoms



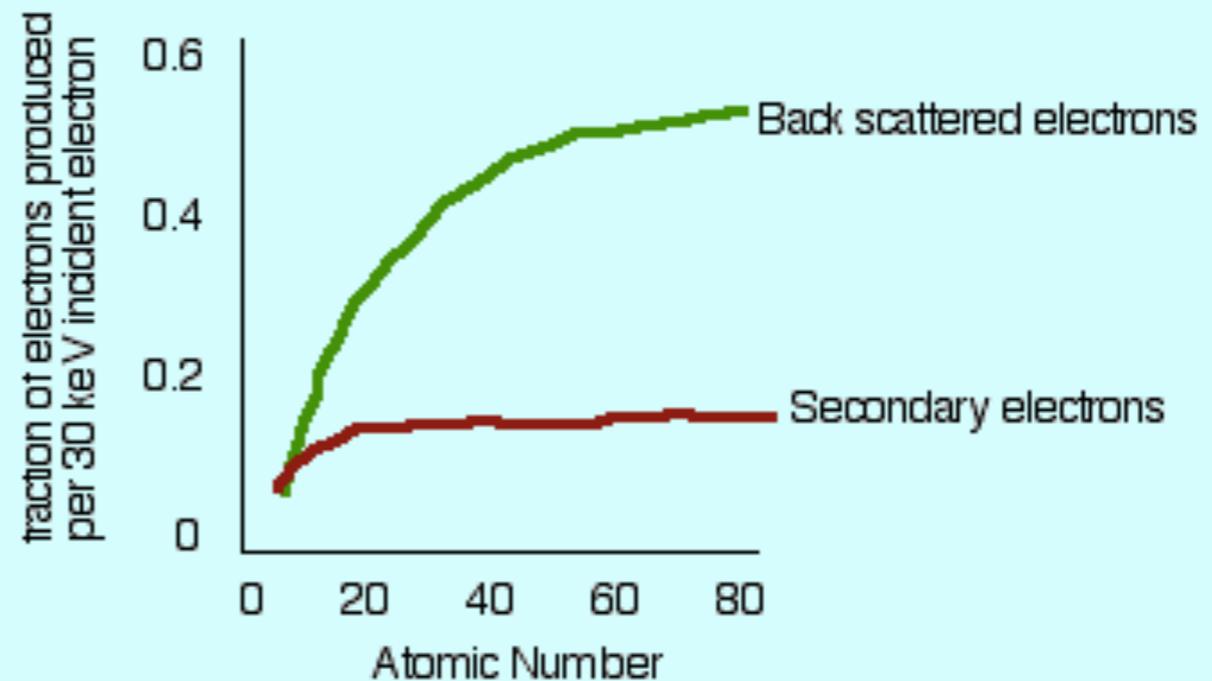
# Backscattered Electron Schematic





# Key Characteristics: Backscattered Electrons

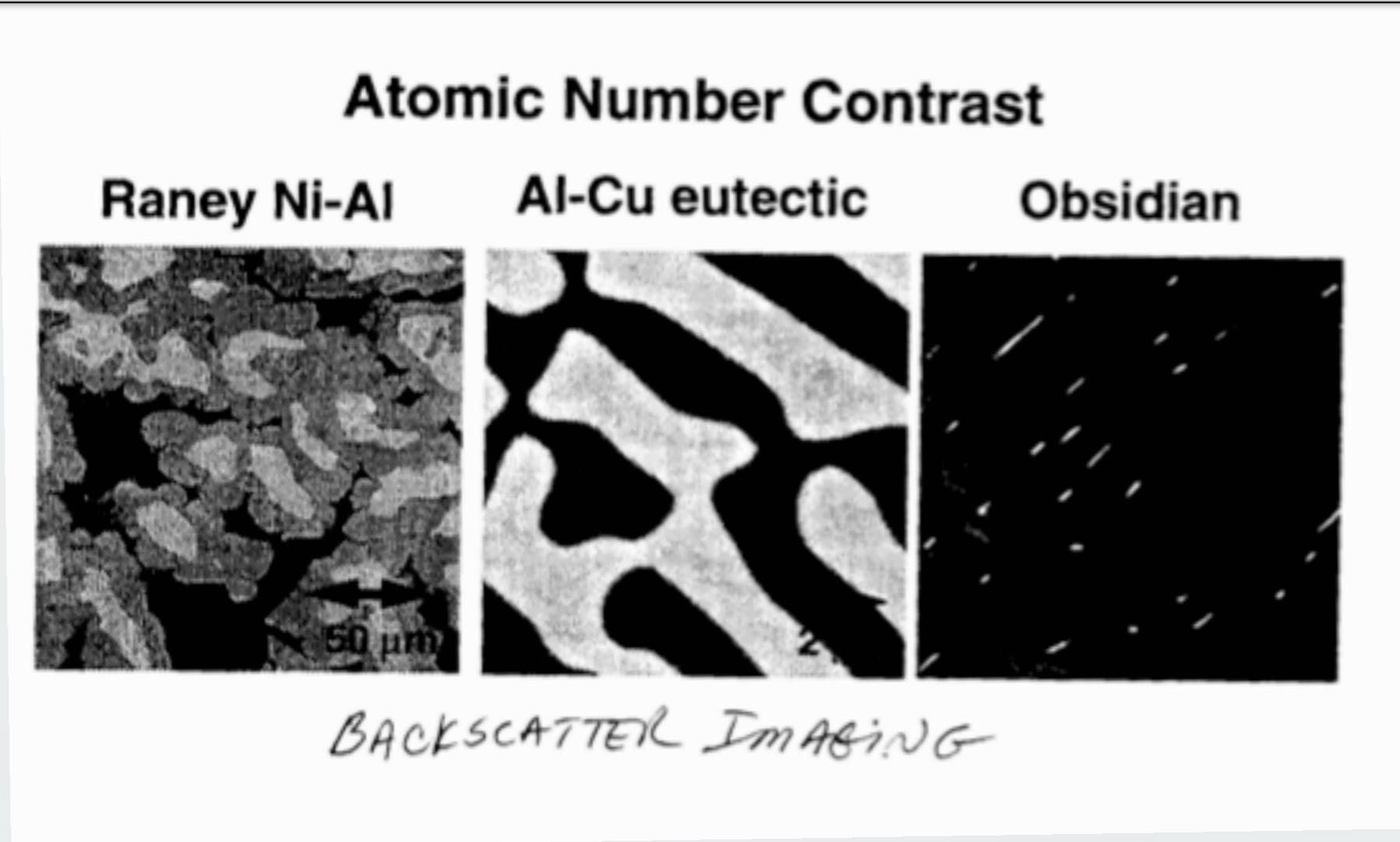
Backscattered electron intensity is proportional to atomic number. This is a key contrast mechanism for SEM analysis.





# Atomic Number Contrast

Higher Atomic Number elements are brighter in SEM backscatter collection mode



Cu is bright ( $Z=29$ ), Al is darker ( $Z=13$ )



# Summary: Backscattered Electrons

- Backscattered electrons- elastically scattered many times
- Information from BS electron:
  - composition of host (atomic number contrast)
  - topography of surface
- BS electrons originate from a layer approximate 33% of the depth of the total interaction depth ( $0.33 R_{KO}$ )
- 2D Image on SEM screen is actually coming from a 3D volume!!

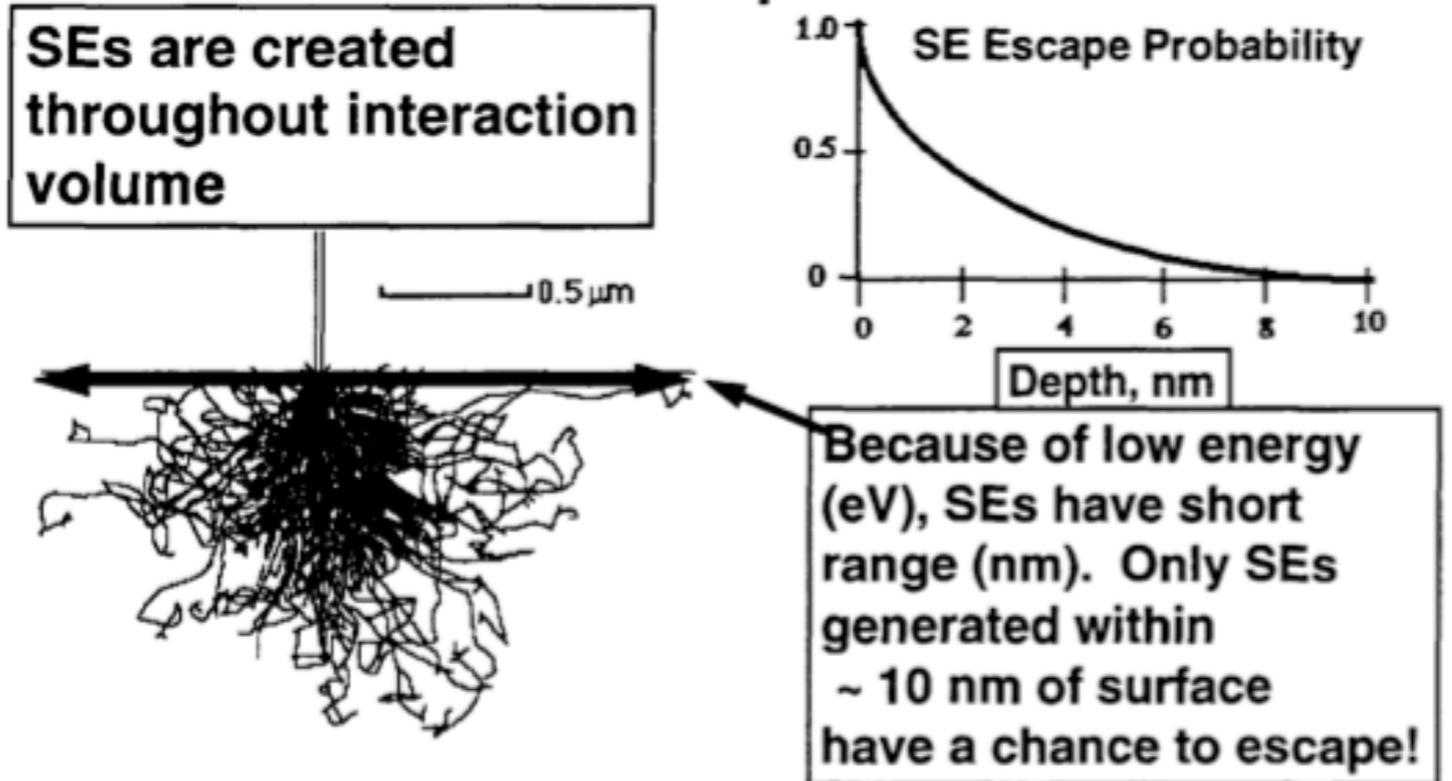


# Depth of Origin: Secondary Electrons

Secondary Electron beam intensity depends on the work function of the host, not atomic number

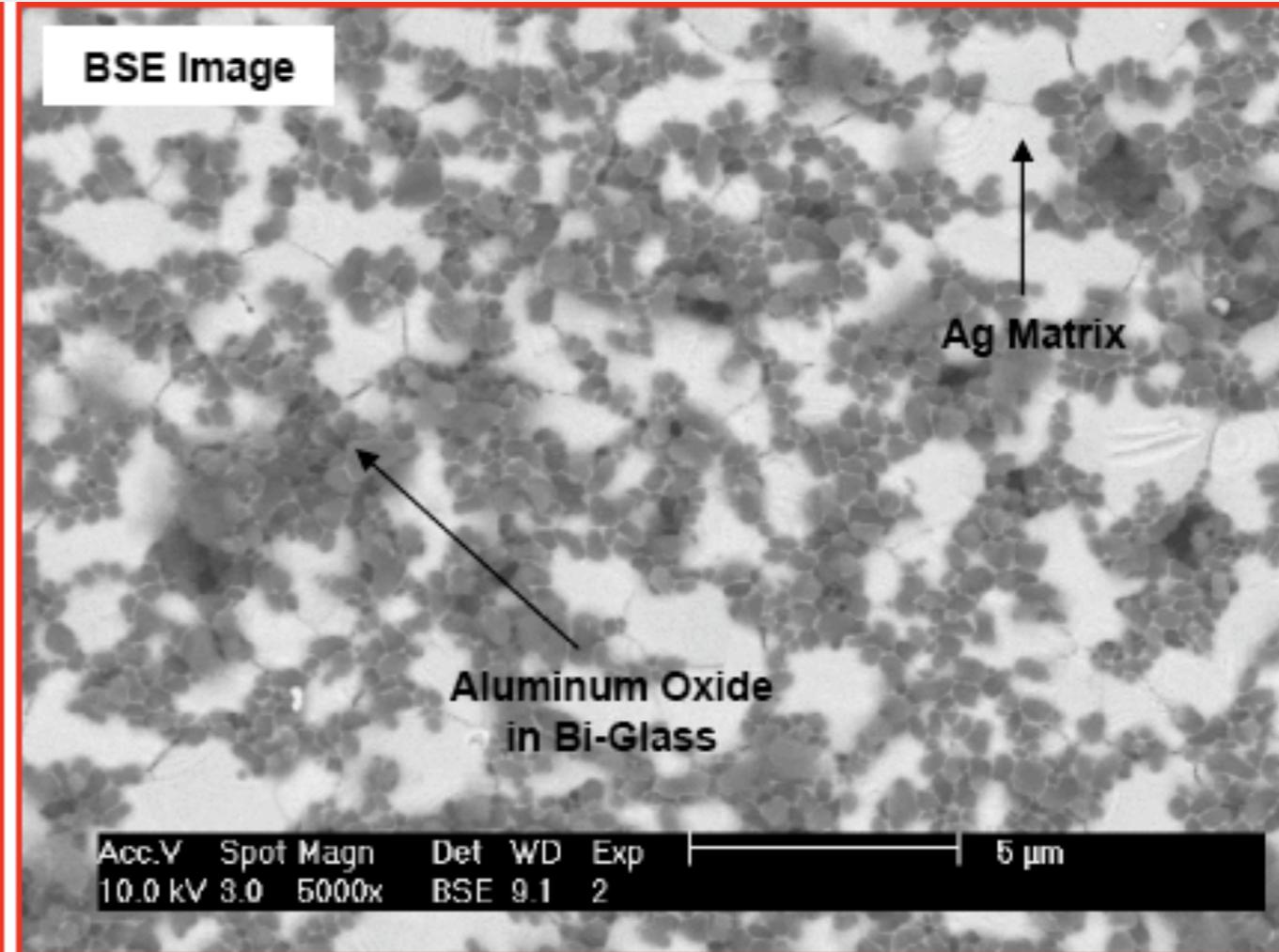
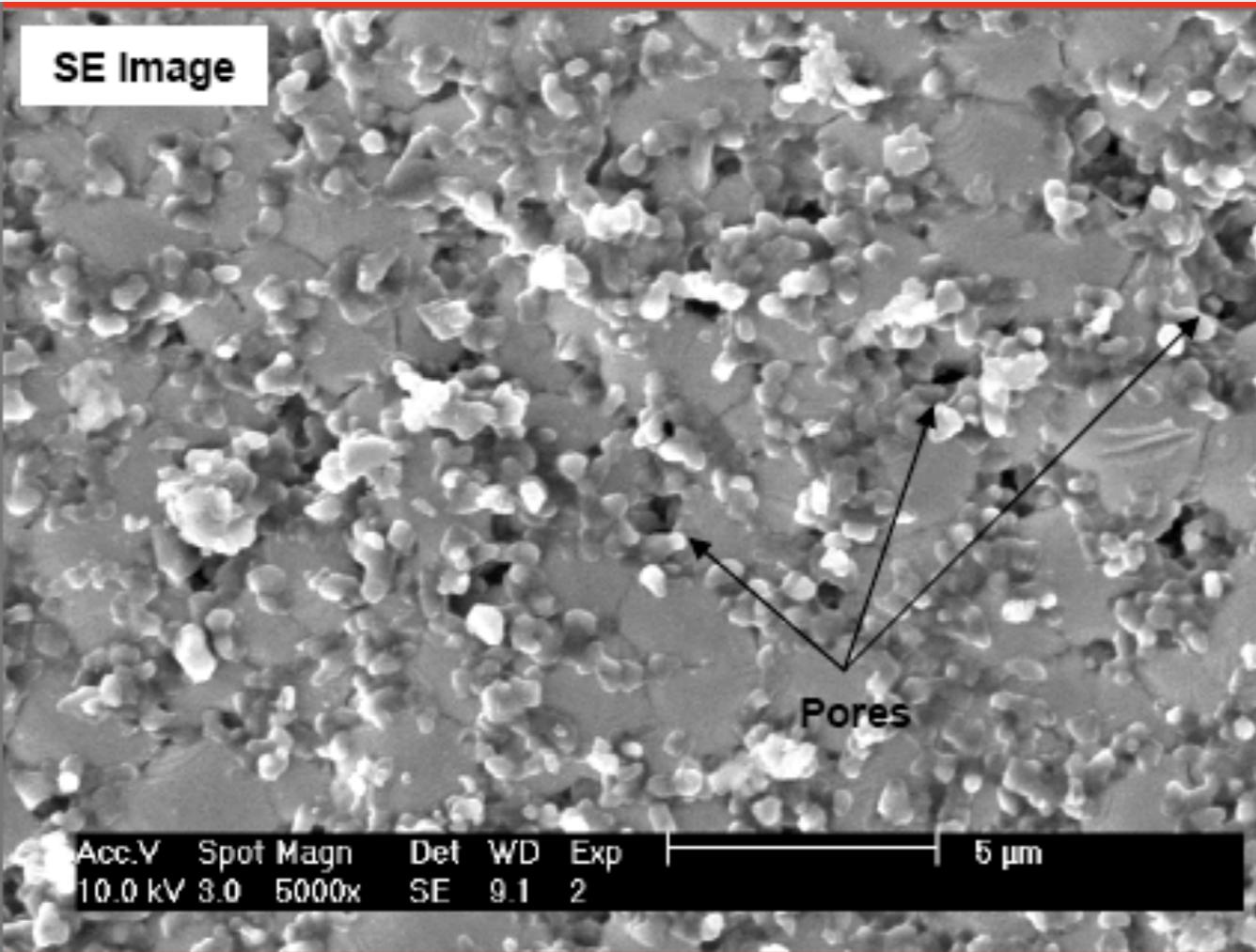
Completely different imaging mechanism than backscattered electrons

## Where Do Secondary Electrons Escape from the Specimen?





# Secondary v. Backscatter Imaging



Ag thick film with  $Al_2O_3$  on the surface.

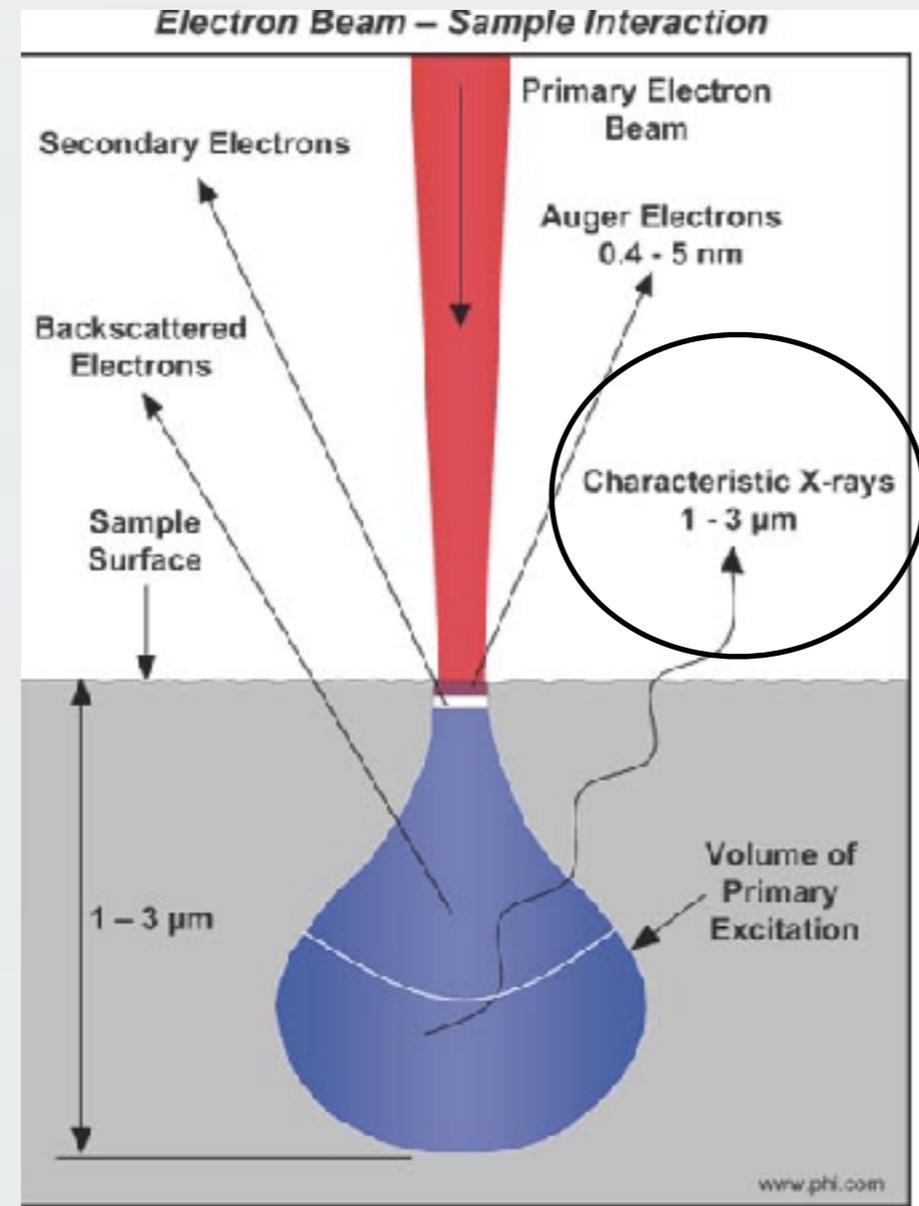


# Secondary Electron Imaging: Summary

- Secondary electrons originate from inelastic collisions with outer shell atomic electrons
- Secondary electron yield increases with decreasing work function of the host material
- Secondary electrons originate from a thin surface layer about 10 nm thick
- Surface sensitive
- Secondary electron imaging offers a highly complementary imaging approach to BS electron imaging. Some materials with very similar  $Z$  (no contrast in BS) have very different work functions (good contrast in secondary electron image).

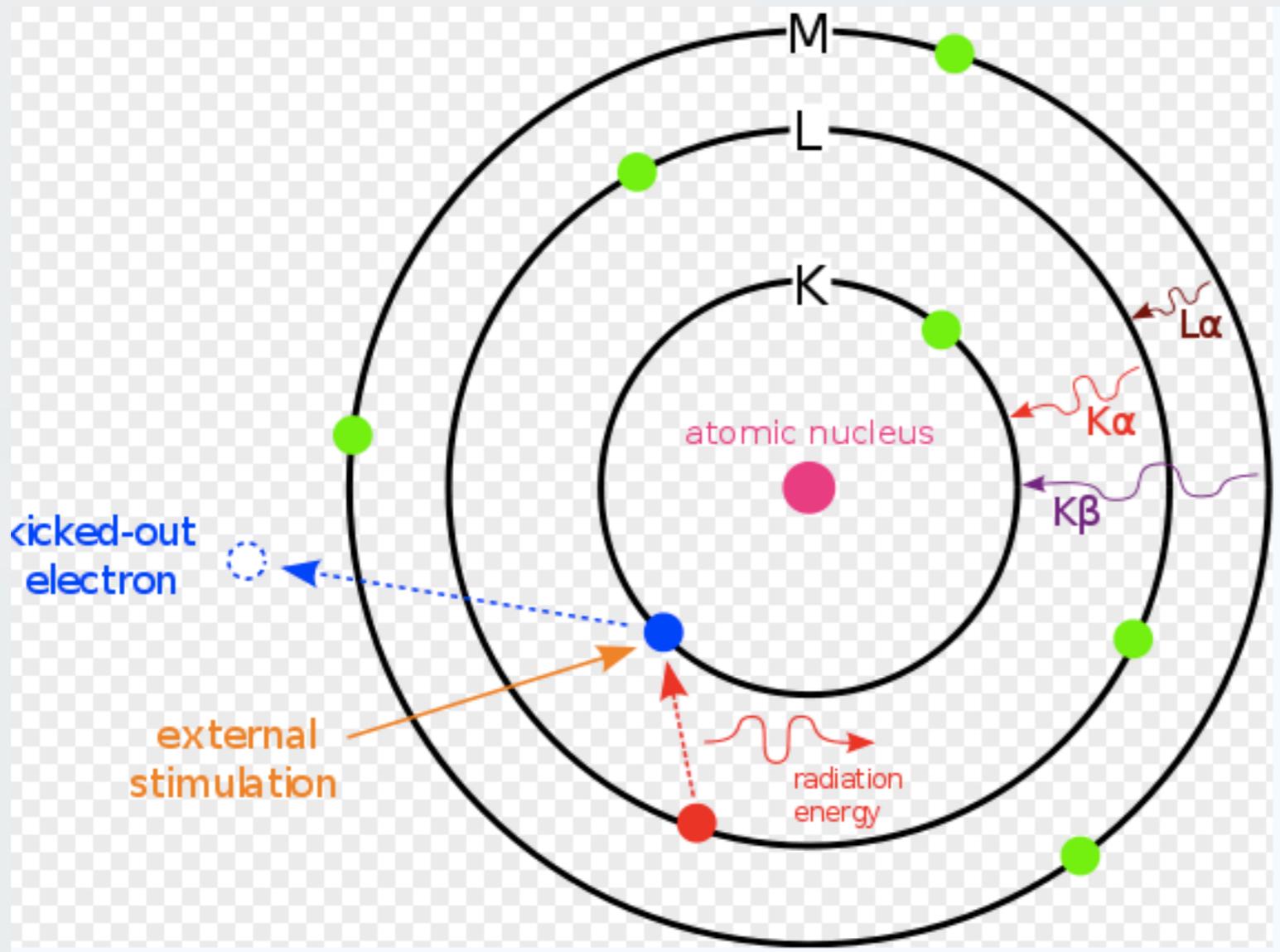


# EDS





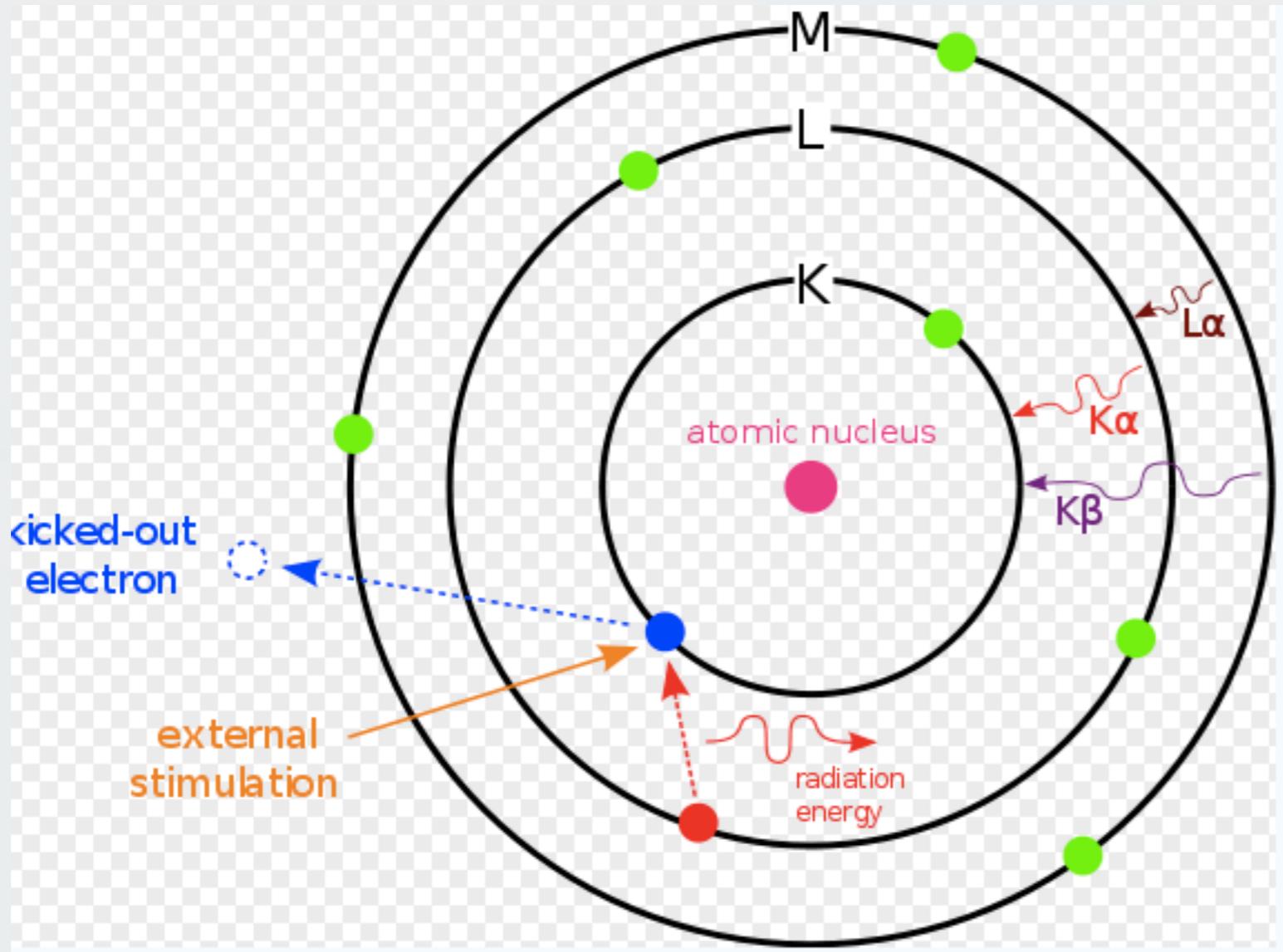
# EDS



1. Electron beam (from SEM) incident on atom in sample material
2. Energy from the incident electron knock a core electron out of the material (atom is ionized)
3. An outer shell electron falls into the core atom vacancy
4. An x-ray is emitted whose energy = (core electron energy) - (outer shell electron energy)
5. Thus the x-ray energy depends on the electronic shell structure of the atom
6. Process is very similar to Auger electron spectroscopy



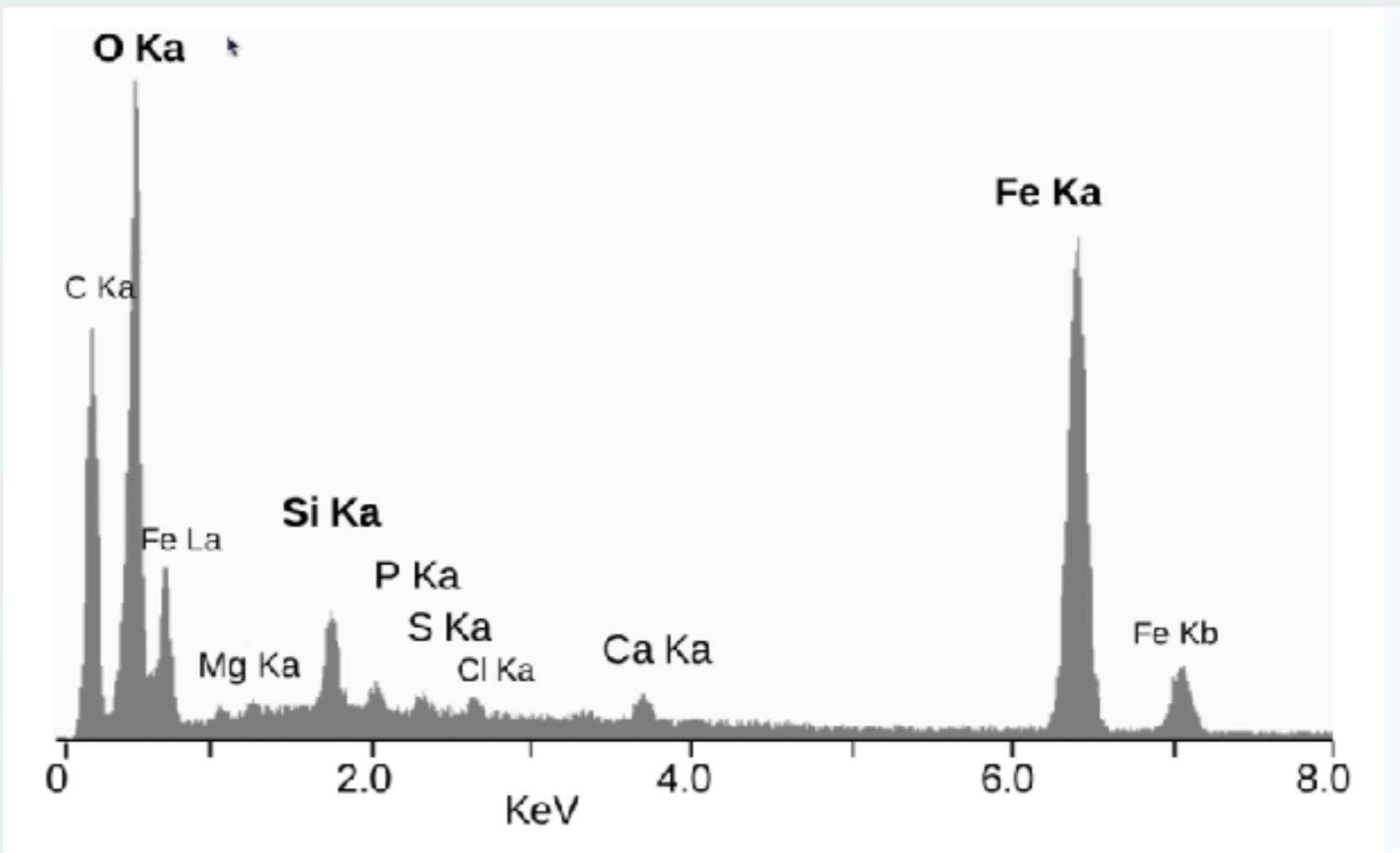
# EDS Naming Transitions



- Transitions are named according to the initial shell where the vacancy forms and the outer shell electron which falls into that vacancy
- $\alpha$  refers to an outer shell one energy level higher than the vacancy shell
- $\beta$  refers to an outer shell two energy levels higher
- $\gamma$  is three energy levels higher
- If an electron falls from the L orbital to a vacancy in the K orbital, it is an K $\alpha$  transition
- If an electron falls from the M orbital to a vacancy in the K orbital, it is an K $\beta$  transition



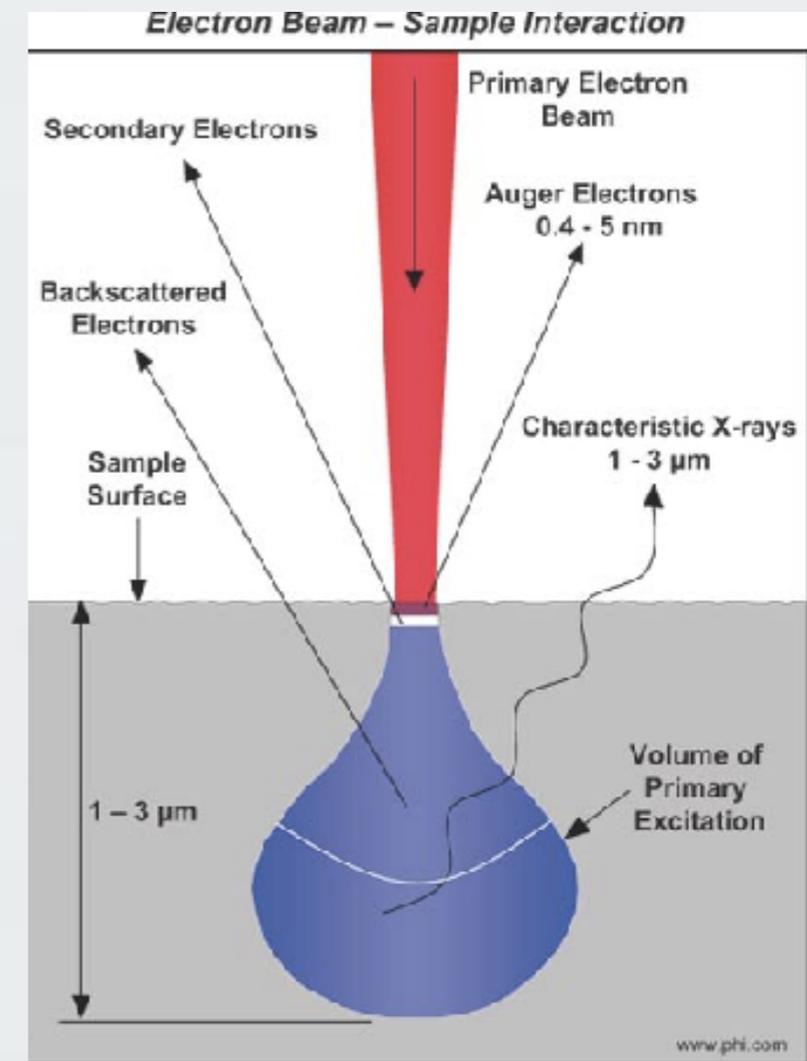
# EDS Spectra





# Guidelines for Identifying EDS Peaks

- EDS is not a surface measurement
  - signal comes from a  $\mu\text{m}$  depth within sample
  - Underlayers microns below the surface will contribute to EDS spectra
- Use multiple lines to identify any unexpected elements
- Beware of signal artifacts- double energy peak
- Use materials judgement: If an element really should not be present- it probably isn't there!





# Families of X-ray Lines

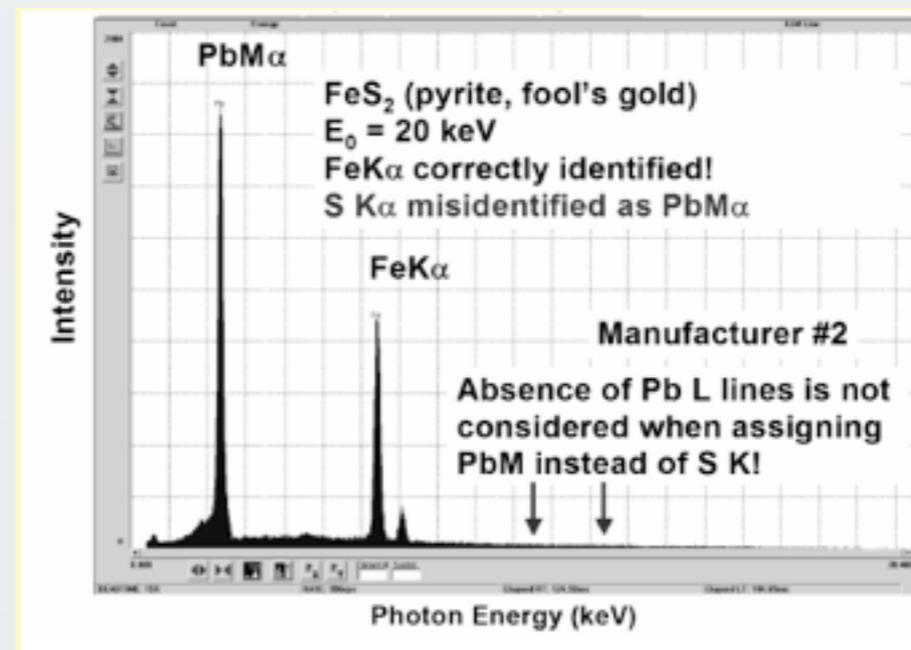
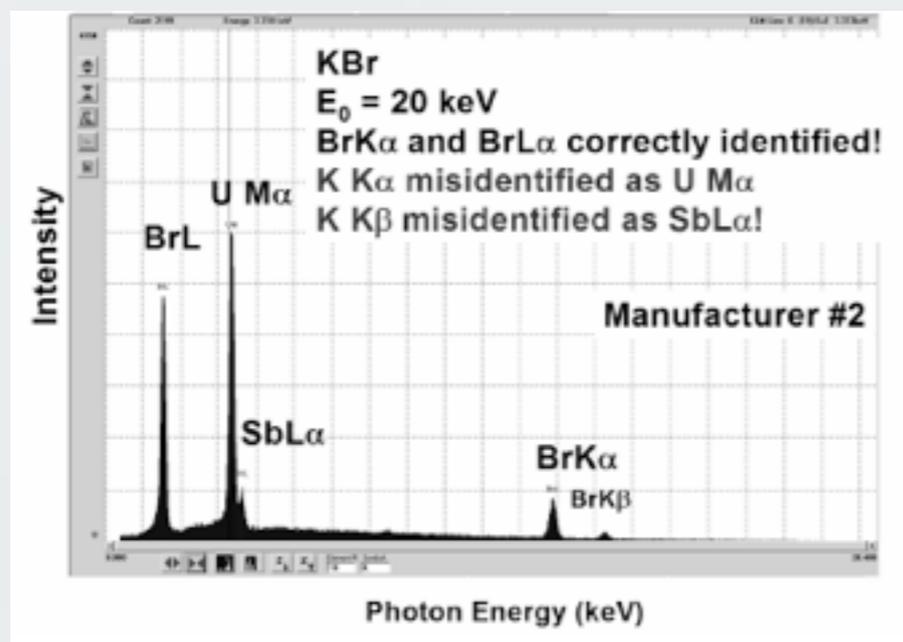
- Due to the probabilistic nature of X-ray transitions, when a  $K\alpha$  transition occurs, a  $K\beta$  will also occur at a different intensity (lower probability transition)
- The general relationship between transitions:
  - Ratio of  $K\alpha/K\beta = 10/1$
  - Ratio of  $L\alpha/L\beta_1/L\beta_2/L\gamma = 10/7/2/1$
  - Ratio of  $M\alpha/M\beta = 10/6$
- Look for accompanying family transitions to re-enforce element identification
- The whole family should be seen if not covered by other X-ray lines



# Multiple Peaks to Identify Unexpected Elements

Correct identification- Use Br  $K\alpha$  and  $K\beta$

In correct identification- Use Pb  $M\alpha$  but didn't consider absence of Pb L





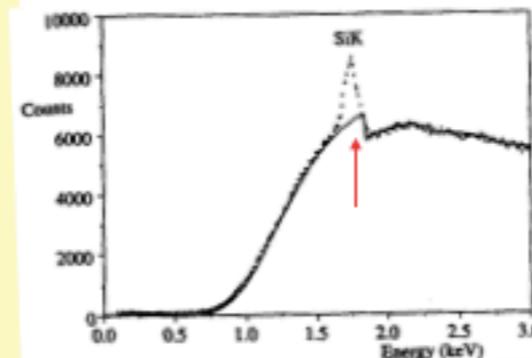
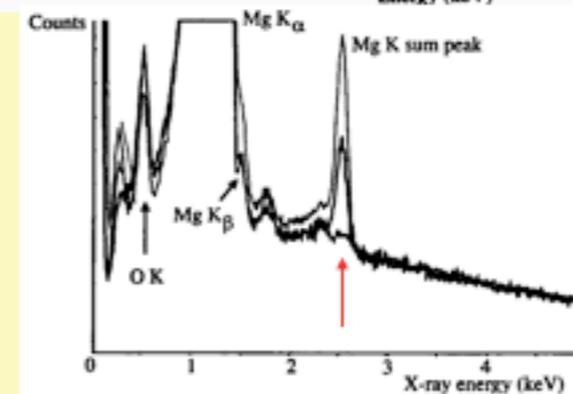
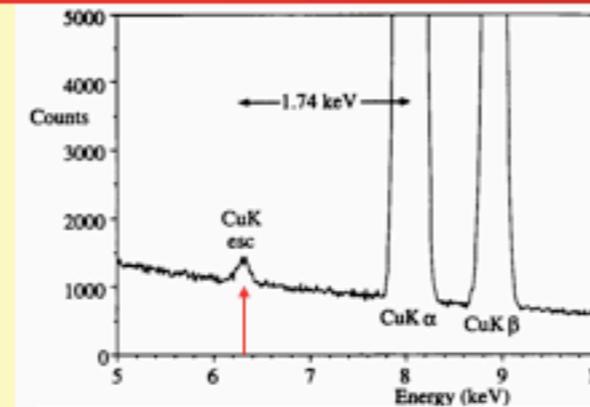
# EDS: Double Energy Peak

## Si "escape peaks"

- » Si Ka escapes the detector
- » Carrying 1.74 keV
- » Small peak ~ 1% of parent
- » Independent of count rate

## Sum peaks

- » Two photons of same energy enter detector simultaneously
- » Count of twice the energy
- » Only for high count rates



from Williams and Carter, *Transmission Electron Microscopy*, Springer, 1996

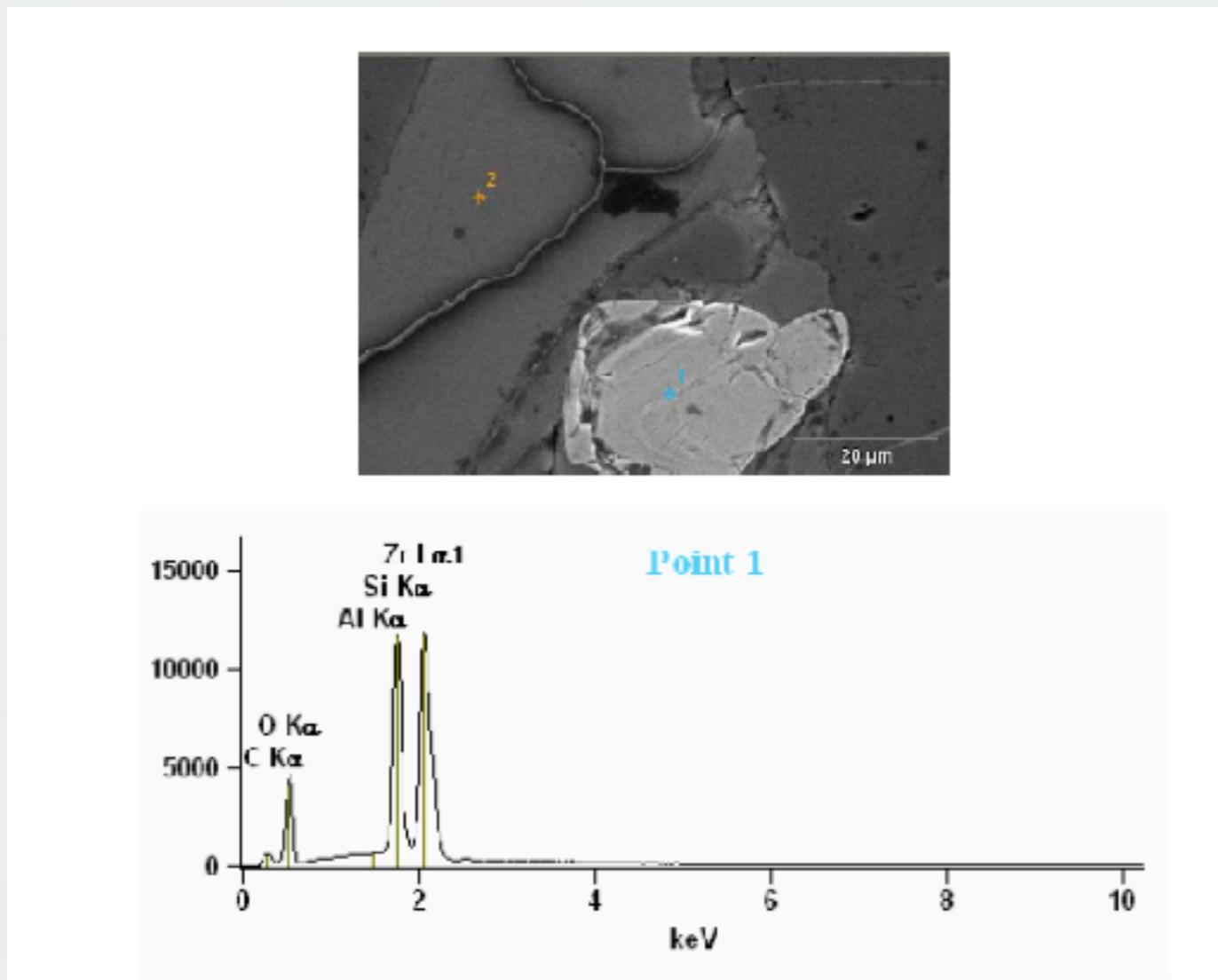


# EDS Elemental Identification Options

- Point scans
- Line scans
- Maps

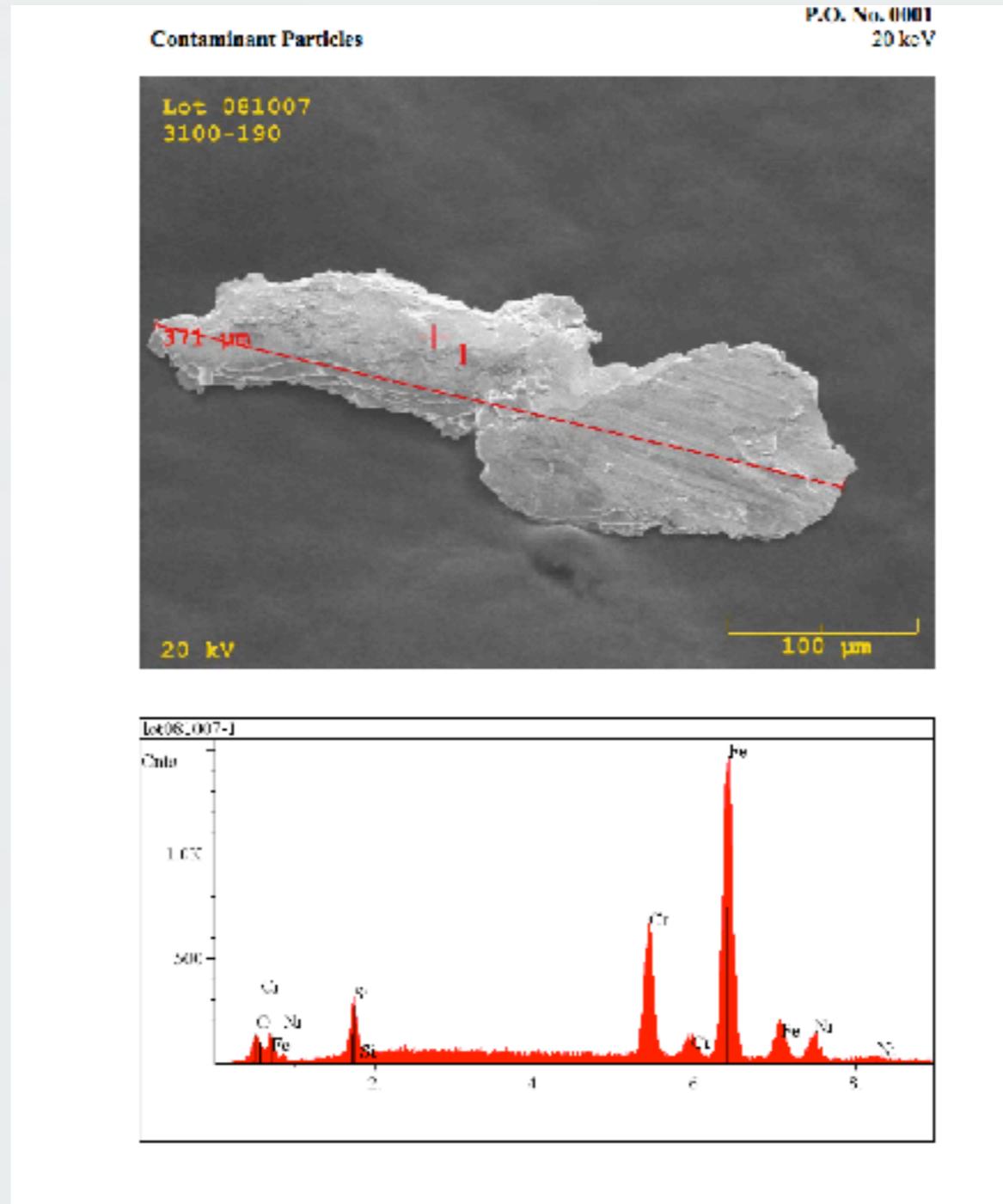


# Point Scan



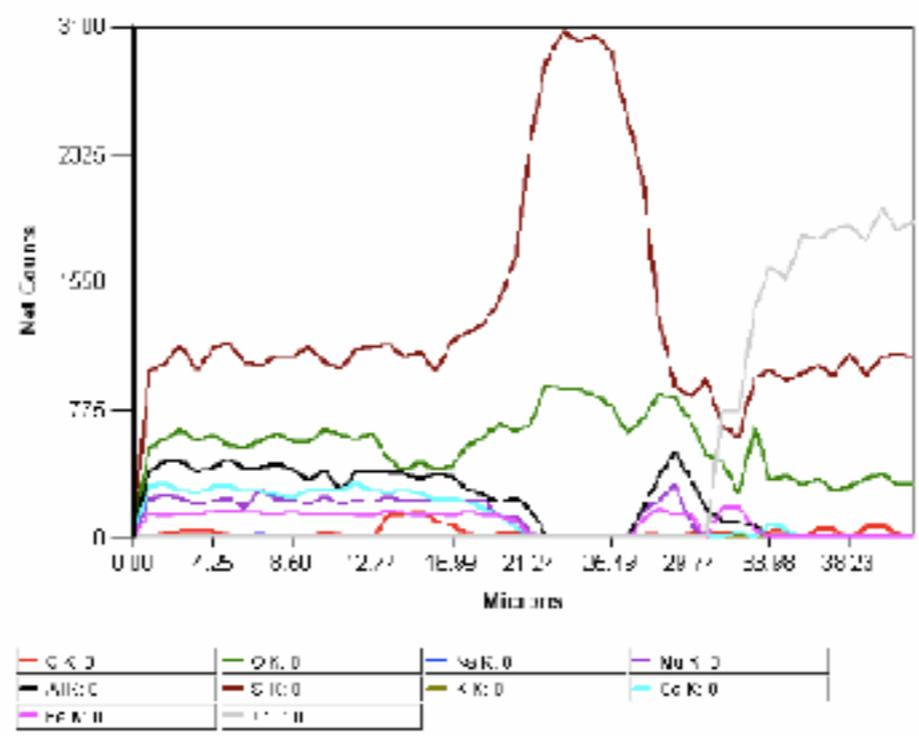
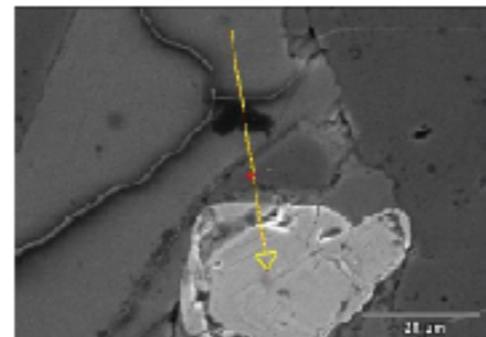


# Line Scan



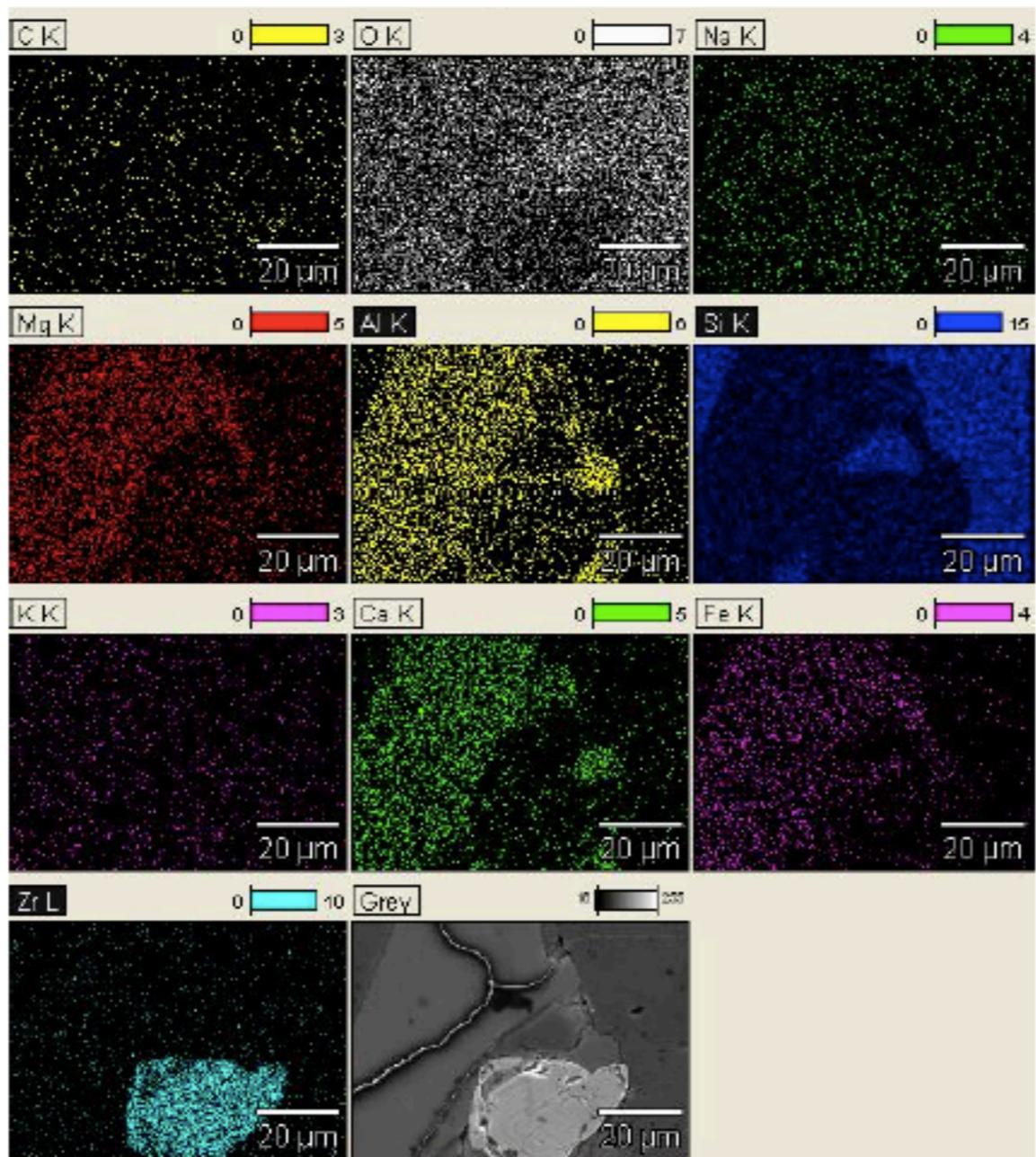


# Line Scan



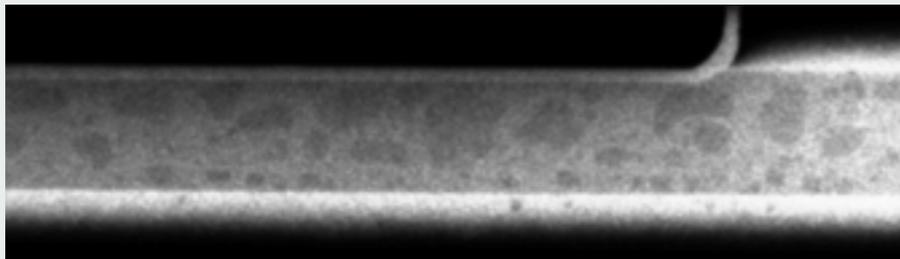


# Elemental Map

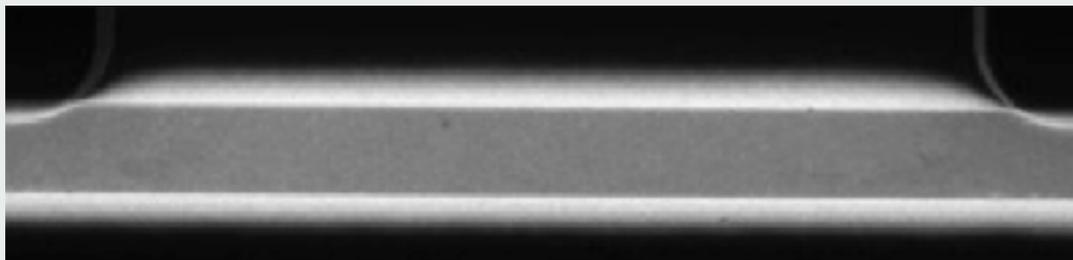




# X-ray Radiography



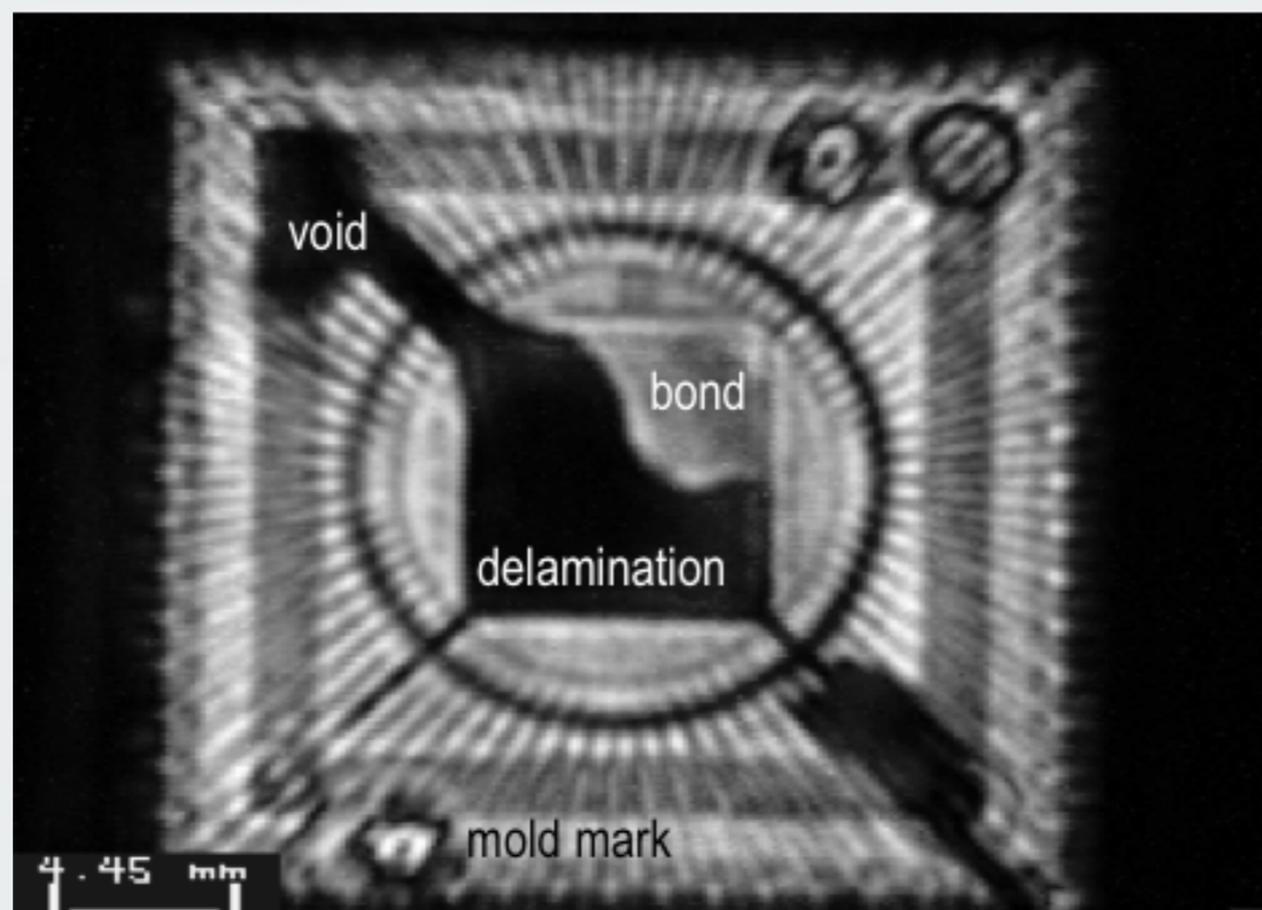
Original AuSn conditions- extensive voiding with voids on the order of 50% of the joint width



Lower temperature, no flux AuSn bonding with modified fixture geometry yielding void free AuSn structure



# Acoustic Microscopy



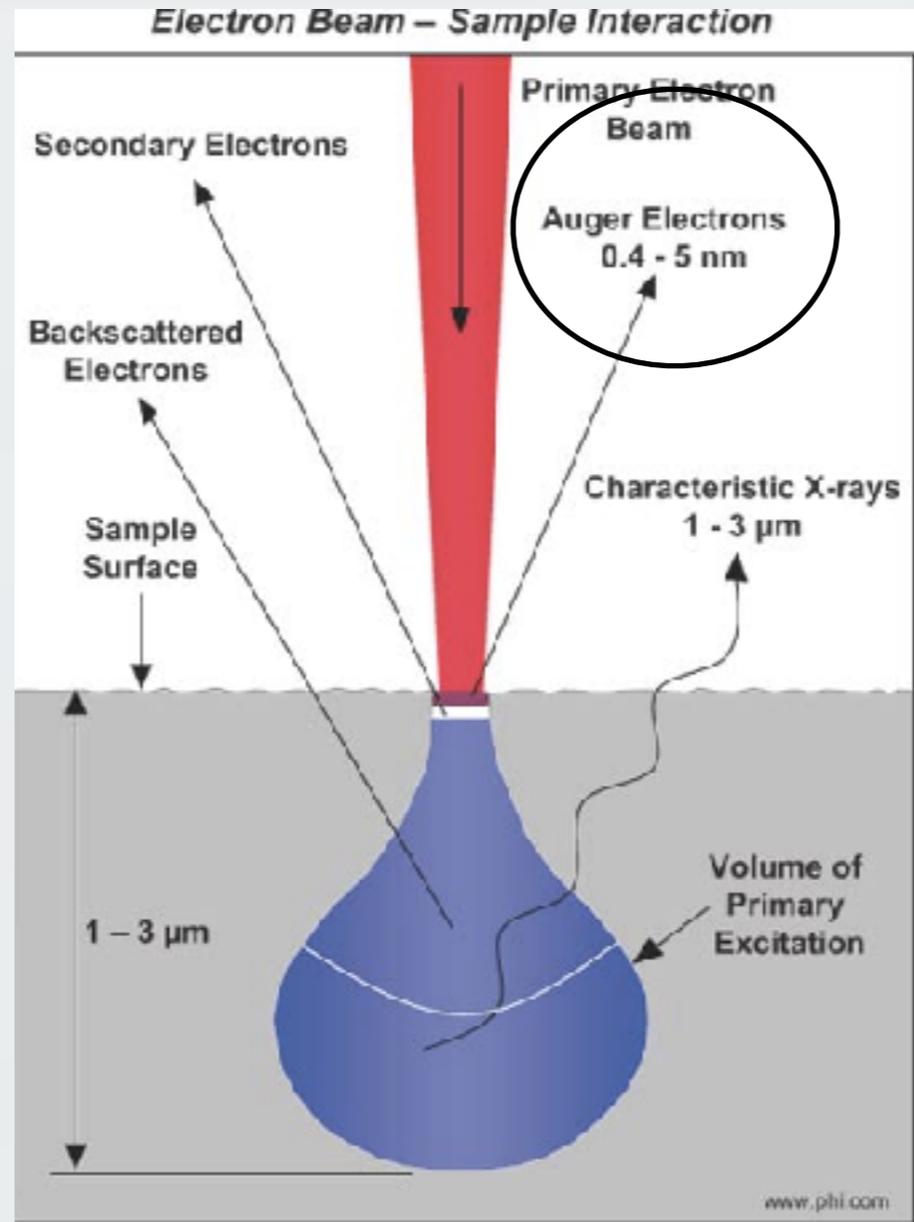


# Elemental Analysis

Analytical Technique	What is Measured	How it works
EDS (Energy Dispersive X-ray Spectroscopy)	The elemental composition of a region that is being imaged by the SEM.	As the SEM electron beam interacts with a sample, some atoms absorb the electron beam energy and promote electrons to an excited state. When these electrons relax, some will emit x-rays. The x-ray energy will correspond to energy levels of the excited atoms and can thus be used to identify the specific emitting element. The EDS detector measures the energy, location and intensity of these emitted x-rays.
AES (Auger Electron Spectroscopy)	Identification of surface atoms with high spatial resolution (10nm). Very useful for identifying the composition of surface features. Sensitive to a very wide range of elements.	A high energy electron beam scans across the sample surface and excites electrons in surface atoms. When these excited atoms relax, the energy of relaxation is sometimes transmitted to neighboring electrons which can be emitted from the sample. These are the so-called Auger electrons. The energy of these "Auger" electrons reflects the energy level of the originally excited atom and can thus be used to identify the specific atomic species.
SIMS (Secondary Ion Mass Spectroscopy)	Low concentration of dopants (semiconductor) or impurities as a function of depth. Used for semiconductor dopant profiles. Also C, O, N.	Primary beam sputters into the surface. Secondary ions that are sputtered off the surface are identified with a mass spectrometer.
RBS (Rutherford Backscattering)	Quantitative elemental analysis without requiring standards.	High energy He <sup>++</sup> ions are scattered projected at the sample and scatter off surface atoms. The scattering angle is measured. Since the scattering cross section for He <sup>++</sup> is different for different materials, the angle can be used to identify the element that scattered the He <sup>++</sup> ion.

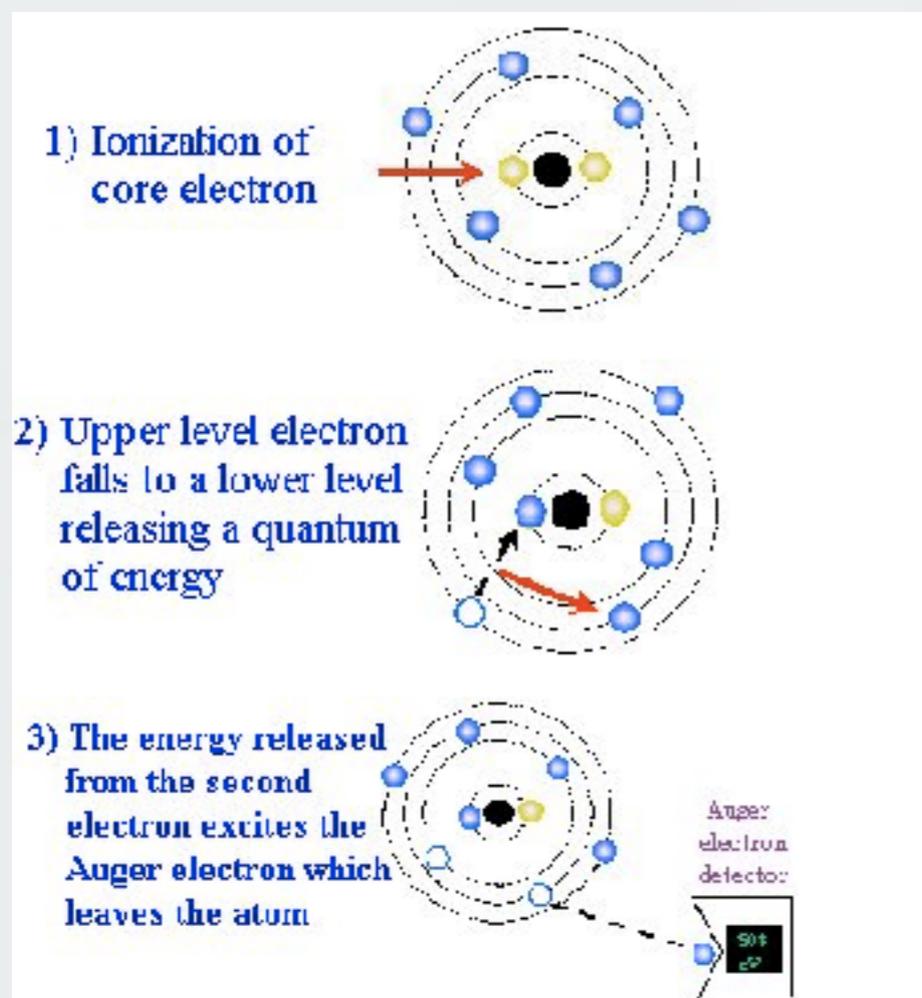


# Auger Electron Spectroscopy





# Auger Electron Generation



Auger Spectroscopy is a method used to determine the composition of the surface layers of a sample. There are three steps:

- 1) atom is ionized by removing a core electron,
- 2) upper level electron falls to lower level,
- 3) third electron (Auger electron) is excited by the energy given off in step 2 and detected

The atom is left with two vacancies.

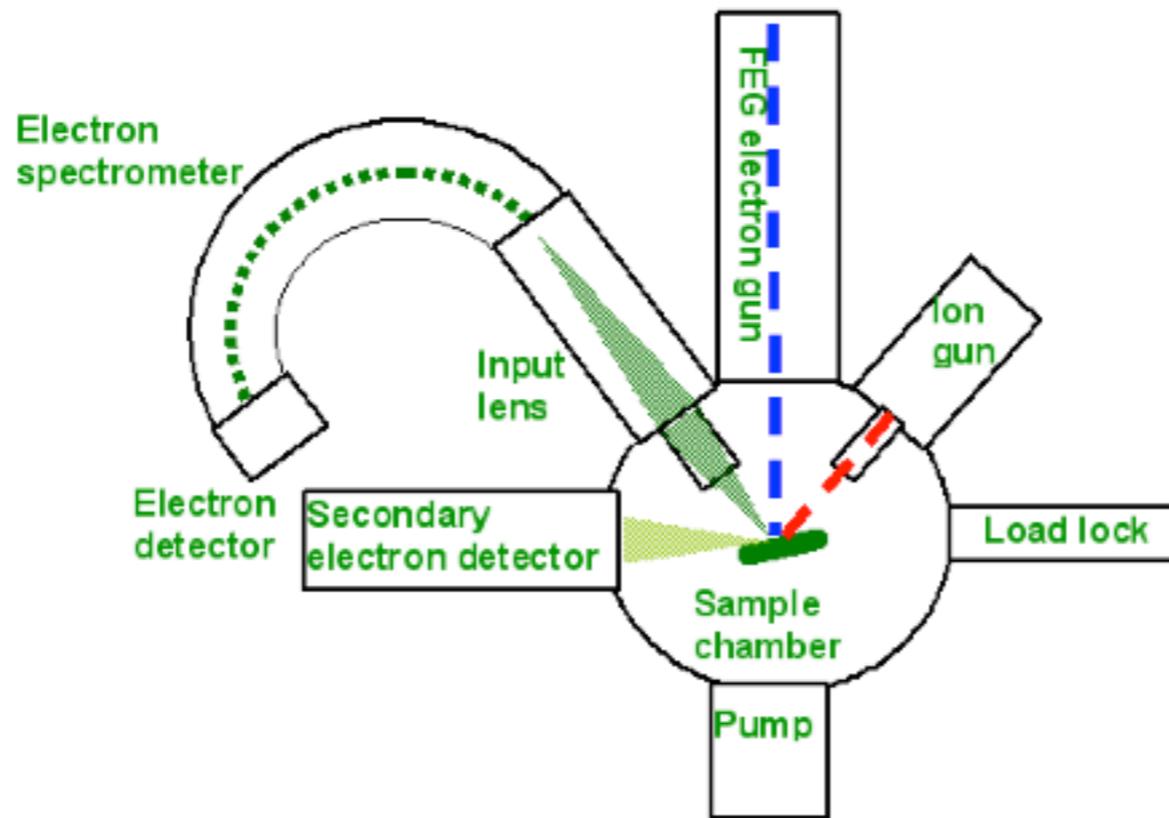
#### Key

-  energy
-  electron (originally K-shell)
-  electron (originally L-shell)



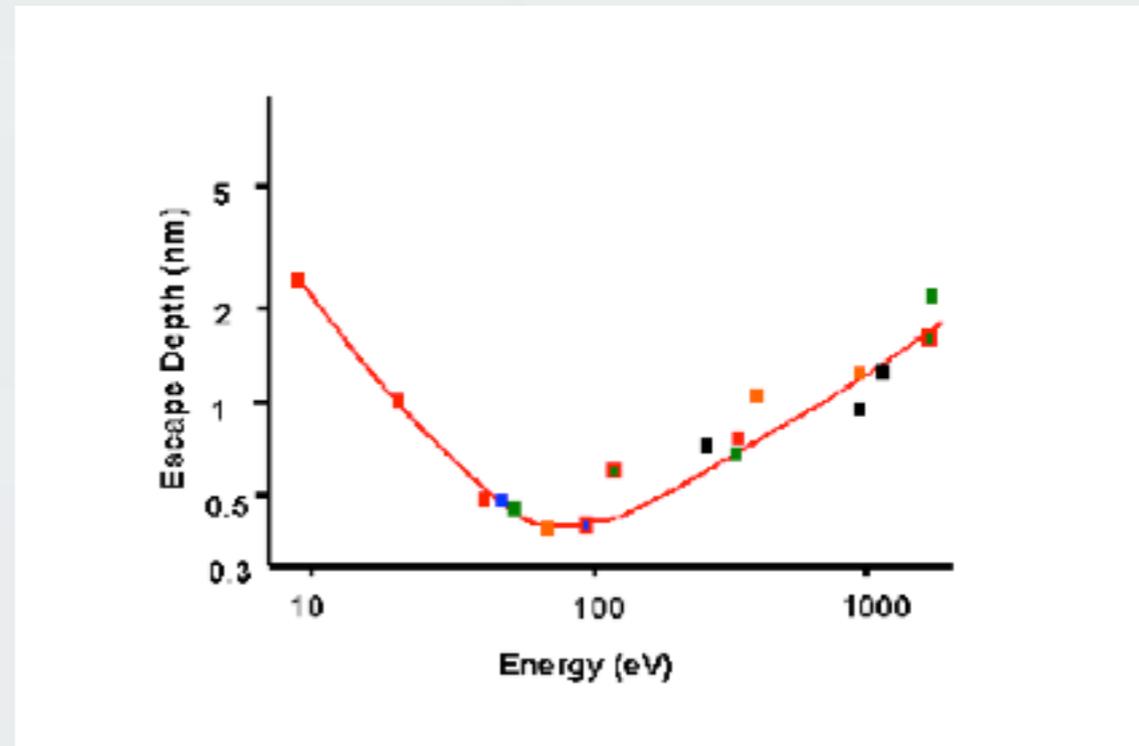
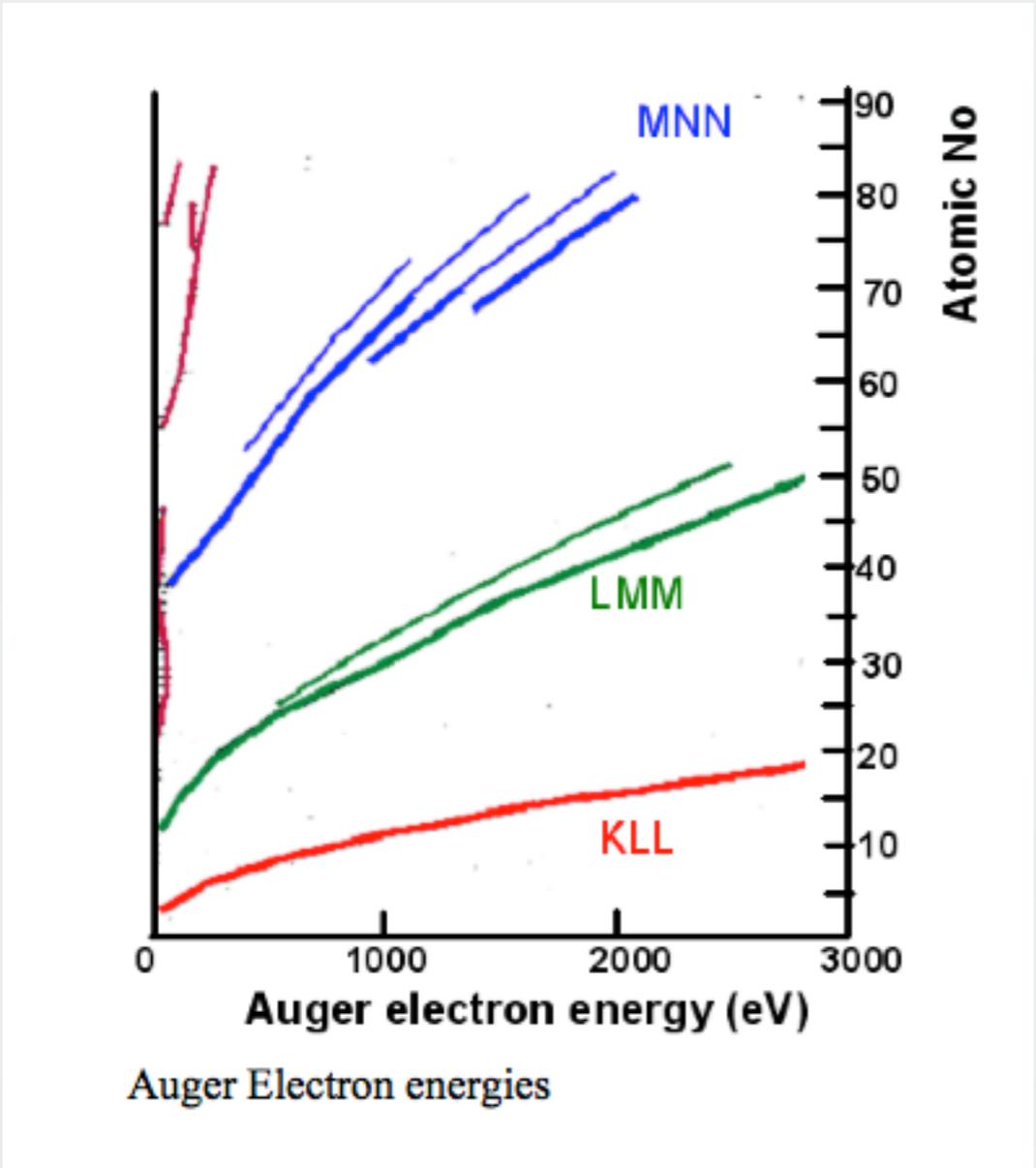
# Auger Spectrometer- Similar to SEM

**Schematic of Auger analysis system**





# Auger Electron Spectroscopy

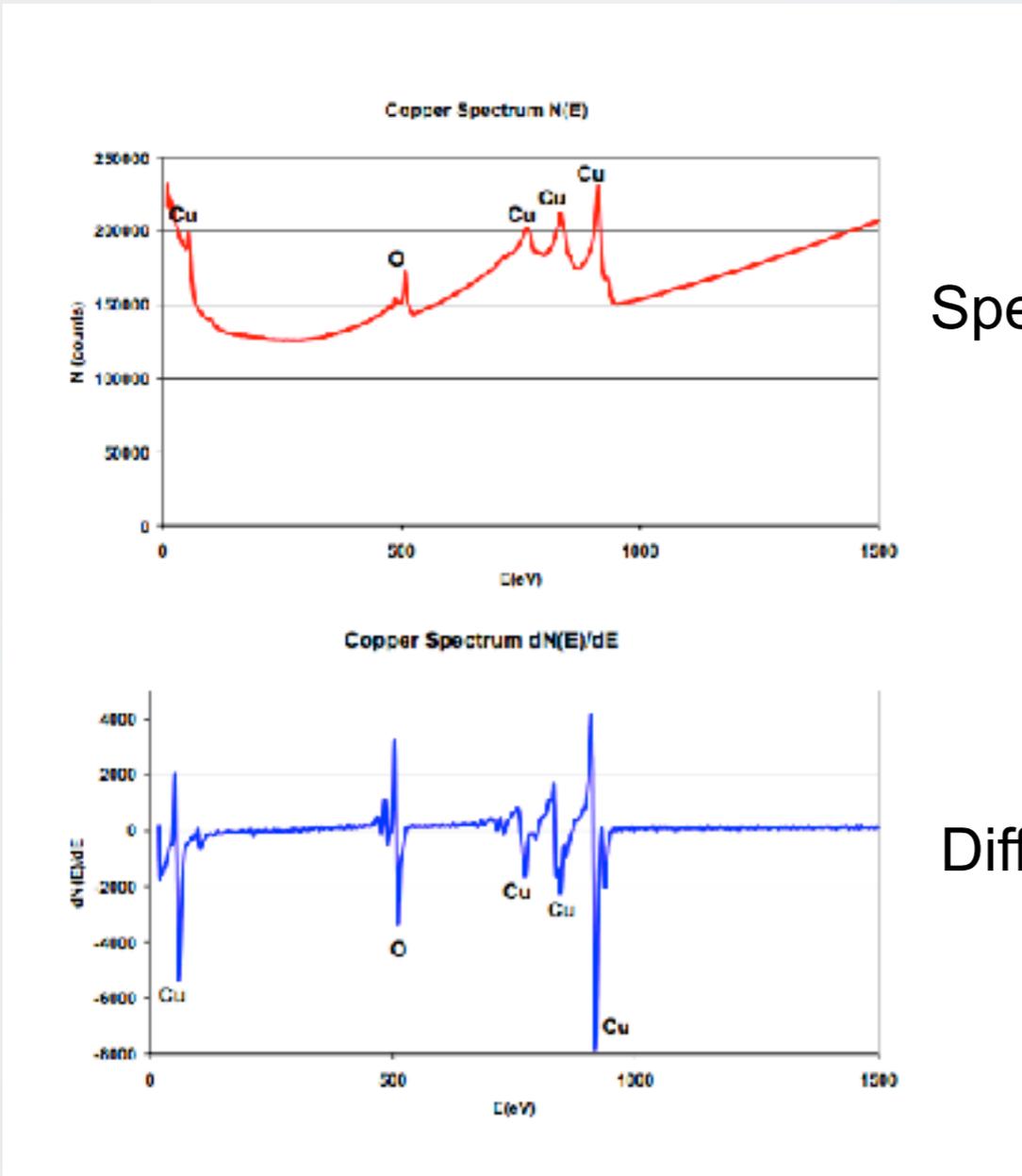


Auger is highly surface specific

Auger Electron Energies specific to atom



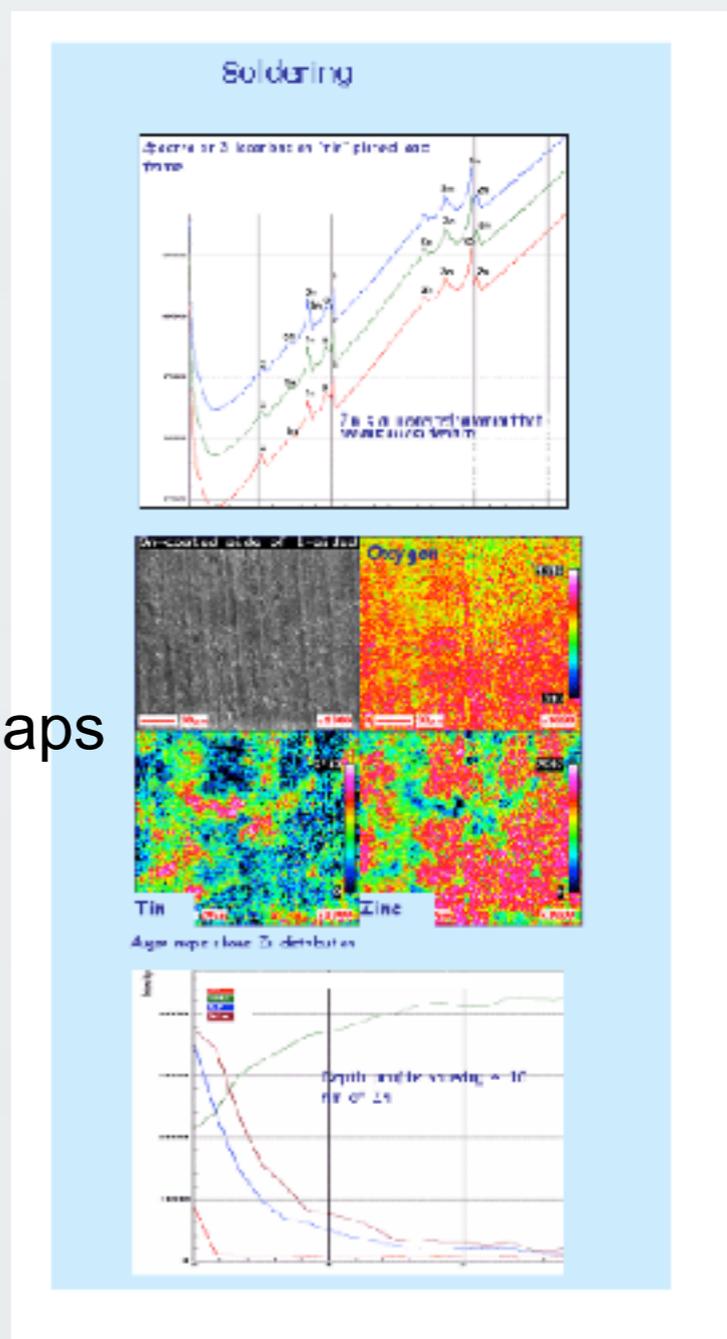
# Auger Spectra



Spectra

Differential of Spectra

Elemental Maps



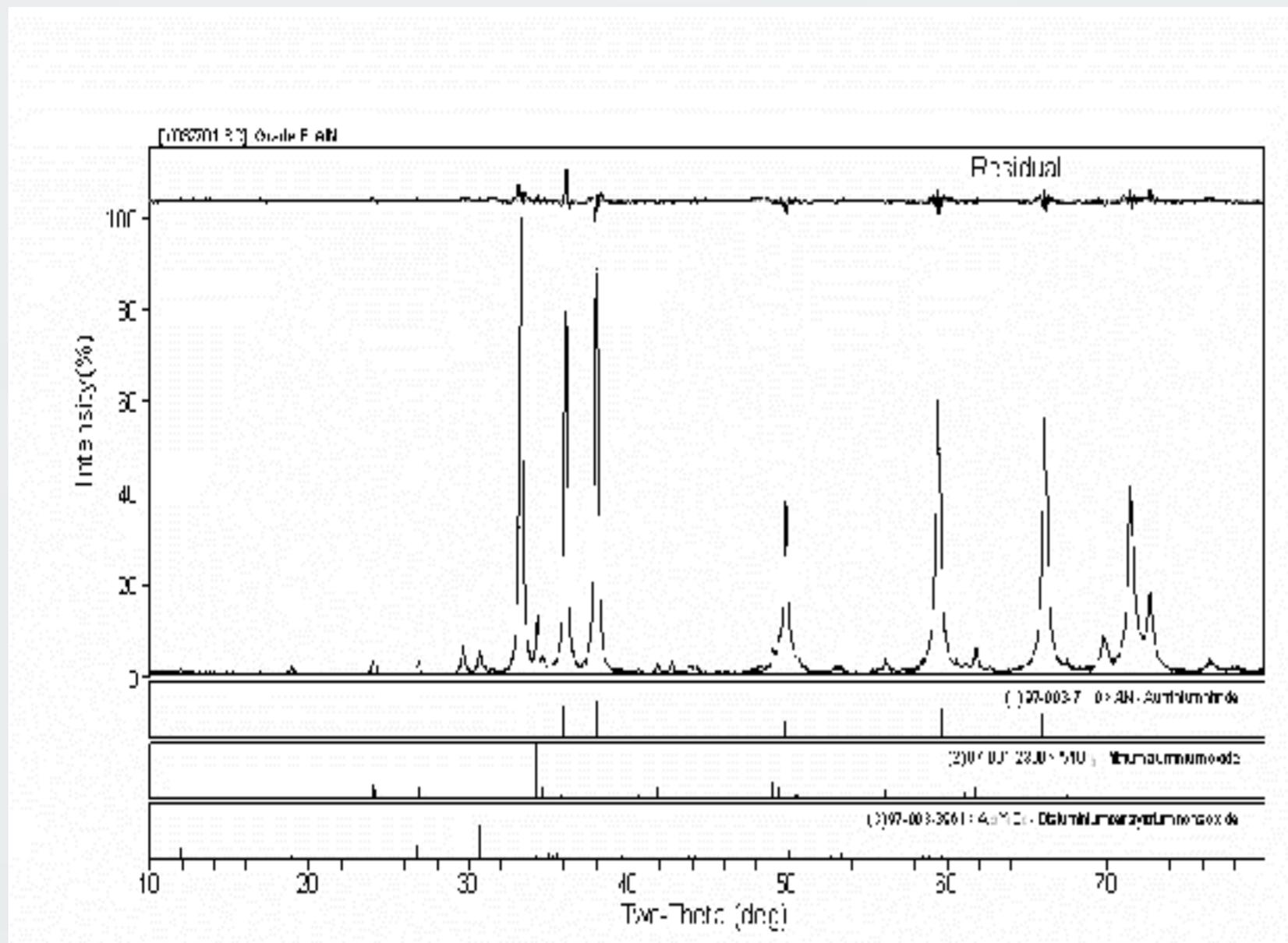


# Chemical Bonding and Structure

Analytical Technique	What is Measured	How it works
XRD (X-ray Diffraction)	Interatomic spacing within a crystallite. Used to identify unknown materials by comparing to known crystal structure. Can identify specific compounds. This is a bulk measurement.	X-rays are incident on sample which is in powder form. The X-ray diffract from the crystal structure at specific angle depending on the interatomic spacing. The diffractometer collects X-ray intensity versus angle.
FTIR (Fourier Transform Infra-red Spectroscopy)	Intra-red absorption characteristics of a material. Very useful for identifying specific polymer compositions by comparing IR absorption to known absorption spectra. Can also be used to identify groups of atoms bonded together by their characteristic vibrational frequencies.	
XPS (X-ray Photo-emission Spectroscopy)	Chemical state information on detected elements. Quantitative analysis of composition as well as information on the type of bonding (oxidation state)	X-rays are incident on sample. Photo-electrons are emitted and their energy is measured. Photo-electron energy is signature of specific element and its chemical oxidation state.



# X-ray Diffraction

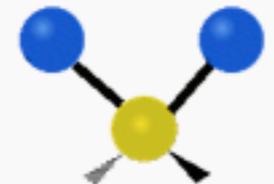
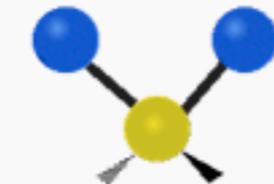
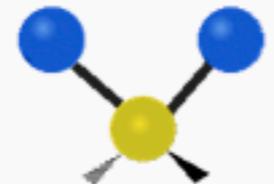
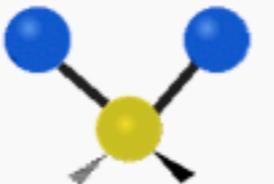
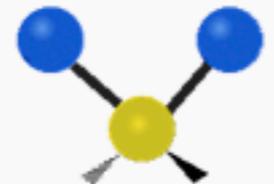
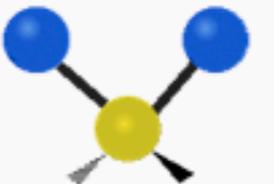


X-ray diffraction shows that the compound AlN is present, not just Al and N atoms. Identifies the specific crystal phase.

AlN Peak Locations  
YAP second phase  
YAM second phase



# IR Absorption Spectroscopy (FTIR)

Symmetrical stretching	Antisymmetrical stretching	Scissoring	Rocking	Wagging	Twisting
					

- Each different vibration mode occurs at a different frequency
- Frequency depends on specific atoms and surrounding atoms
- IR energy is absorbed when  $E_{IR} = E_{vibration\ mode}$
- Organic compounds have many different vibration modes (degrees of freedom)
- The vibration spectrum can be used to identify specific organic compounds or polymers by looking at all of the constituent vibration energies
- Usually the FTIR spectra is compared to know spectra to make the identification



Attenuated Total Reflectance (ATR) can be used to enhance the FTIR signal by increasing the absorption path length



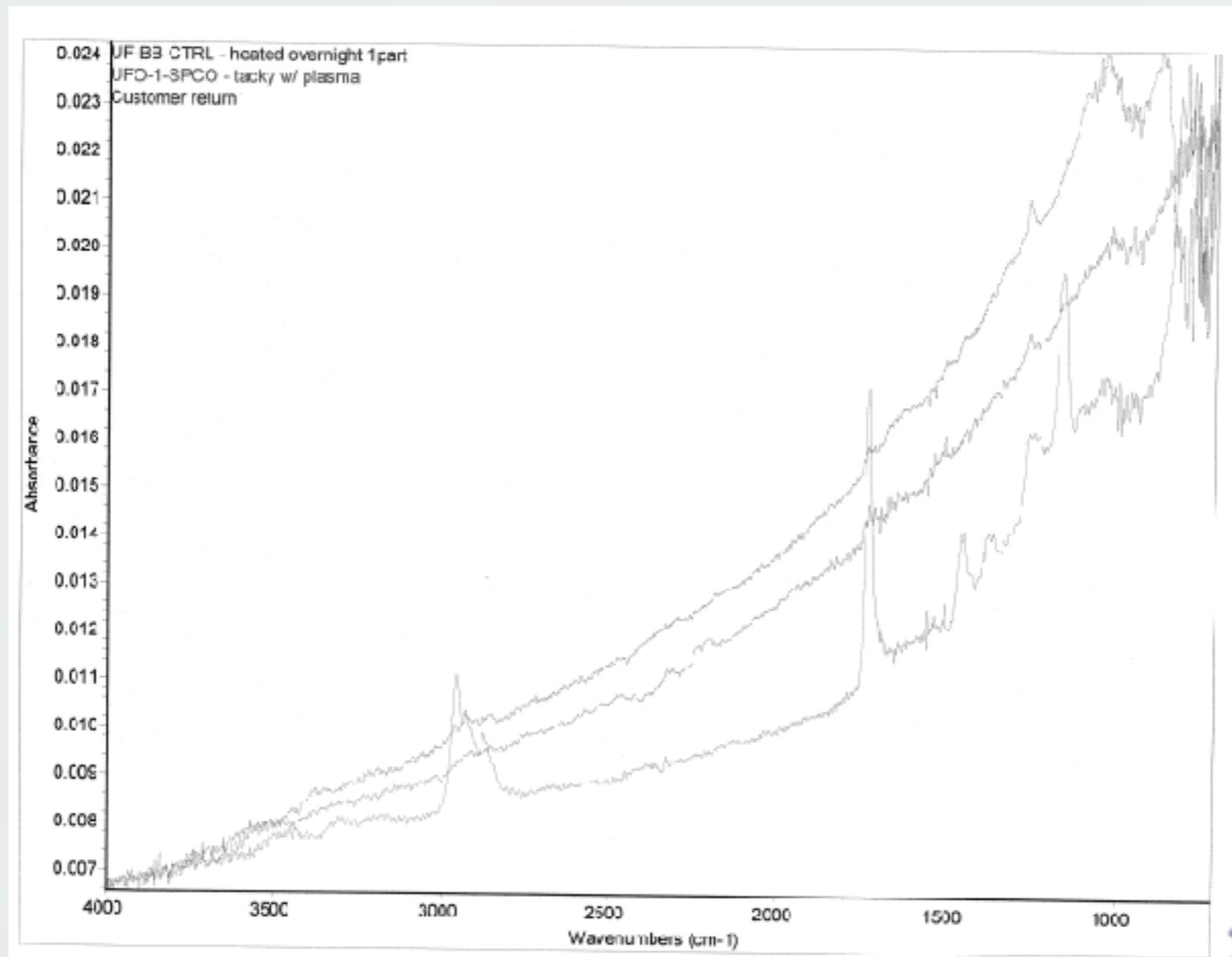
# FTIR Spectra

C—C	acyclic C—C	monosub. alkenes	1645 cm <sup>-1</sup>
		1,1-disub. alkenes	1655 cm <sup>-1</sup>
		cis-1,2-disub. alkenes	1660 cm <sup>-1</sup>
		trans-1,2-disub. alkenes	1675 cm <sup>-1</sup>
		trisub., tetrasub. alkenes	1670 cm <sup>-1</sup>
	conjugated C—C	dienes	1600 cm <sup>-1</sup>
	with benzene ring		1650 cm <sup>-1</sup>
	with C=O		1625 cm <sup>-1</sup>
	C=C (both sp <sup>2</sup> )		1600 cm <sup>-1</sup>
	aromatic C=C	any	1640–1680 cm <sup>-1</sup>
aromatic C=C	any	1450 cm <sup>-1</sup>	
		1500 cm <sup>-1</sup>	
		1580 cm <sup>-1</sup>	
		1600 cm <sup>-1</sup>	
C≡C	terminal alkynes	2100–2140 cm <sup>-1</sup>	
	disubst. alkynes	2190–2260 cm <sup>-1</sup>	

C=O	aldehyde/ketone	saturated aliph./cyclic 6-membered	1720 cm <sup>-1</sup>	
		α,β-unsaturated	1685 cm <sup>-1</sup>	
		aromatic ketones	1665 cm <sup>-1</sup>	
		cyclic 5-membered	1750 cm <sup>-1</sup>	
		cyclic 4-membered	1775 cm <sup>-1</sup>	
	carboxylic acids/derivates	aldehydes	1725 cm <sup>-1</sup>	
		saturated carboxylic acids	1710 cm <sup>-1</sup>	
			unsat./aromatic carb. acids	1680–1690 cm <sup>-1</sup>
			esters and lactones	1735 cm <sup>-1</sup>
		anhydrides	1760 cm <sup>-1</sup>	
acyl halides		1820 cm <sup>-1</sup>		
amides		1650 cm <sup>-1</sup>		
carboxylates (salts)		1550–1610 cm <sup>-1</sup>		
amino acid zwitterions		1550–1610 cm <sup>-1</sup>		
O—H		alcohols, phenols	low concentration	3610–3670 cm <sup>-1</sup>
	high concentration		3200–3400 cm <sup>-1</sup>	
	carboxylic acids	low concentration	3600–3650 cm <sup>-1</sup>	
		high concentration	3300 cm <sup>-1</sup>	
N—H	primary amines	any	3400–3600 cm <sup>-1</sup>	
	secondary amines	any	1580–1640 cm <sup>-1</sup>	
	ammonium ions	any	>3000 cm <sup>-1</sup>	
C—O	alcohols	primary	1040–1060 cm <sup>-1</sup>	
		secondary	~1100 cm <sup>-1</sup>	
		tertiary	1150–1200 cm <sup>-1</sup>	
	phenols	any	1200 cm <sup>-1</sup>	
	ethers	aliphatic	1120 cm <sup>-1</sup>	
		aromatic	1220–1260 cm <sup>-1</sup>	
	carboxylic acids	any	1250–1300 cm <sup>-1</sup>	
	esters	any	1100–1300 cm <sup>-1</sup>	

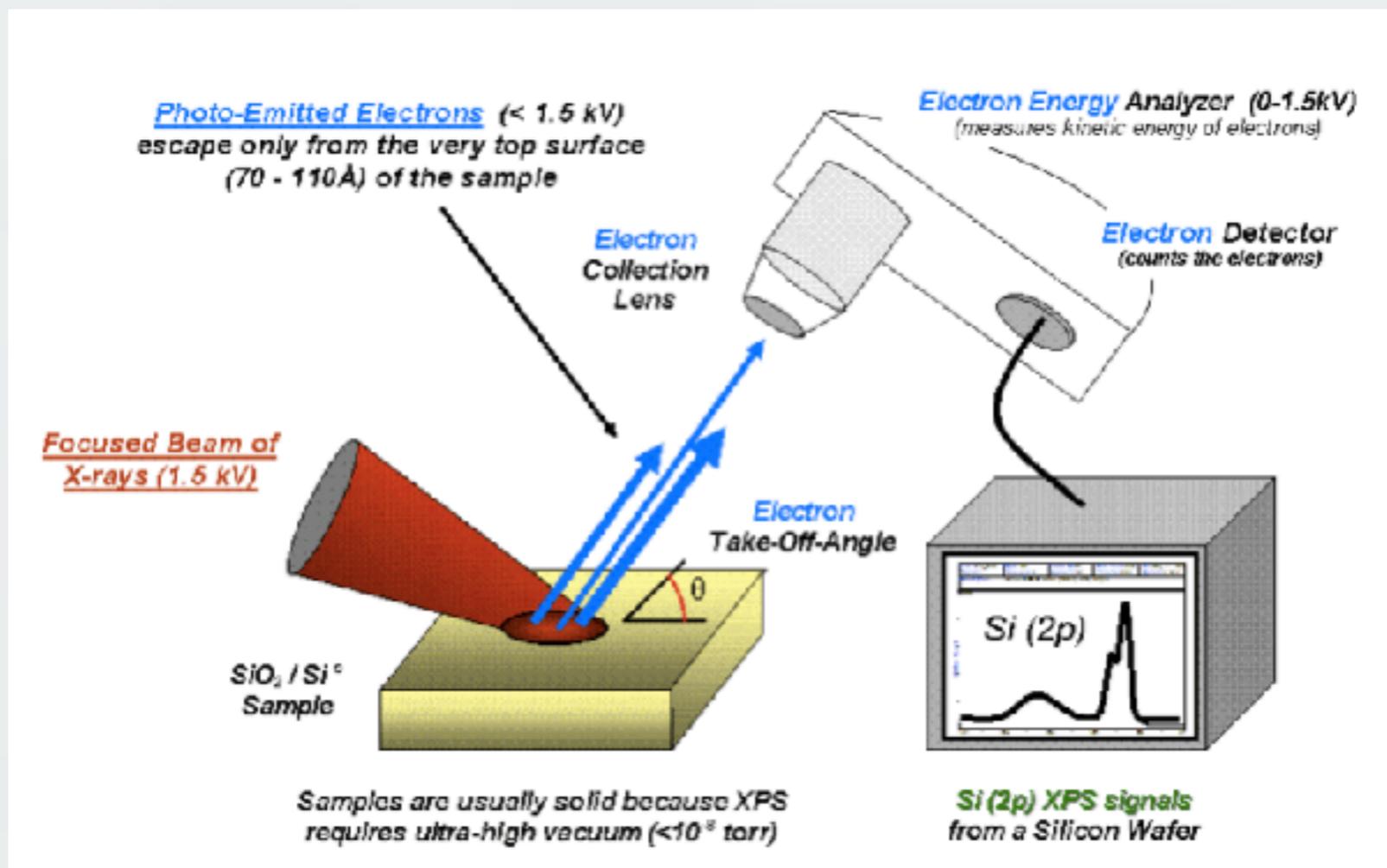


# FTIR Spectra of Silicone



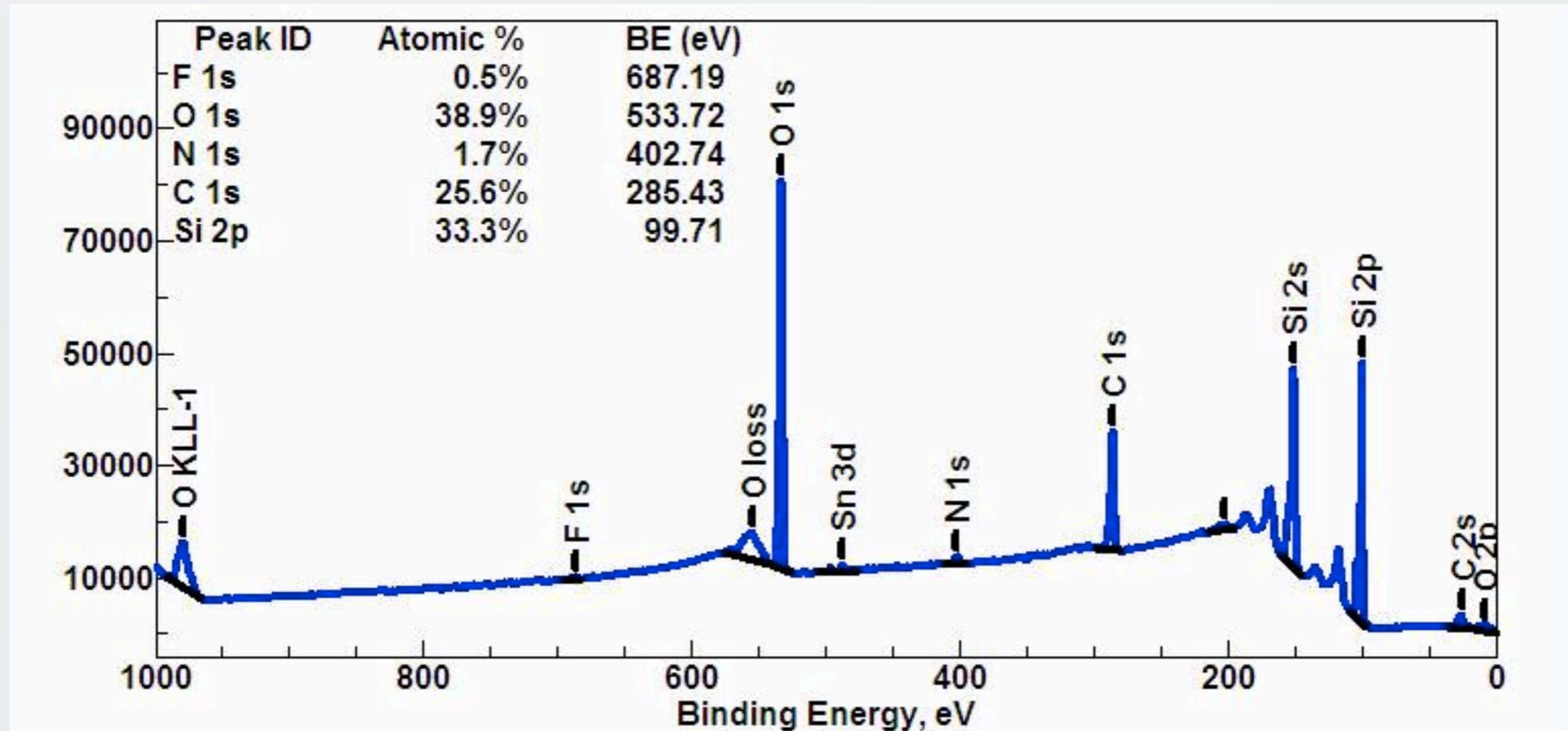


# Schematic of XPS System





# XPS



Electron binding energy reflects the element and the electron orbital where it originates. This gives elemental information and oxidation state of element.



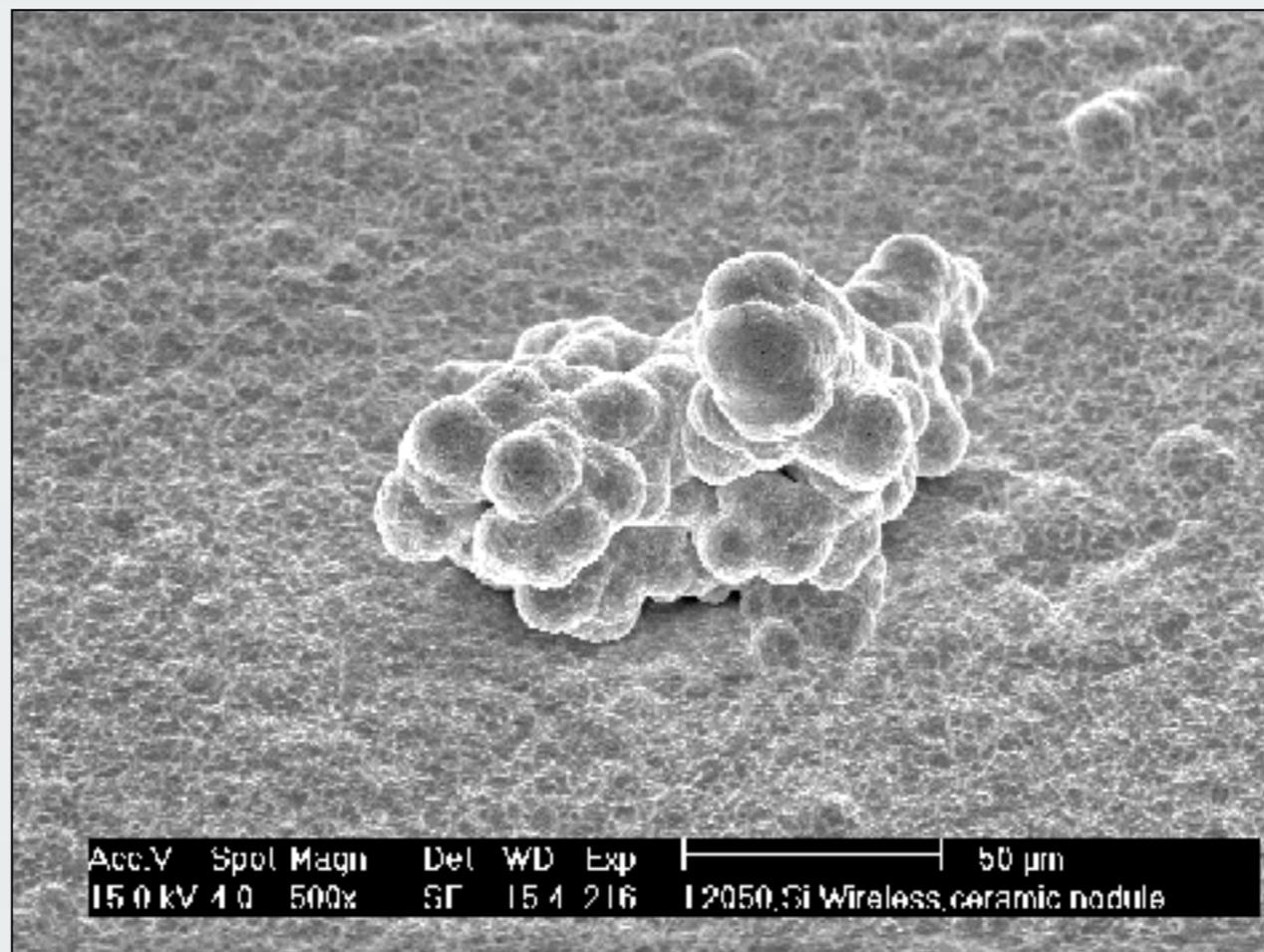
# Examples of Failure Analysis



# SEM/EDS

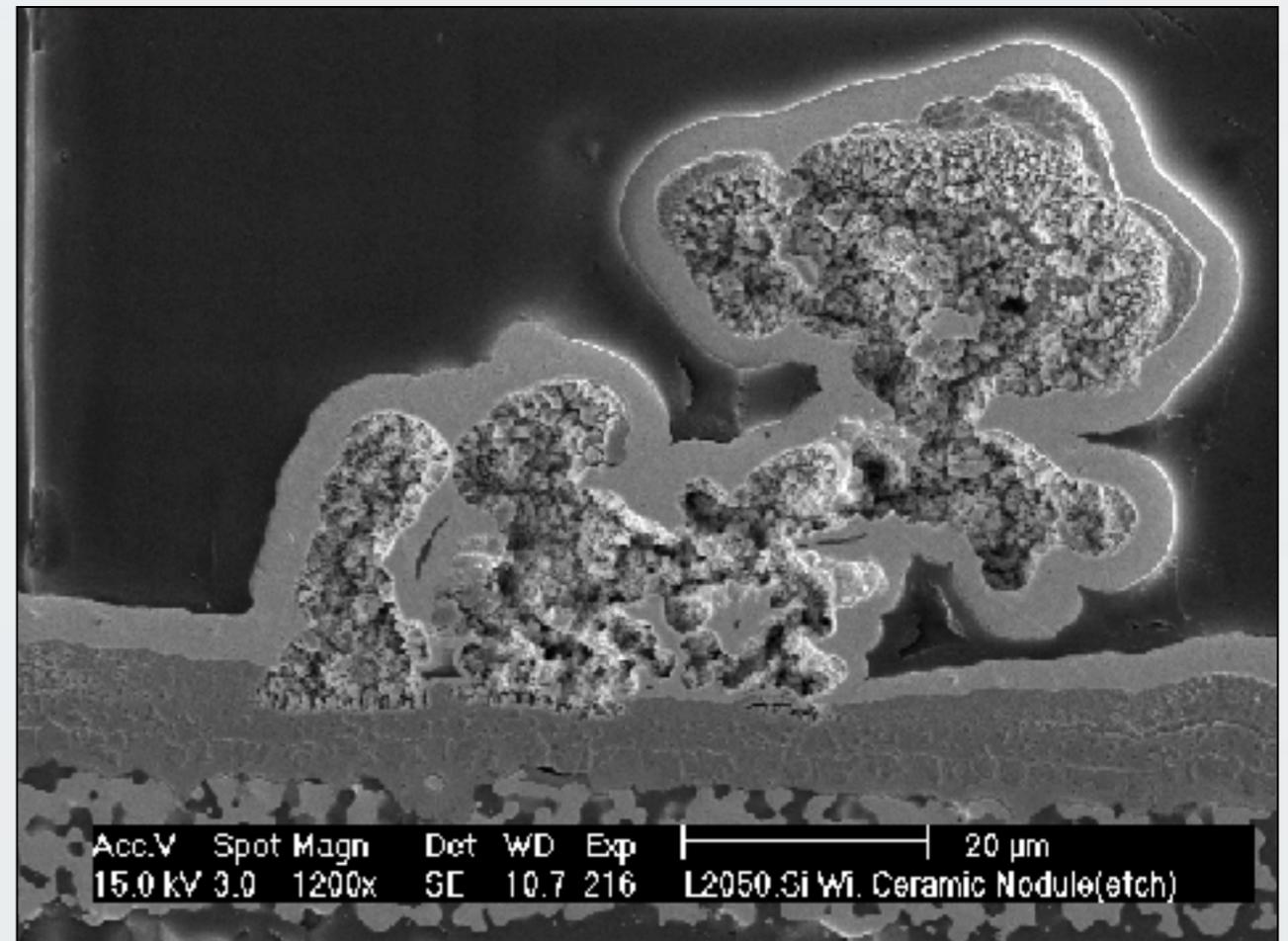


# Nodules Defect





- Nodules form when foreign material in the plating bath plate up with thick metal
- Original foreign “seed” can be very small
- Cross section can identify the foreign particle
- In this case, small metal flakes were present that were from the sputter chamber





# Nodules on Au Plated DPC Substrates



# Contamination



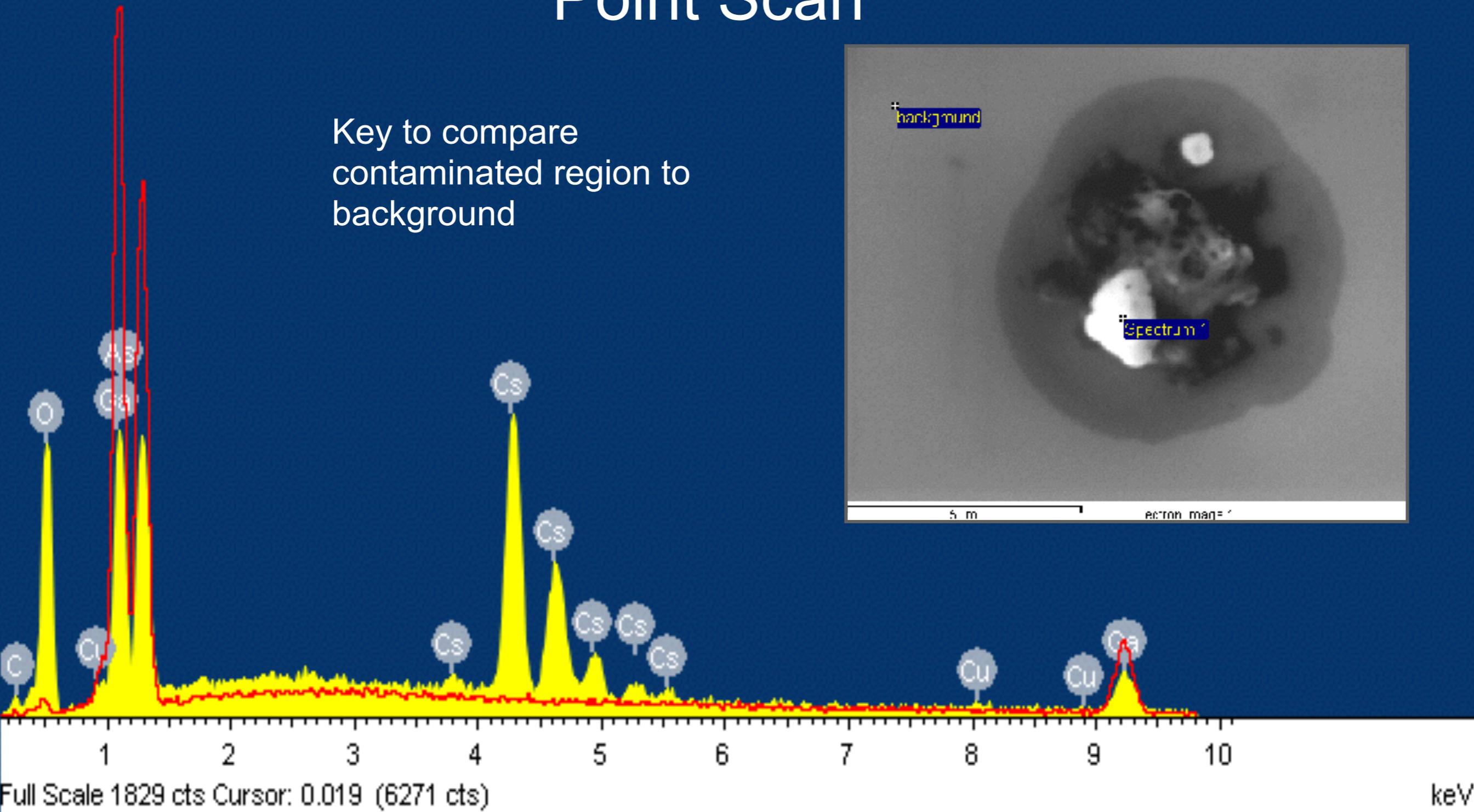
# Contamination on GaAs Devices

- Issues with wirebonding GaAs device
- SEM analysis showed presence of foreign material on surface
- EDS used to identify the impurity
- Traced to production step



# Contamination on GaAs Analyzed with EDS Spectrum 1 Point Scan background

Key to compare  
contaminated region to  
background





## AuSn Oxidation

- Poor wetting observed on backside of AuSn submount
- Area of discoloration observed in optical microscope and SEM
- EDS comparison of discolored and non-discolored areas showed increased oxygen
- Good example of where EDS can be used to analyze for oxygen

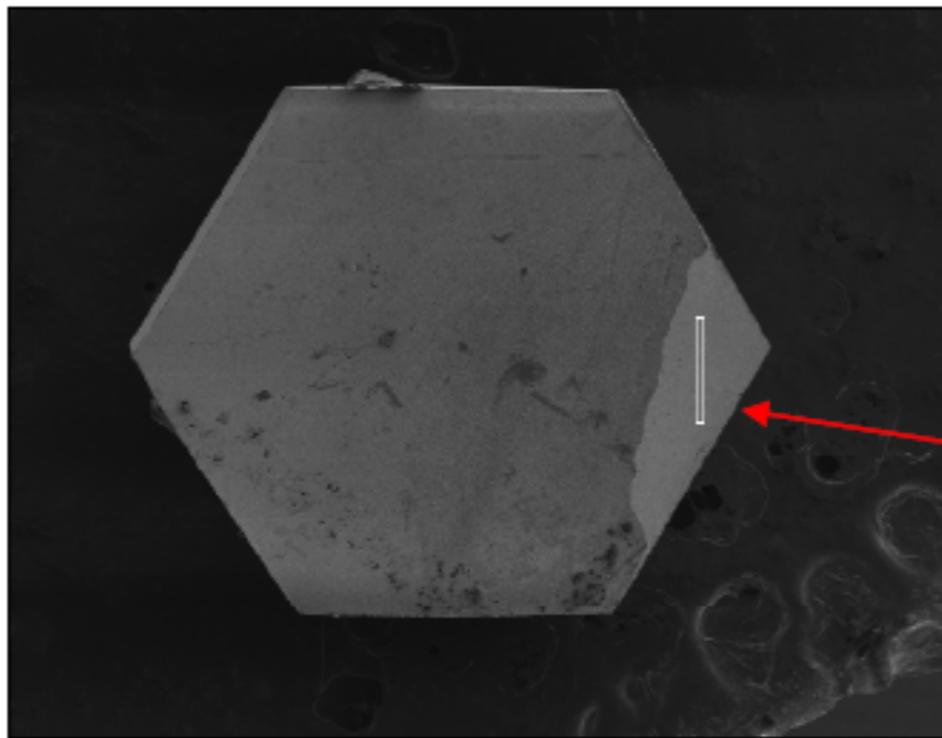
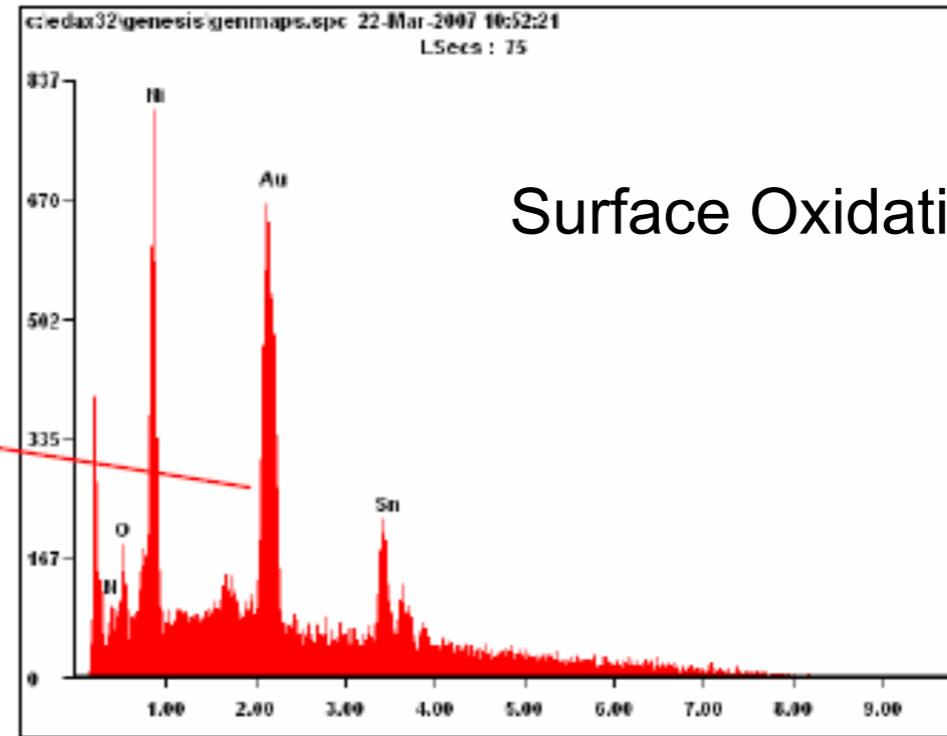
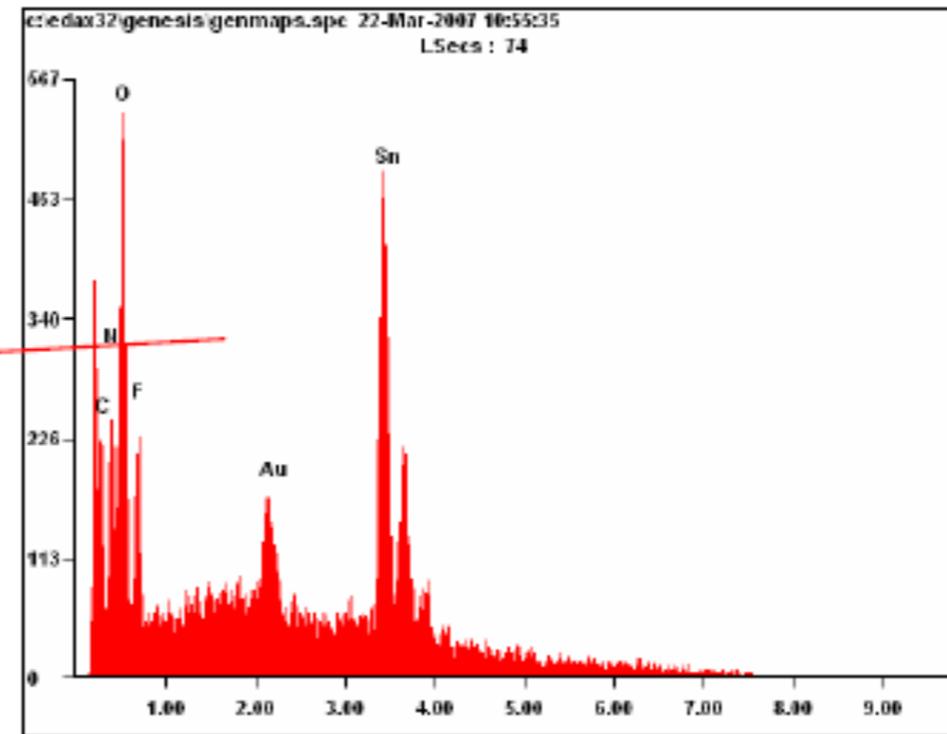
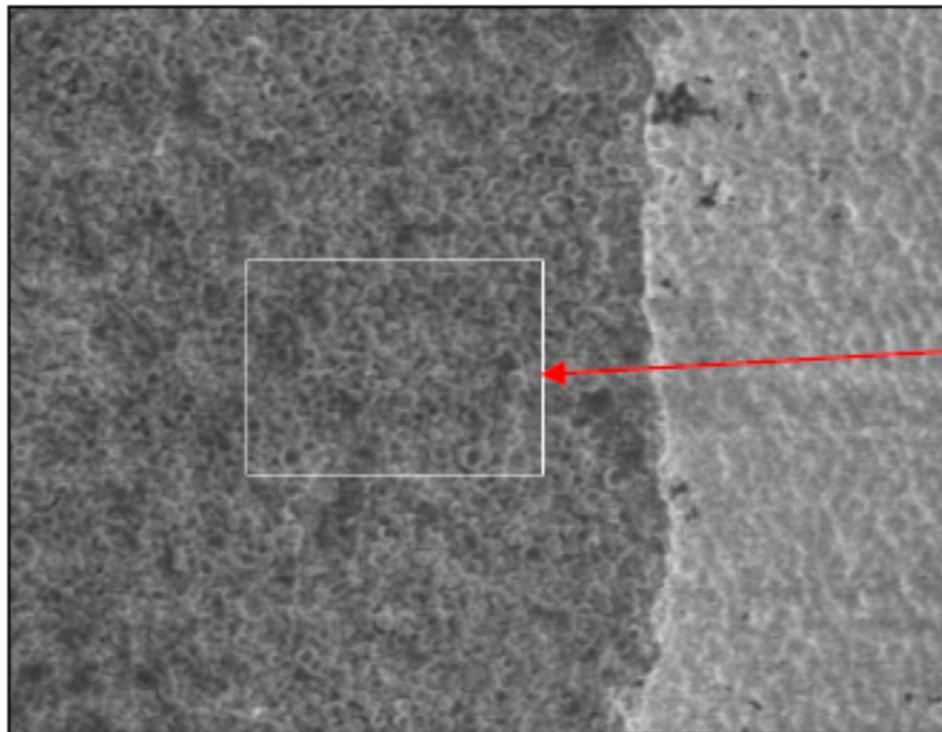


Fig 14 SEM image at 40 x – discoloration



Surface Oxidation of AuSn

Fig 15 EDX on pointed area – Au, Sn, Ni, O





# Cracks, Voids and Blisters

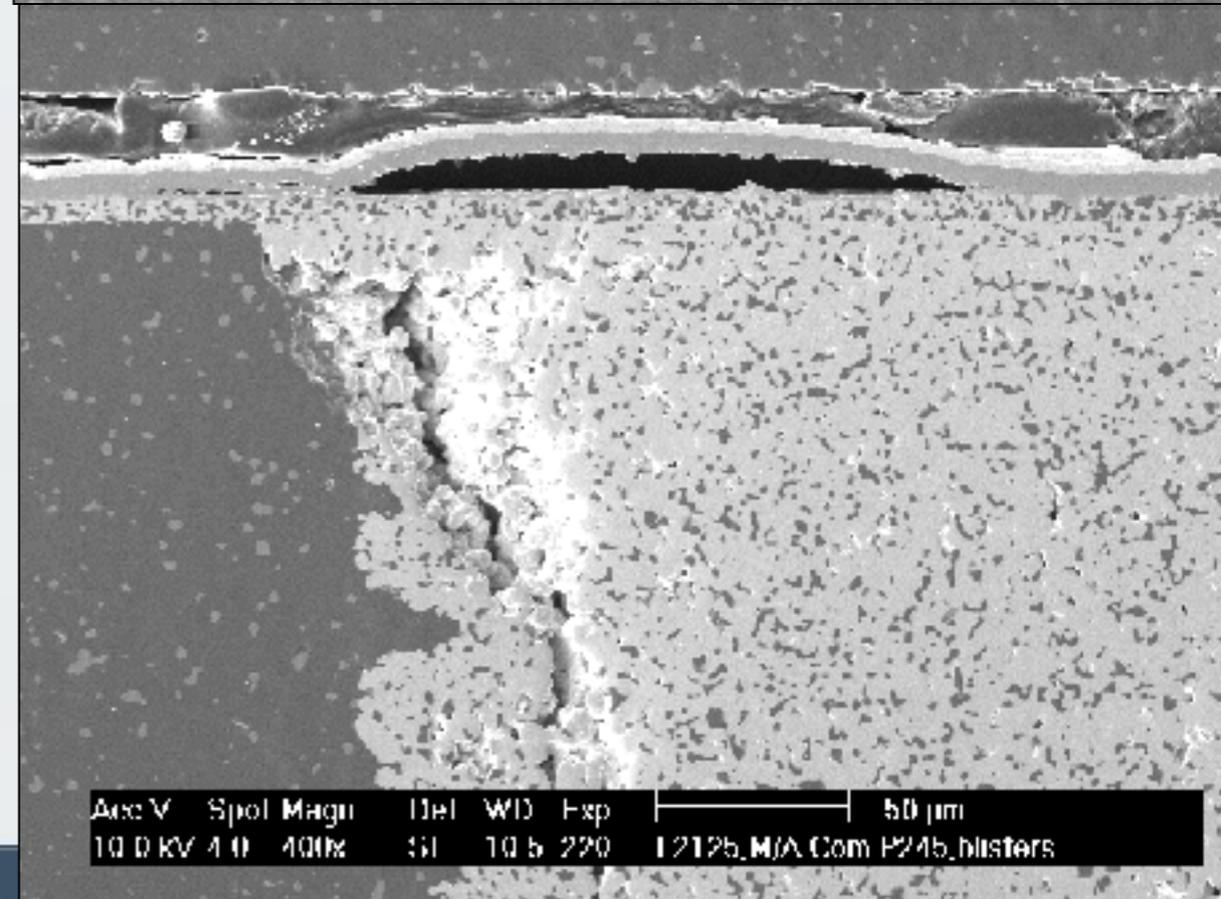
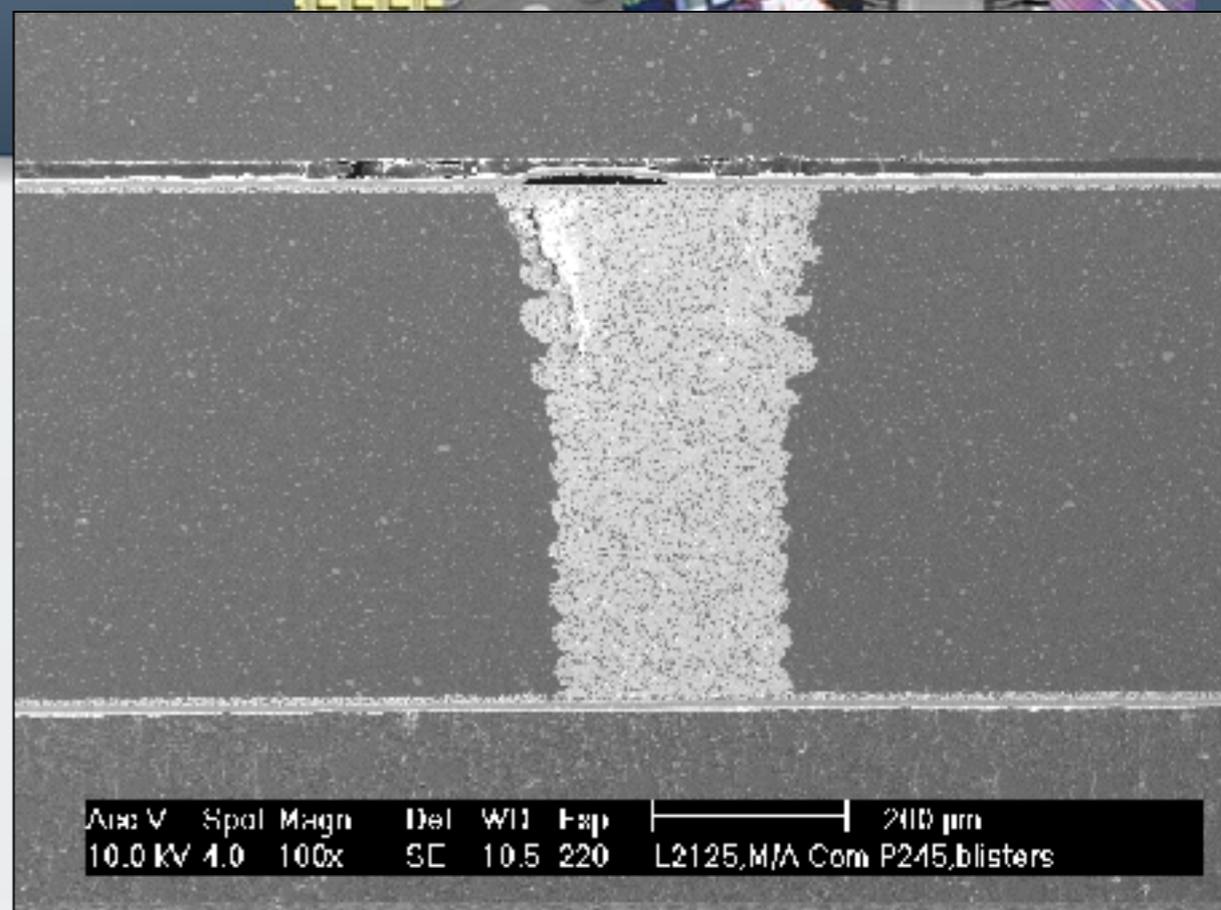
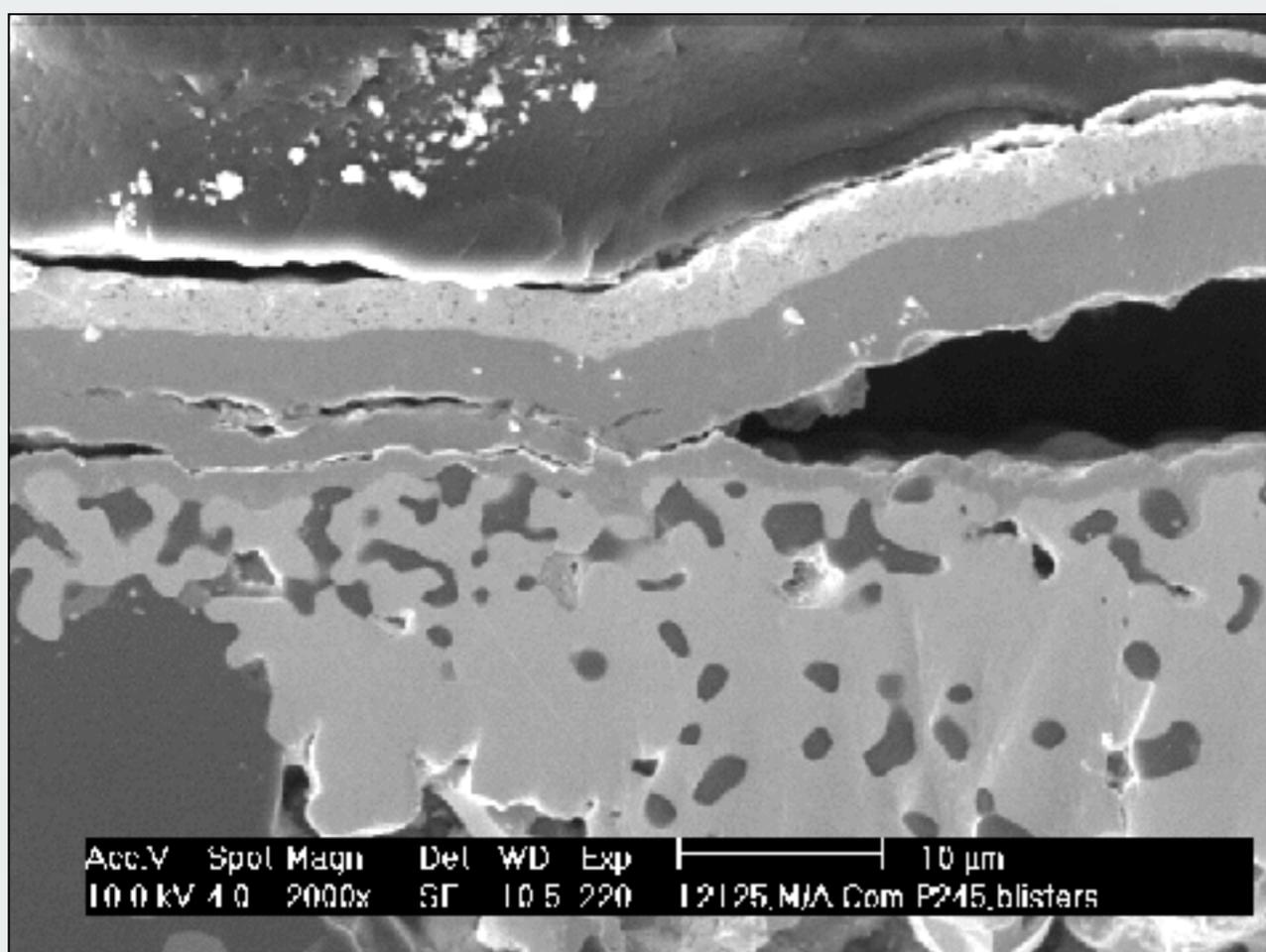


# Analyzing Cracks and Blisters

- Critical sample preparation
- Need to insure that cracks do not form during sample preparation!
- Use wide range of encapsulation materials to provide support during polishing
- CMC often plates layers over soft materials (such as Cu or Au) to retain edge definition during polishing
- Sometimes it takes many tries to get the right combination of preparation techniques

# Blisters

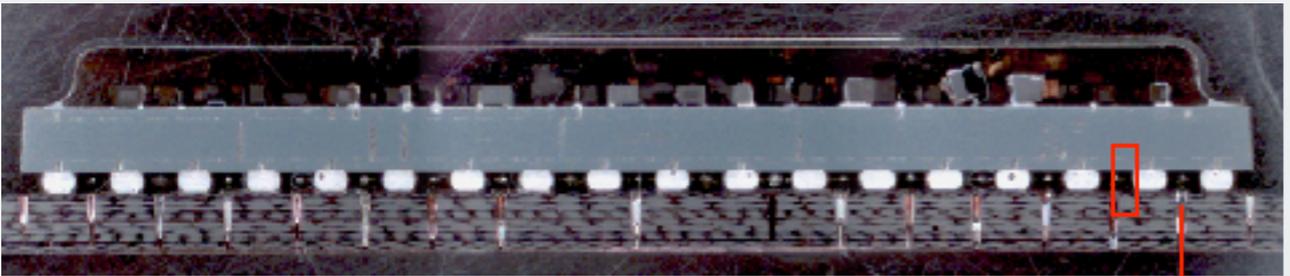
Blister between 1<sup>st</sup> and 2<sup>nd</sup> Nickel  
 Due to crack in tungsten via.



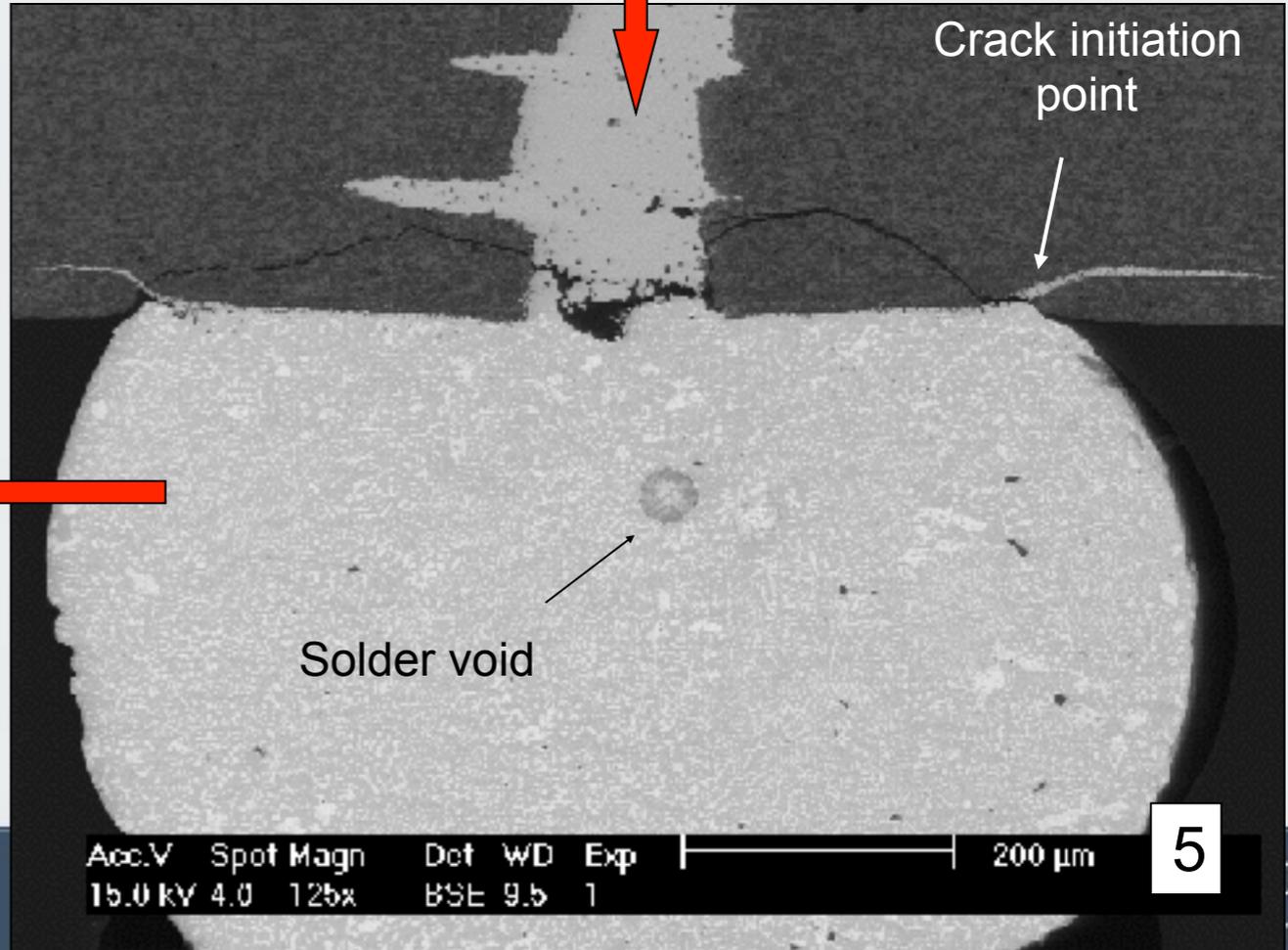
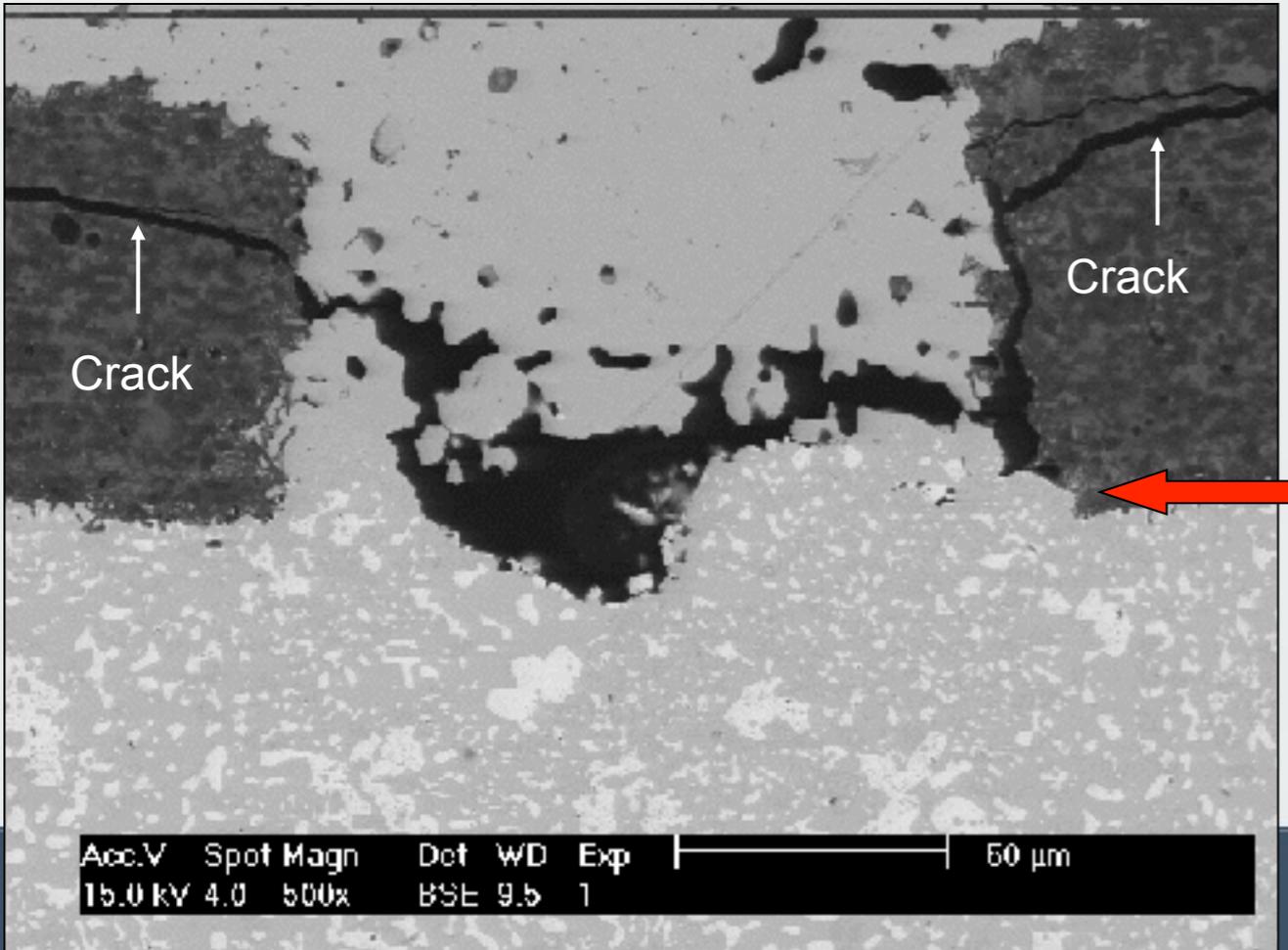
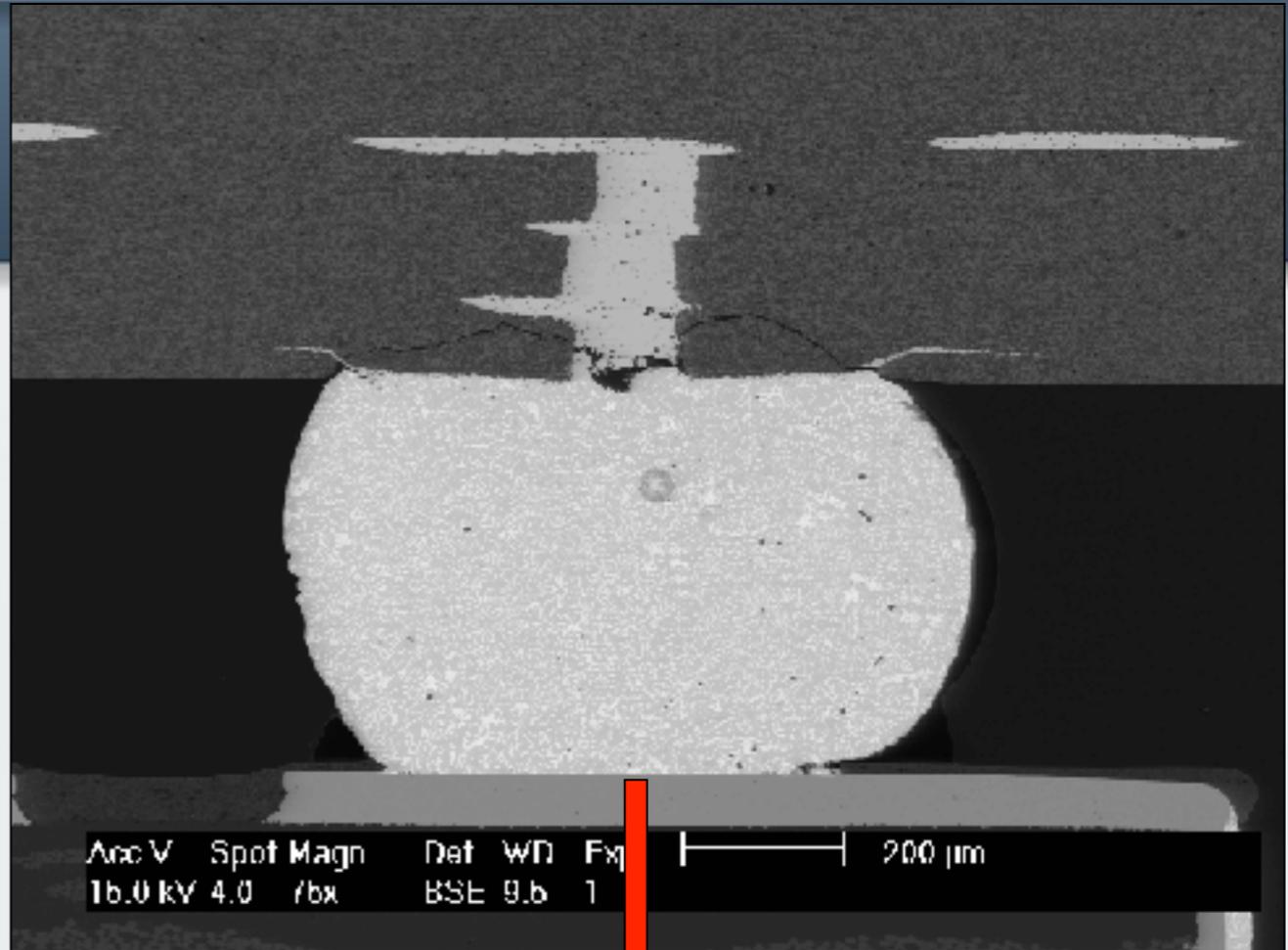


## Ball Delamination

- Ball is observed to fall off BGA
- Likely that the forces that broke this ball off are also influencing adjacent balls
- Cross section of adjacent ball shows crack structure which led to delamination



# Ball Delamination

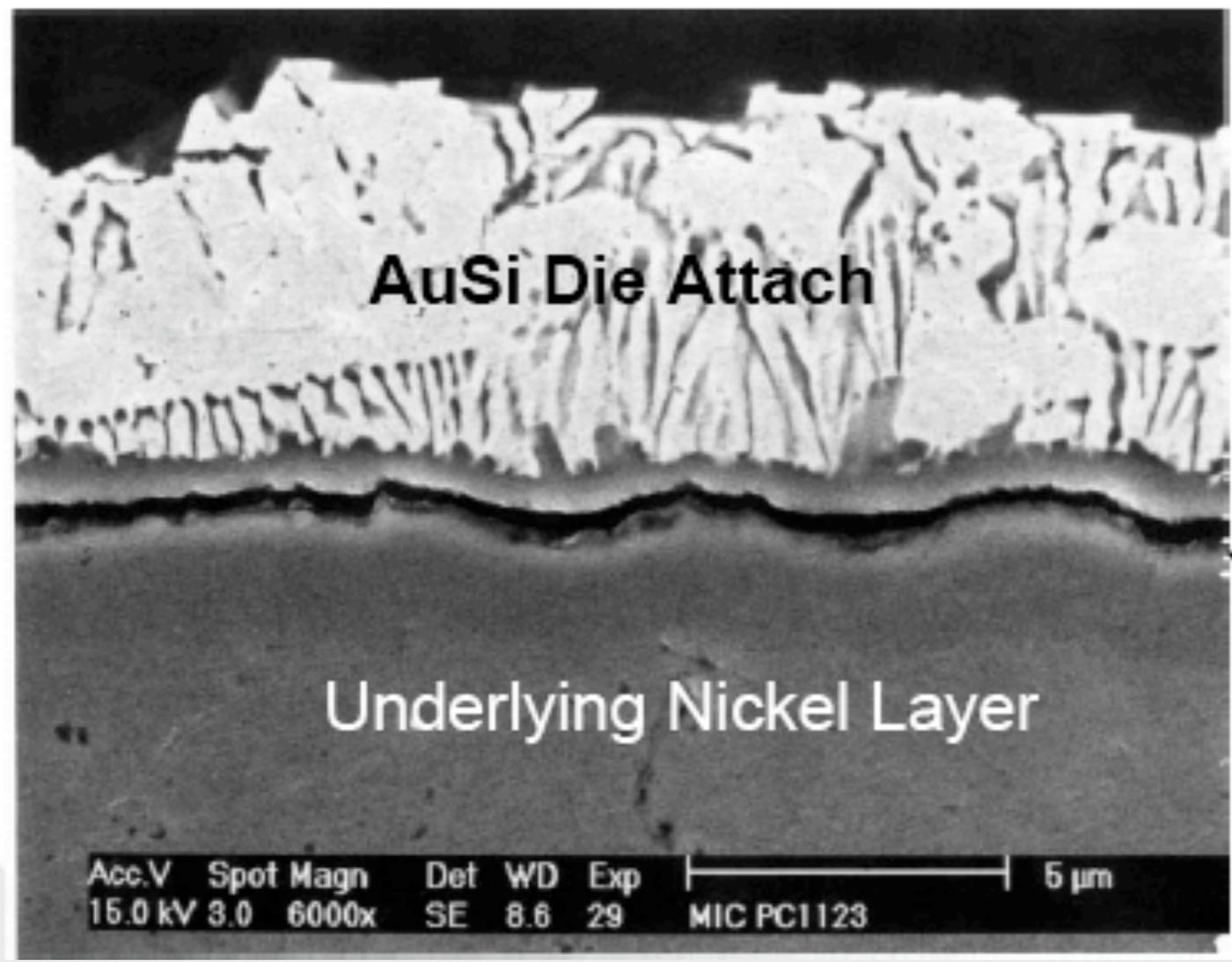




# IMC Interfacial Failures



# Crack Along Thin IMC Layer

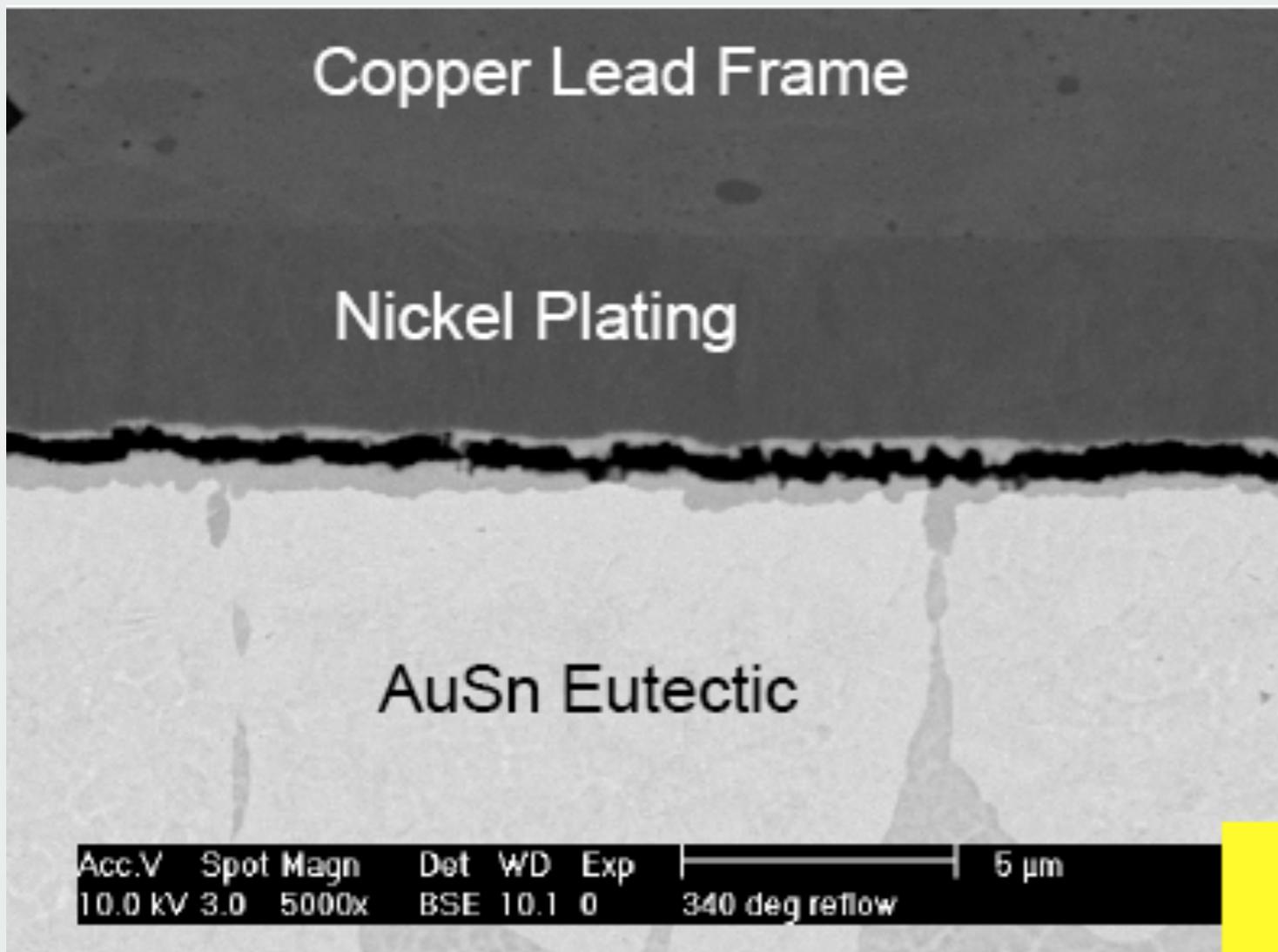


← Thin continuous layer of NiSi along the interface

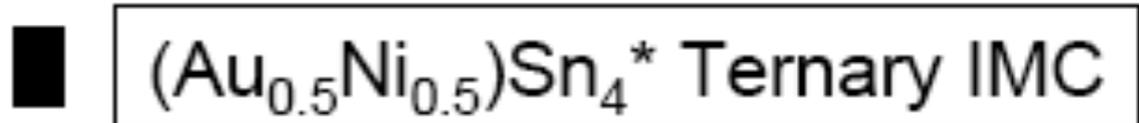
← **DELAMINATION**



## Crack Along Thin IMC Layer



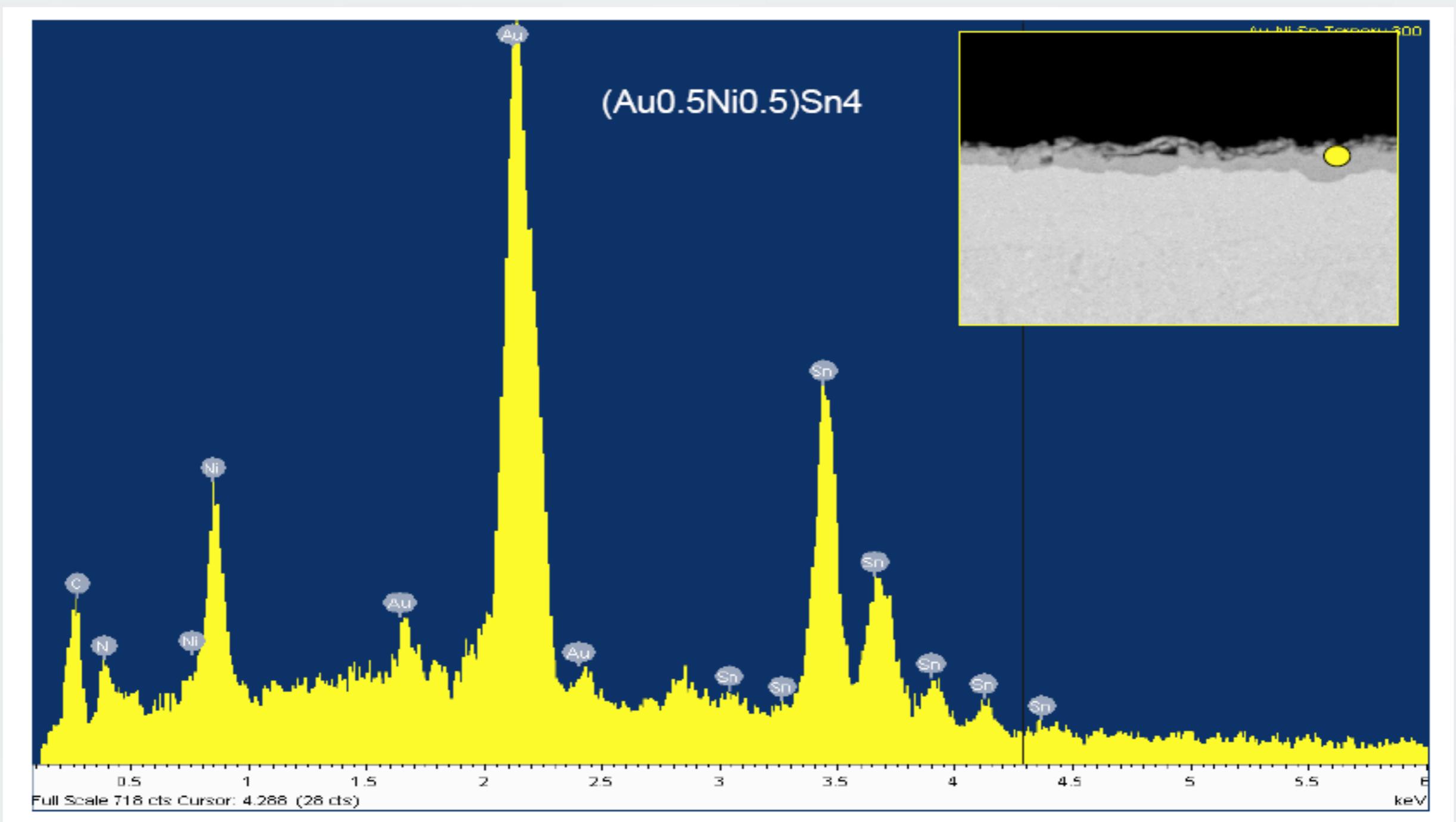
- Temperature Shock
- Brittle fracture along the interface
  - Single mode failure mechanism



Copper Lead Frame



# ID of IMC Layer Composition



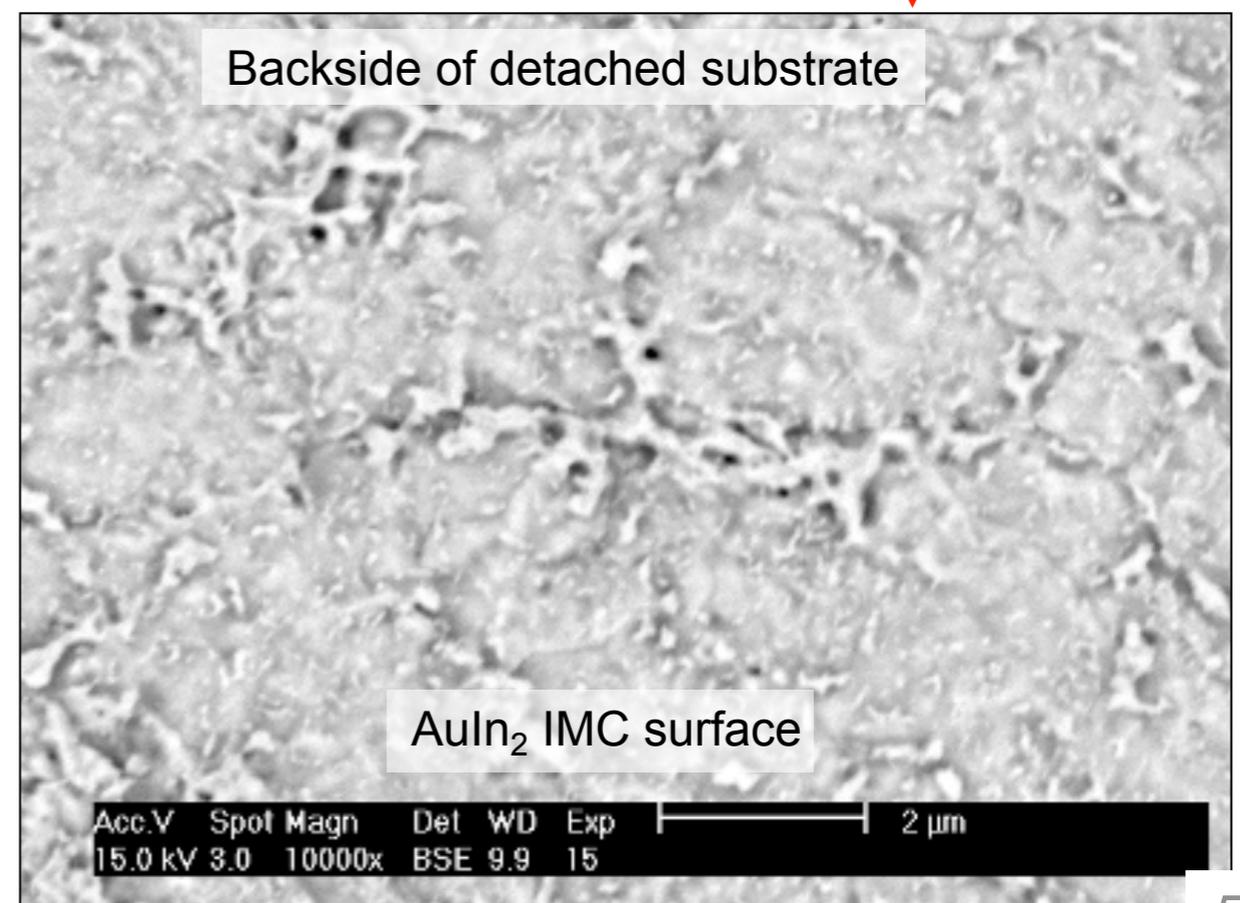
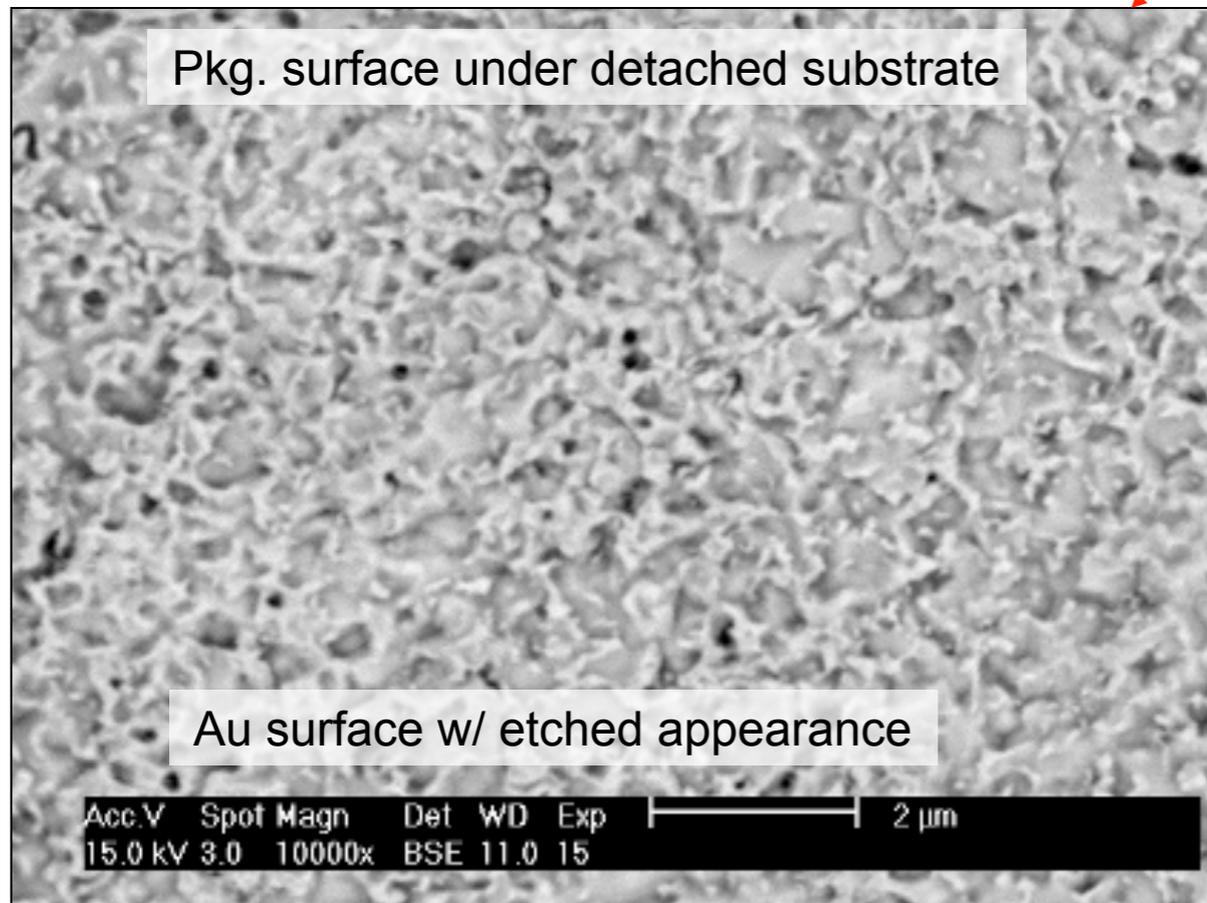
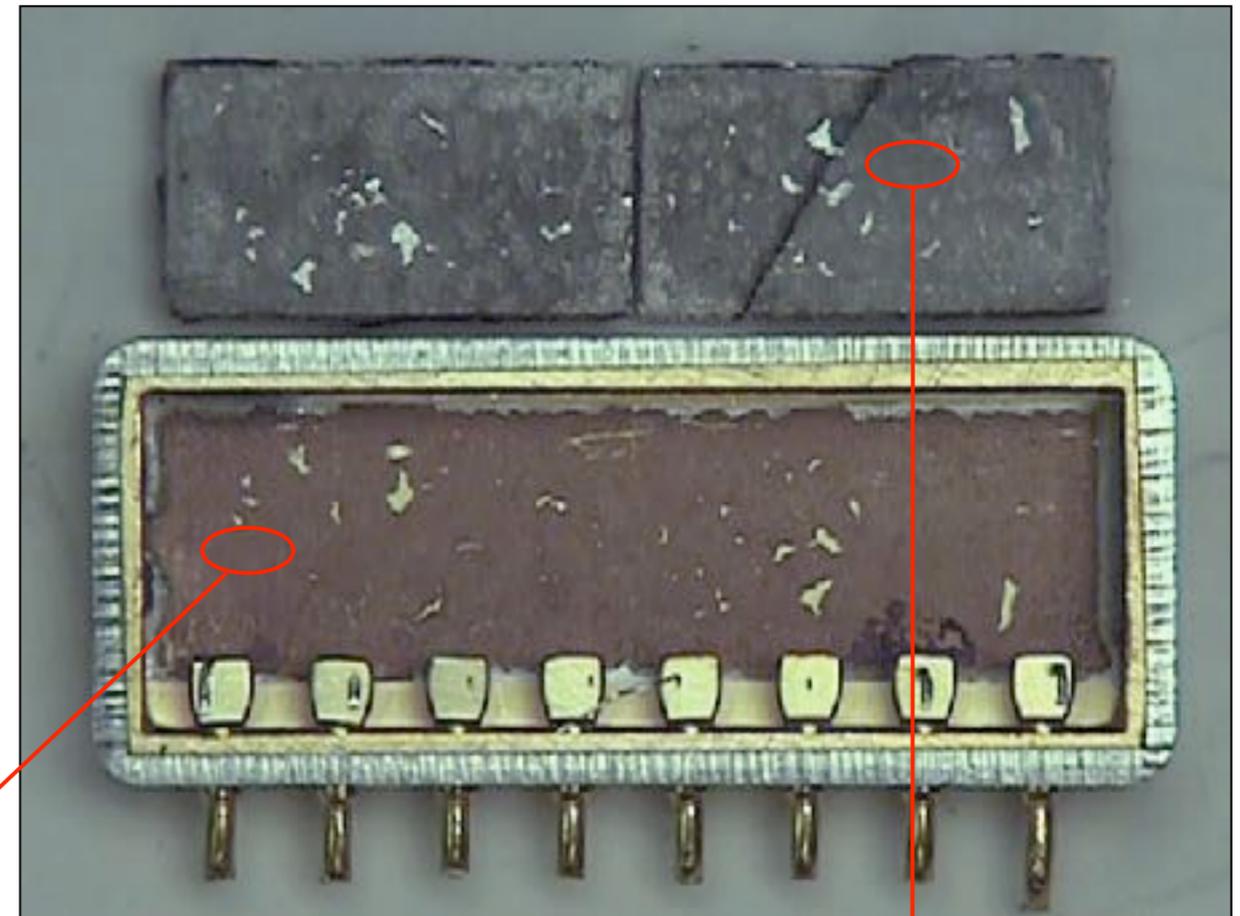


## PbIn Soldered Substrate

- Substrate attached to package with PbIn solder
- Detaches during temperature cycle
- Failure identified as AuIn IMC
- When compared to good samples- Au layer was too thick

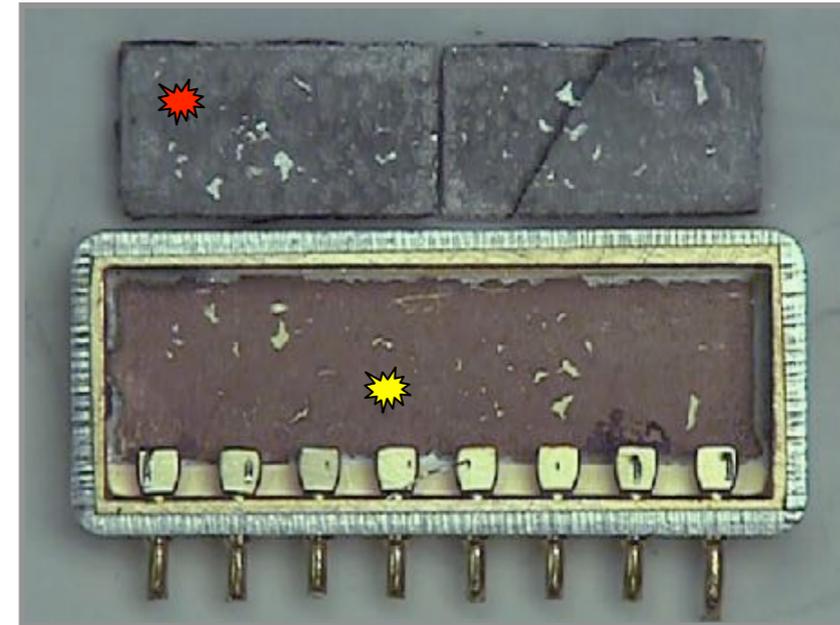
# SEM Analysis of PIND Failure Surfaces S/N 1103

- Primary failure surface on package side is pure gold (excluding void areas). No indium is detected on this surface, indicating a clean separation.
- Primary failure surface on back of substrate is composed of  $\text{AuIn}_2$  IMC.

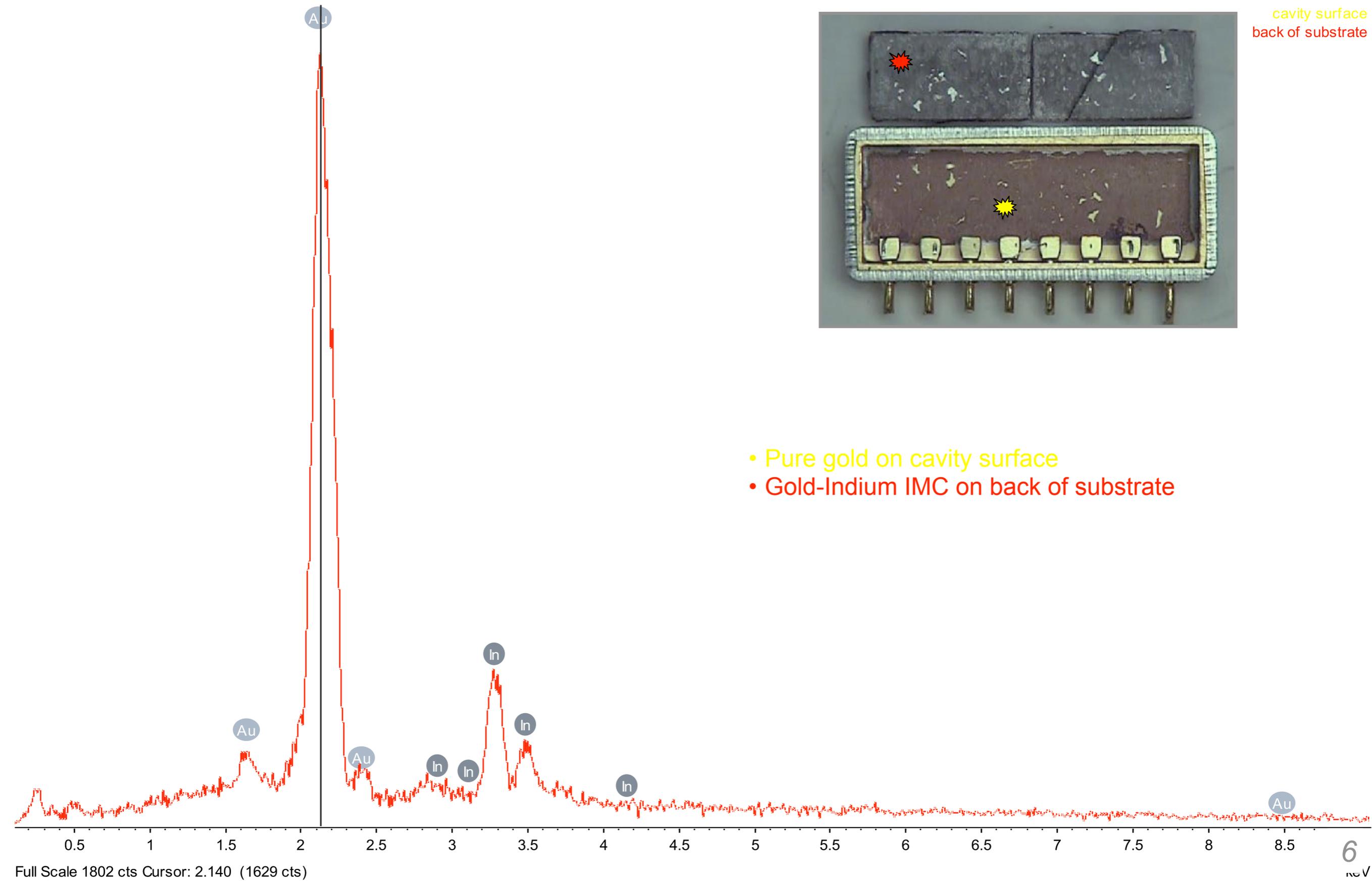


# S/N 1103 EDS Analysis of PIND Failure Surfaces

cavity surface  
back of substrate

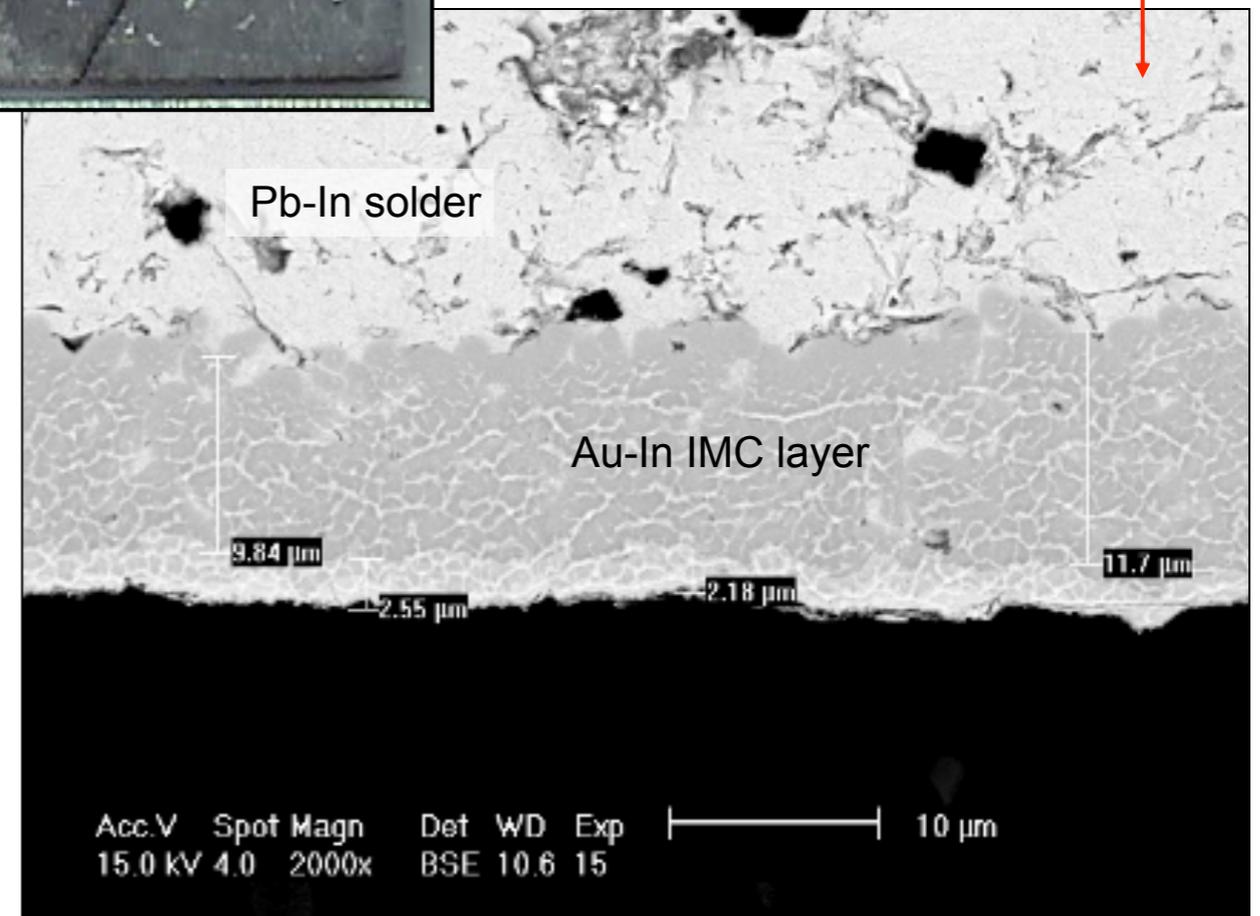
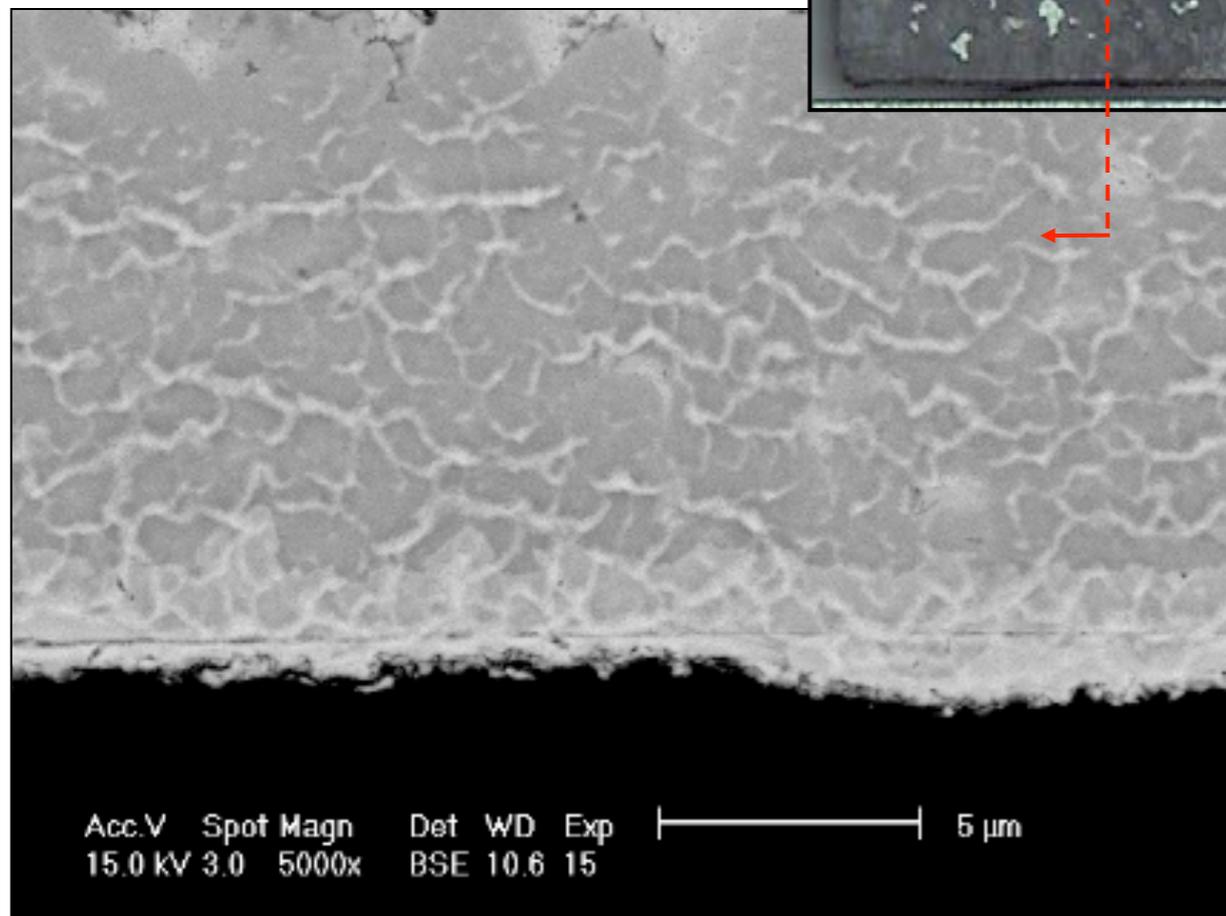
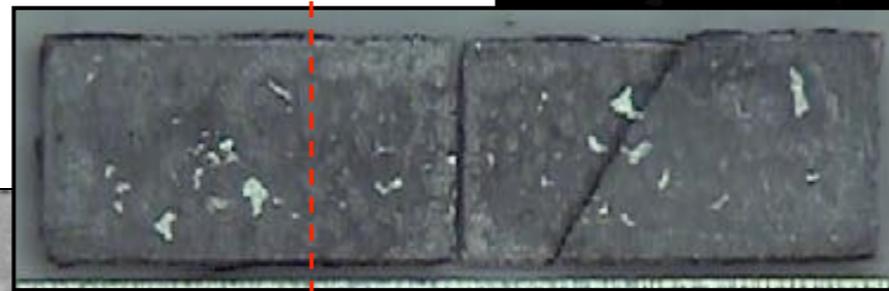
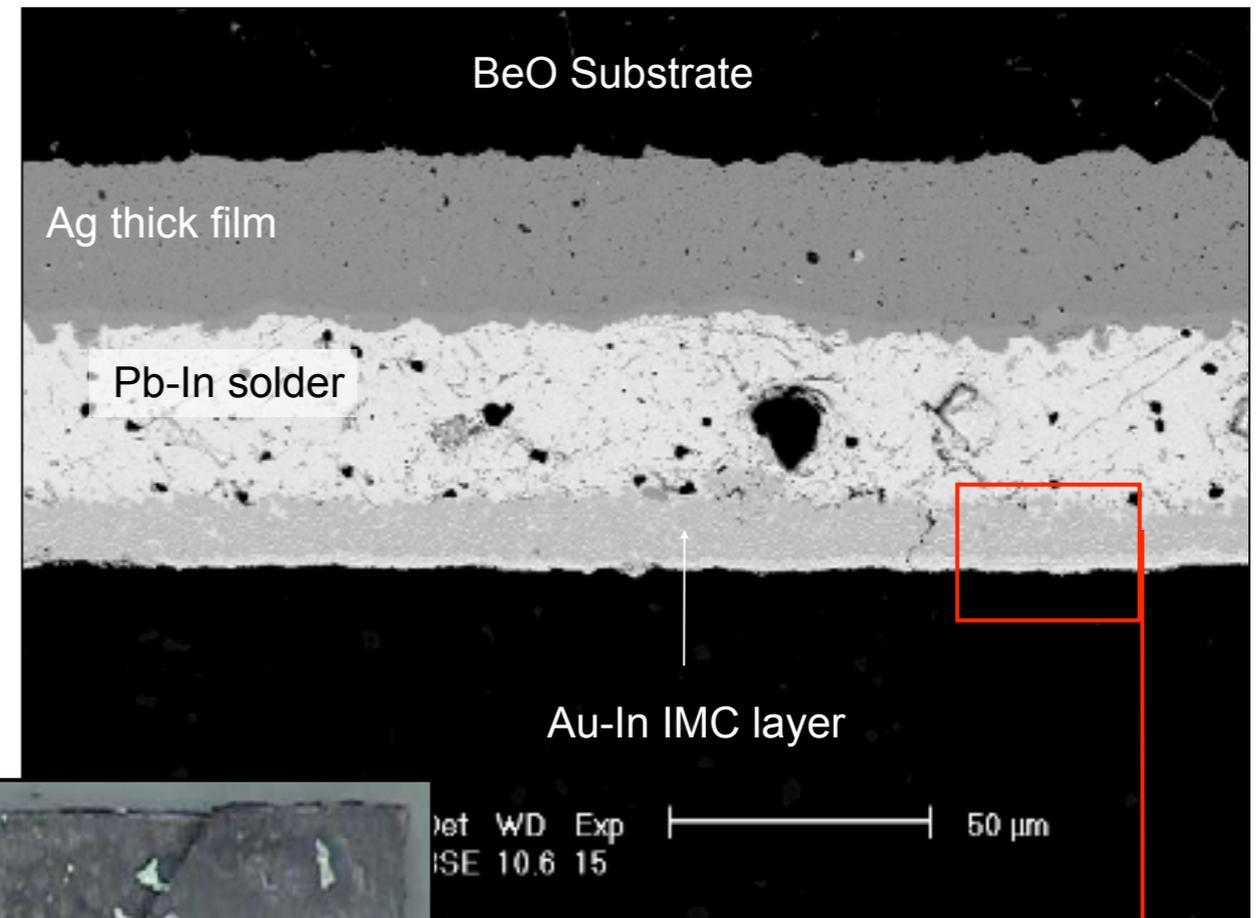


- Pure gold on cavity surface
- Gold-Indium IMC on back of substrate



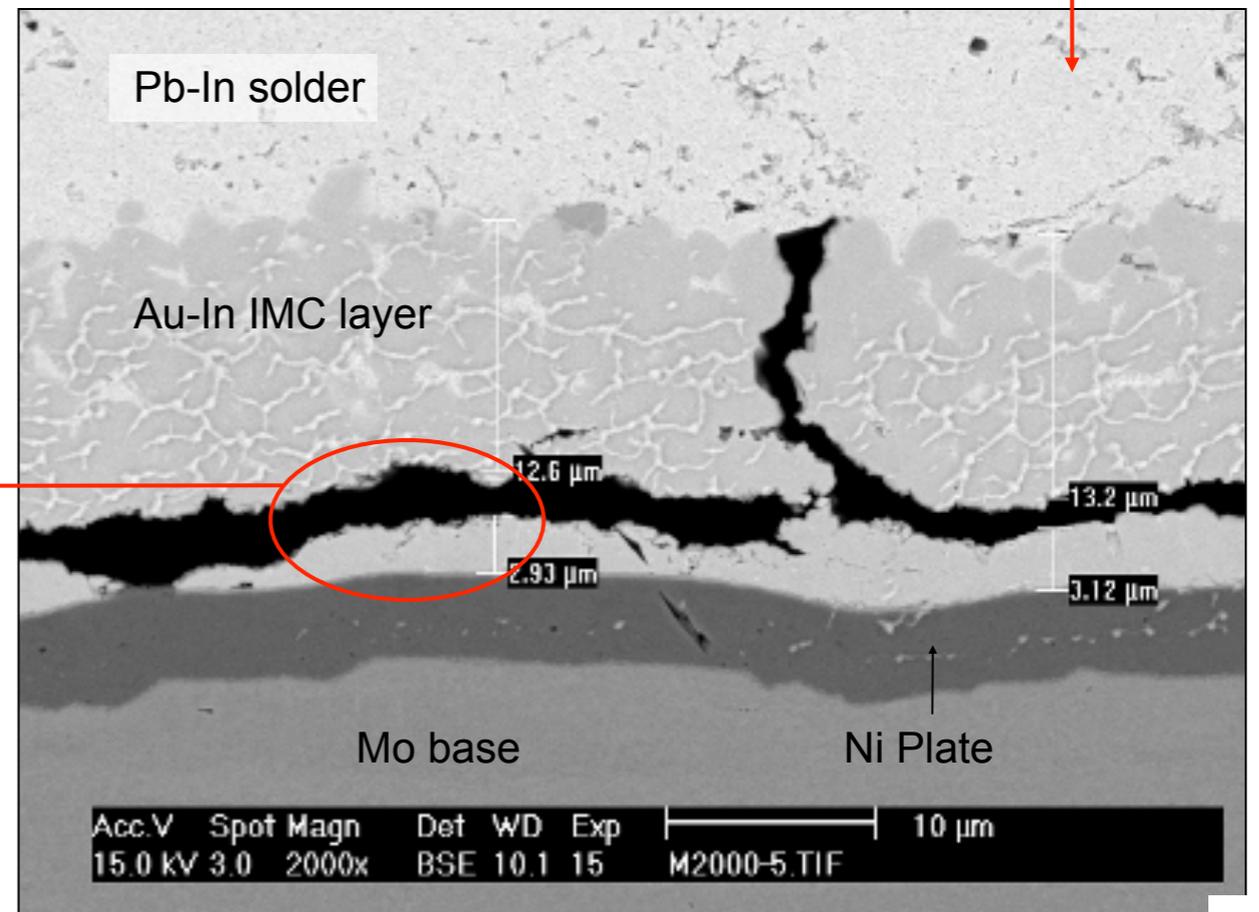
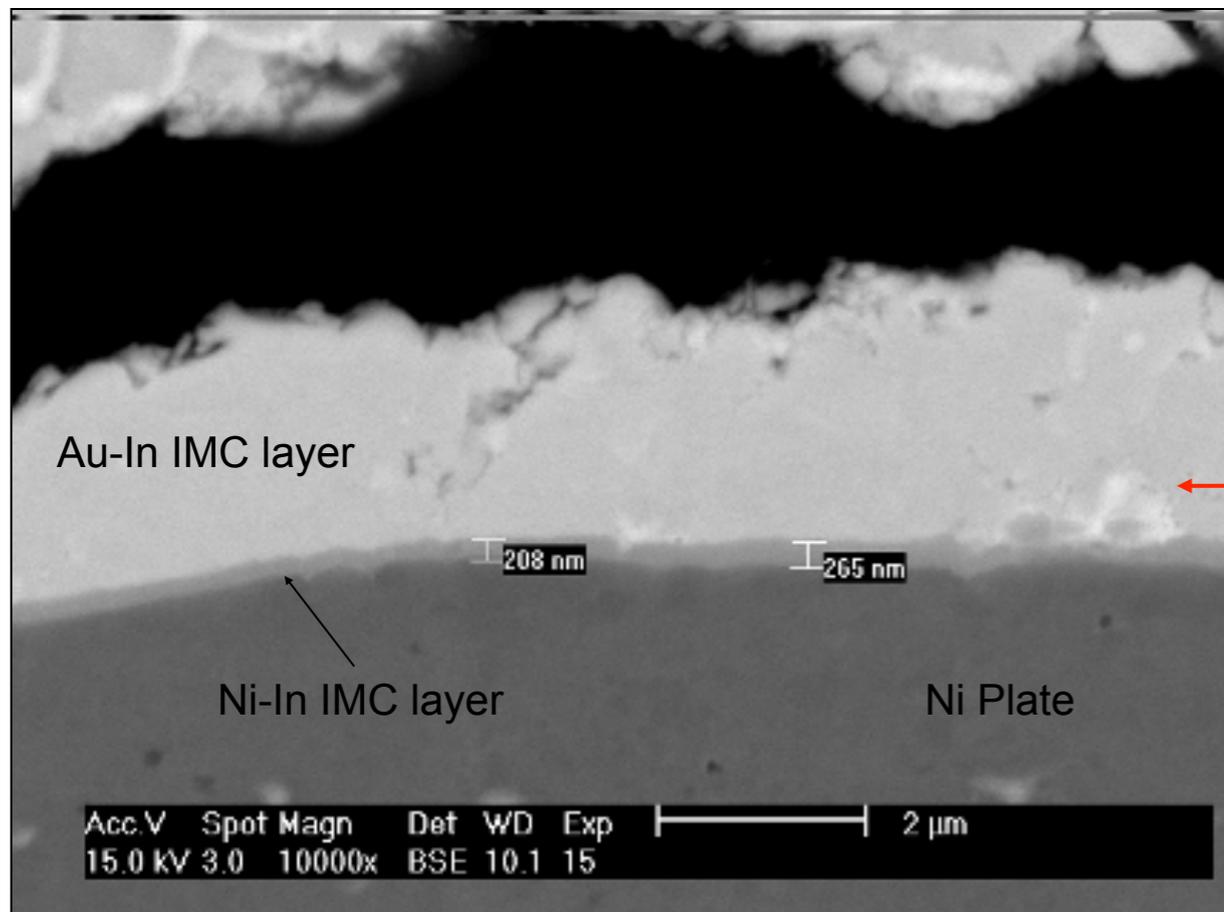
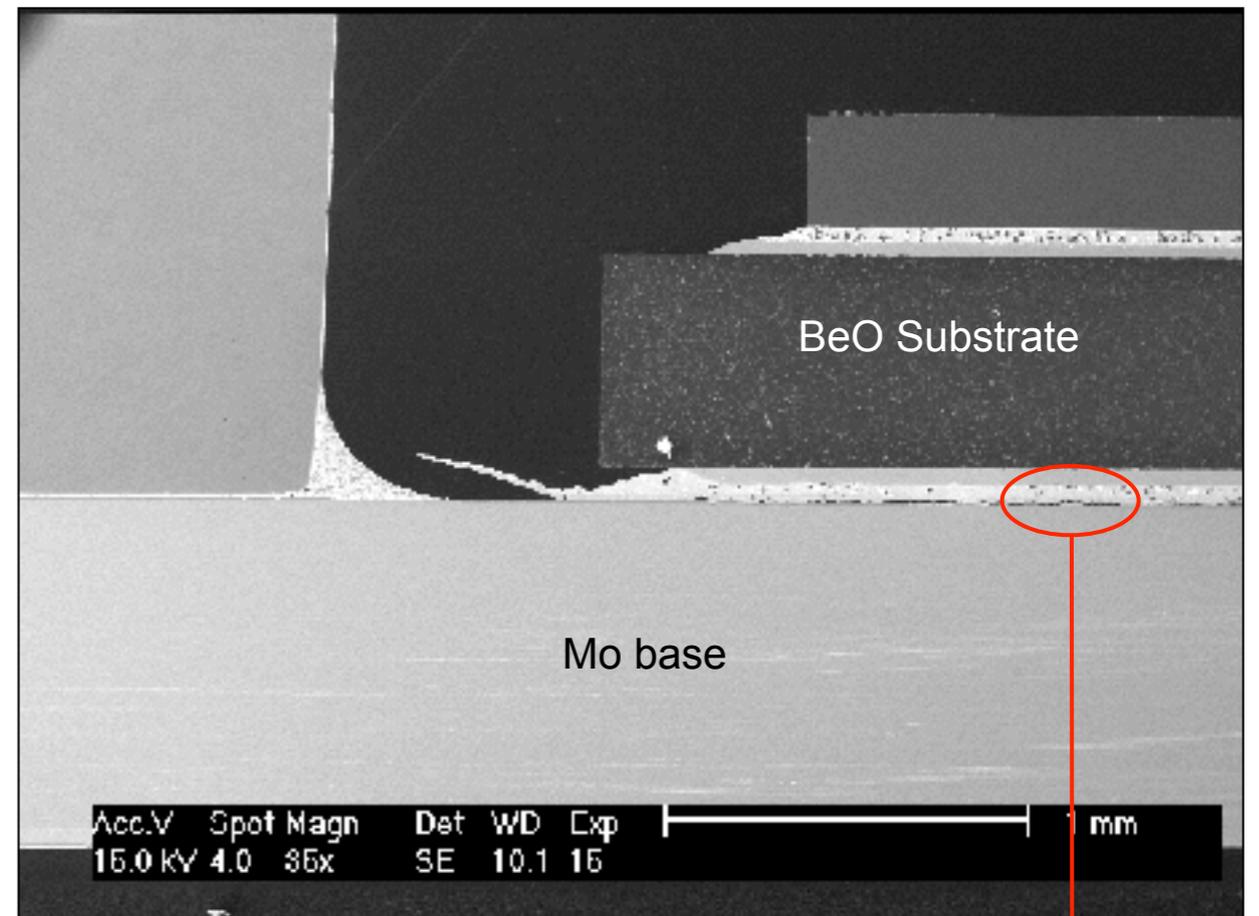
# S/N 1103 (PIND Failure) Cross-section of Detached Substrate

- Primary failure surface on the substrate side is Au-In IMC (total thickness ~13  $\mu\text{m}$ ).



# S/N 1127 (IR Cross-section FA #7132) Failure after 100 T.C.

- Failure occurs within the brittle  $\text{AuIn}_2$  intermetallic layer.
- All gold on the base has been digested by the solder, forming an IMC layer  $\sim 16 \mu\text{m}$  thick.
- The Au-In IMC is firmly bonded to the Ni underplate, evidenced by the formation of a Ni-In IMC layer  $\sim 0.25 \mu\text{m}$  thick.

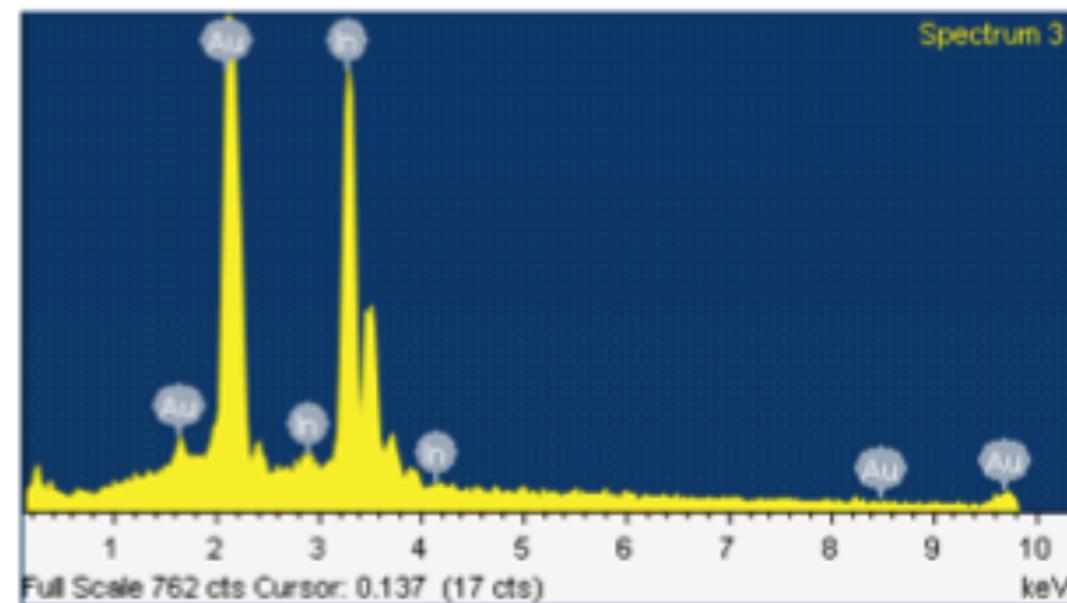
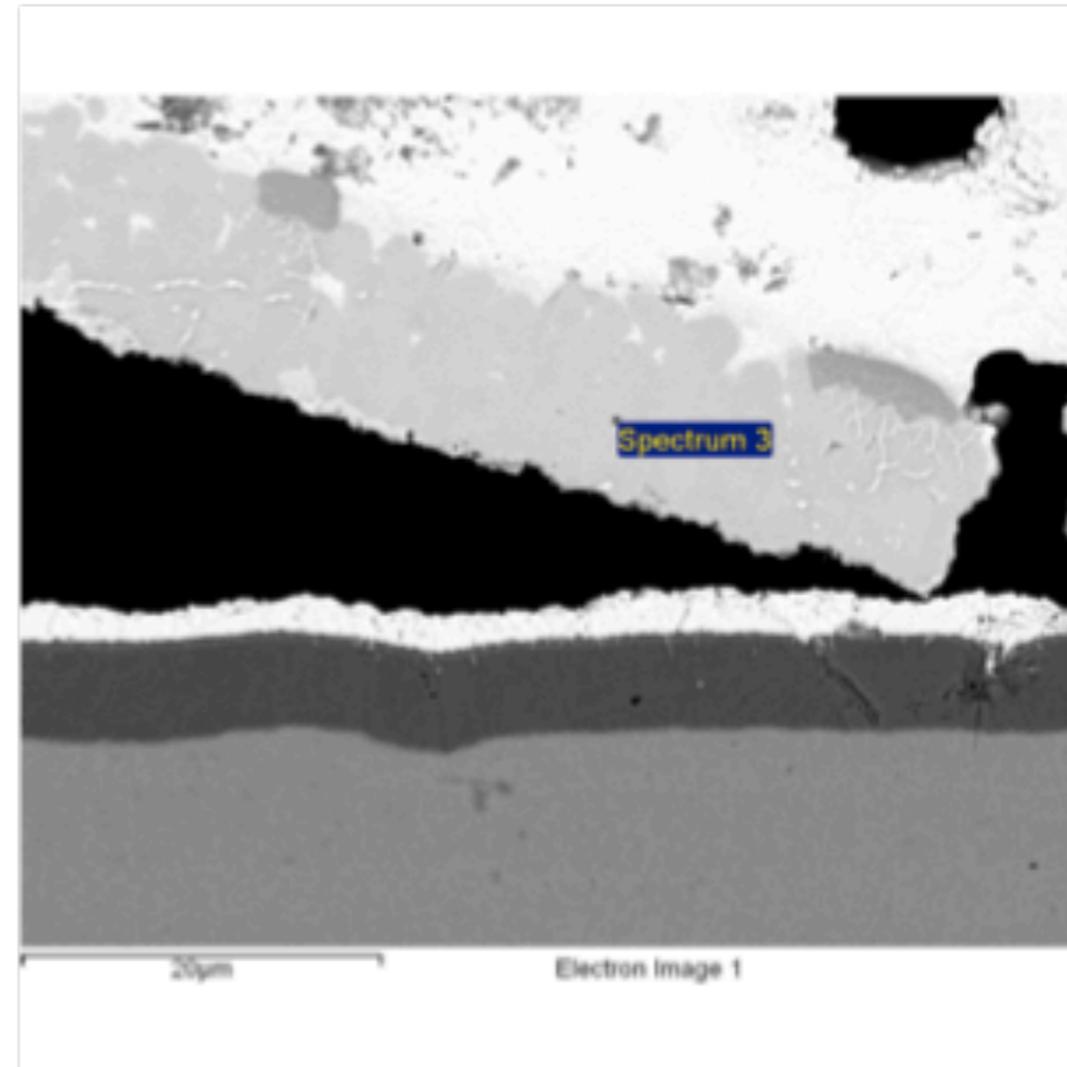


Spectrum processing :  
 Peaks possibly omitted : 0.256, 0.380 keV

Processing option : All elements analyzed (Normalised)  
 Number of iterations = 2

Standard :  
 In InAs 1-Jun-1999 12:00 AM  
 Au 80-20 AuSn 6-Dec-2007 09:42 AM

Element	Weight%	Atomic%
In L	49.62	62.82
Au M	50.38	37.18
Totals	100.00	

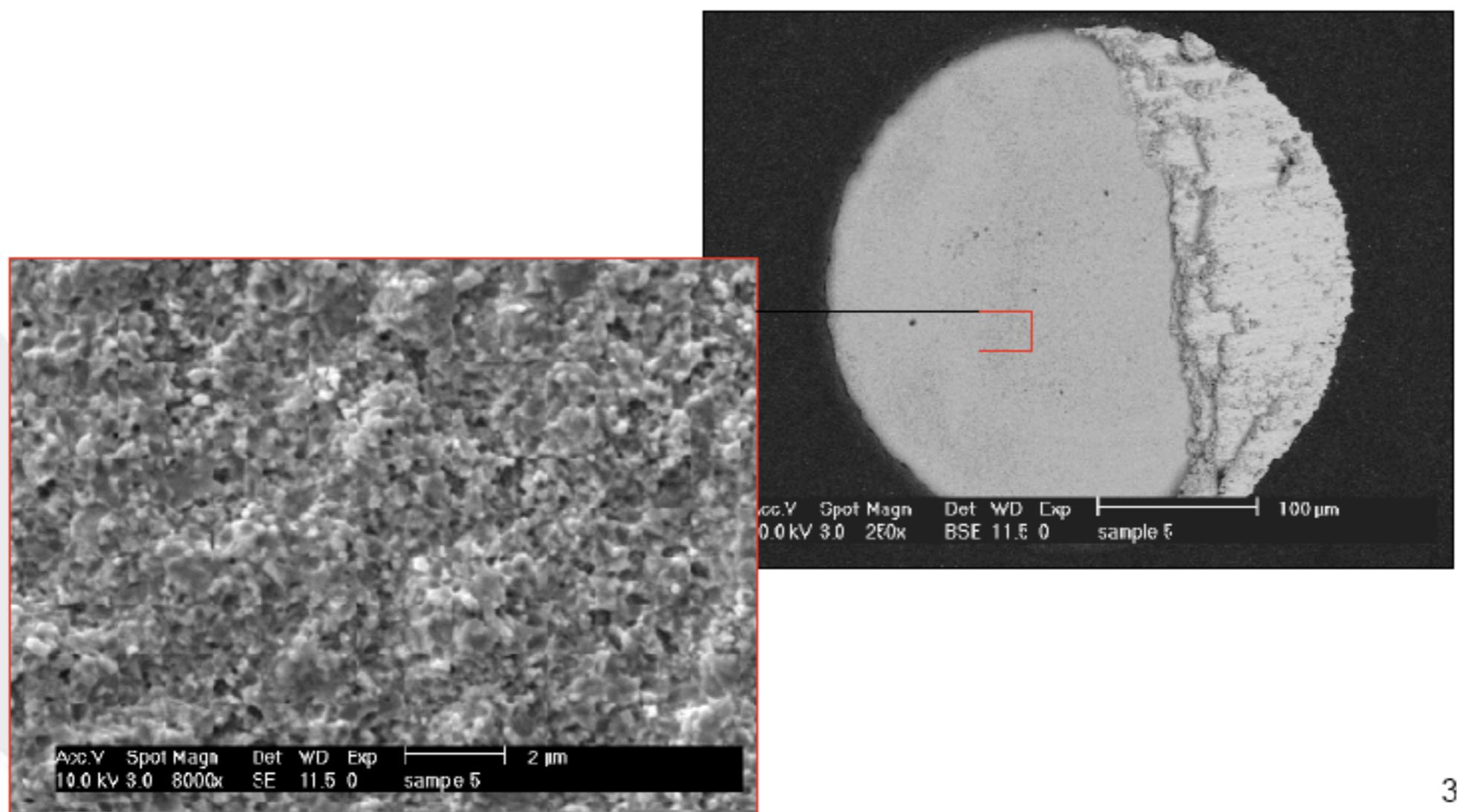


Comment: Very likely AuIn<sub>2</sub> phase



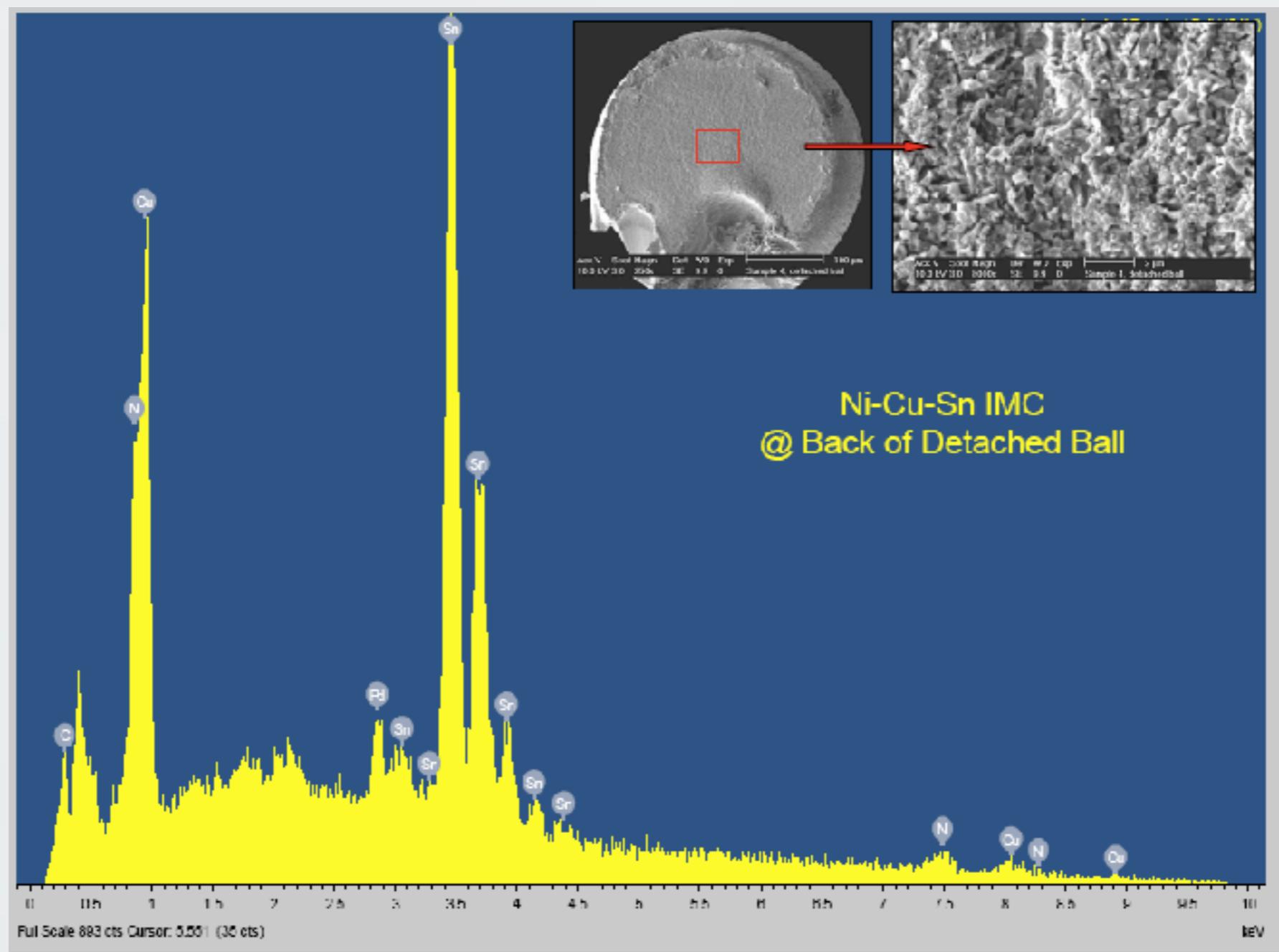
# Brittle Fracture of Ball after Shear Test

Pad- Top View



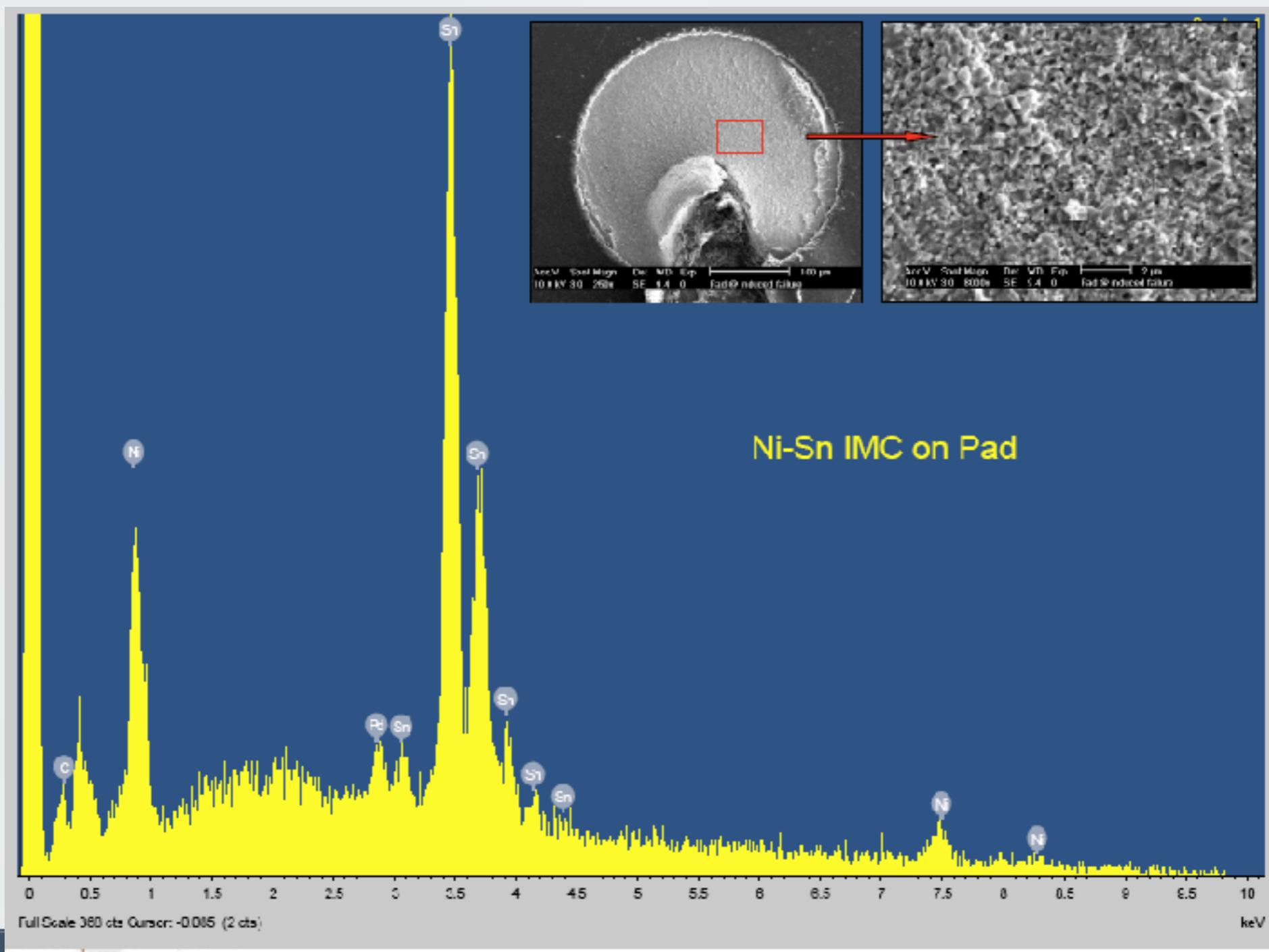


# Brittle Fracture of Ball after Shear Test





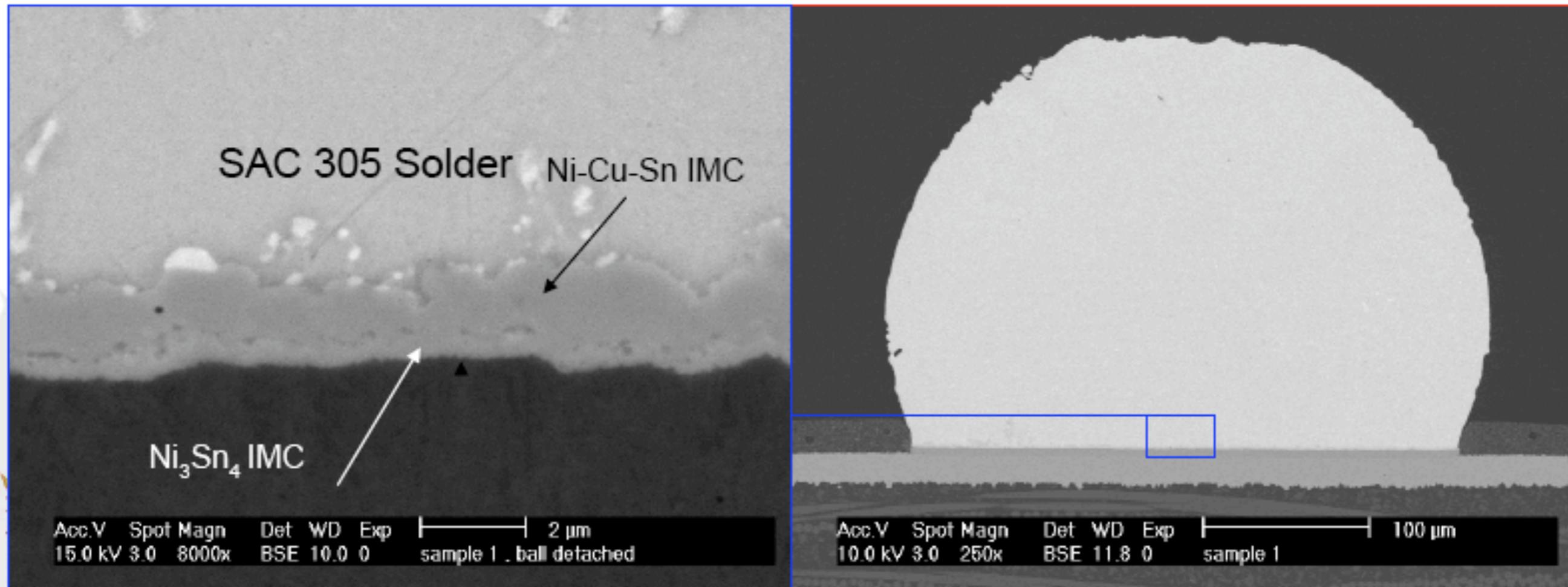
# Brittle Fracture of Ball after Shear Test





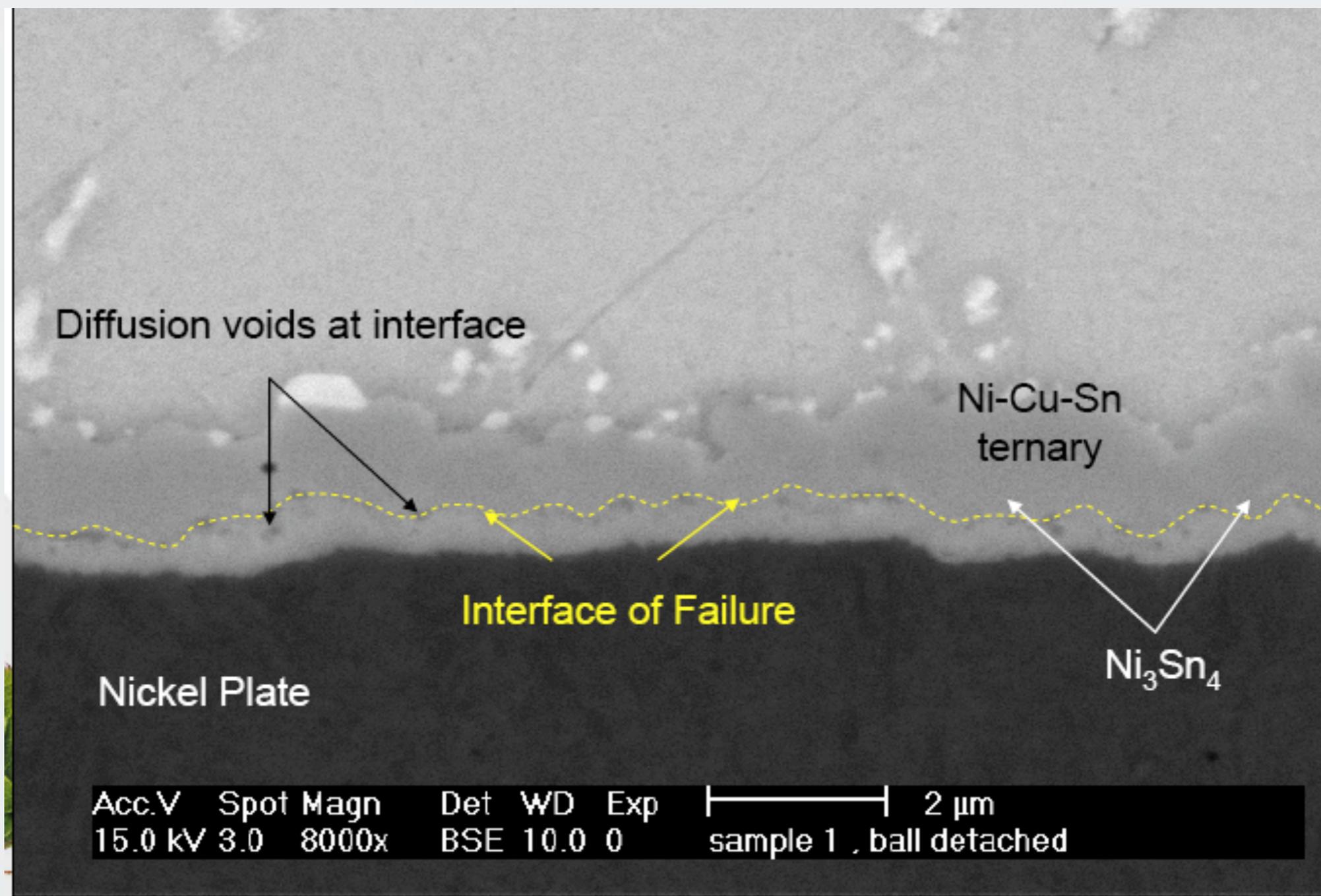
# Brittle Fracture of Ball after Shear Test

Cross section of adjacent ball shows origin of ball failure



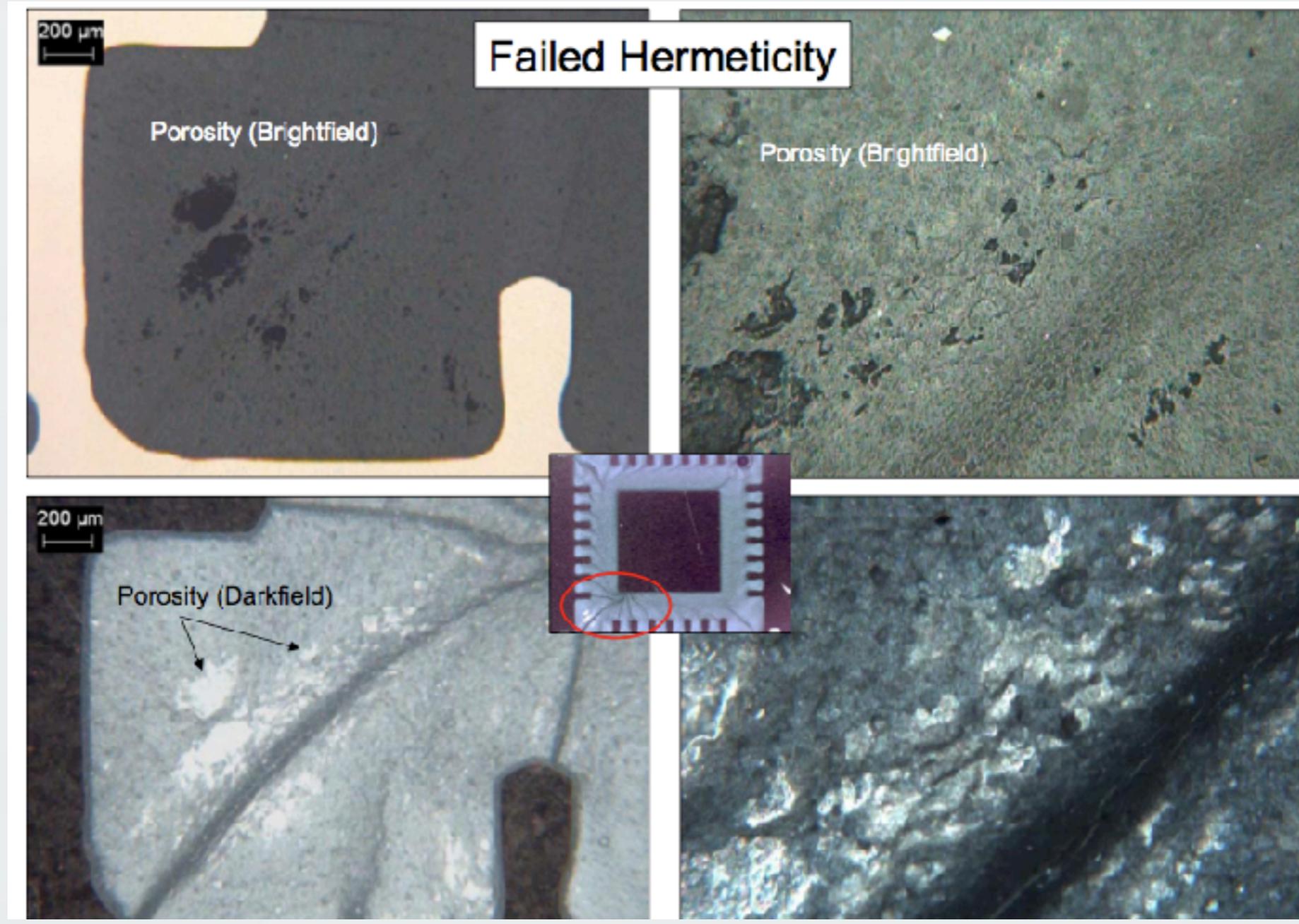


# Brittle Fracture of Ball after Shear Test



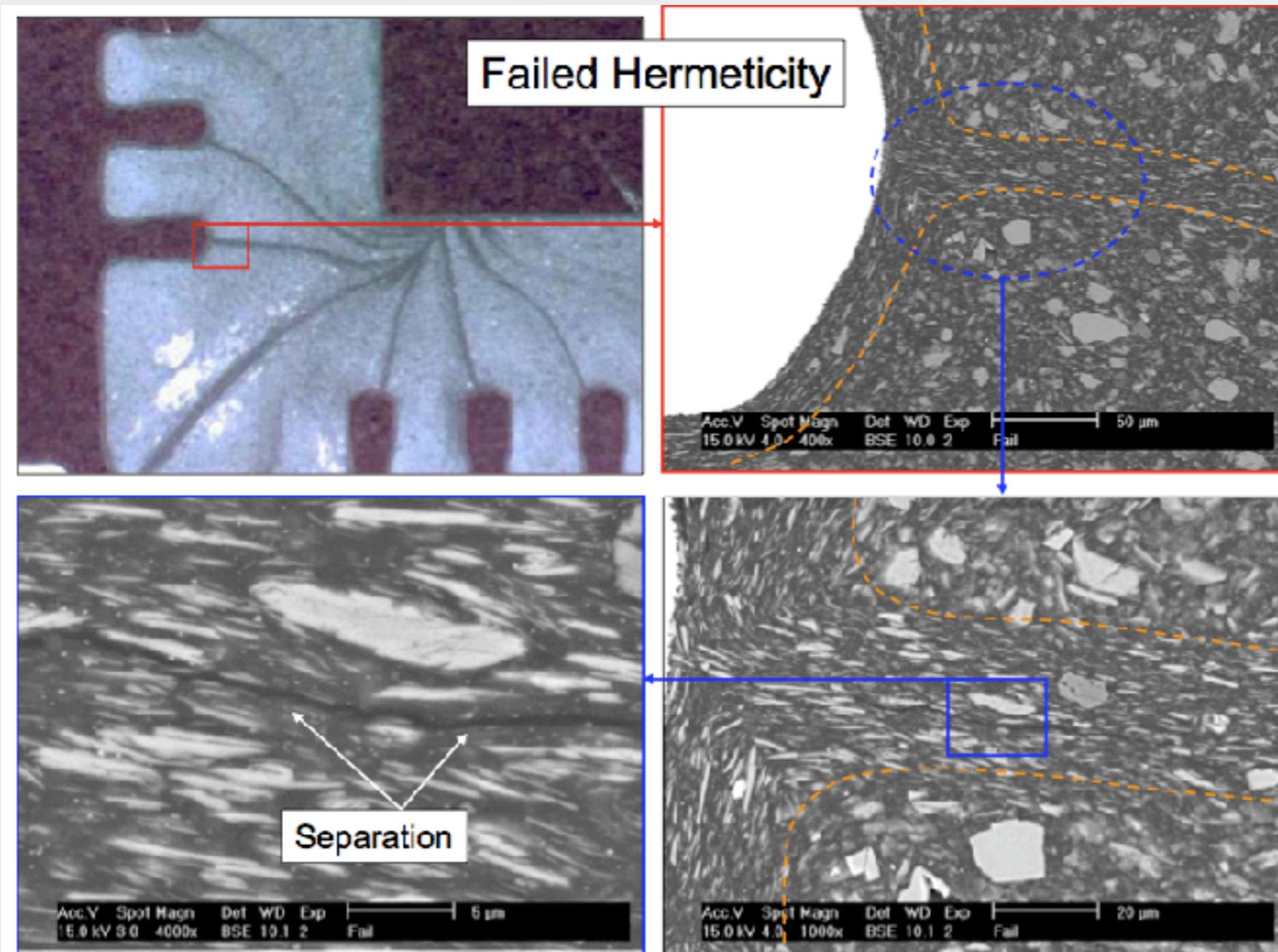


# Porosity and Knit Lines Organic Package



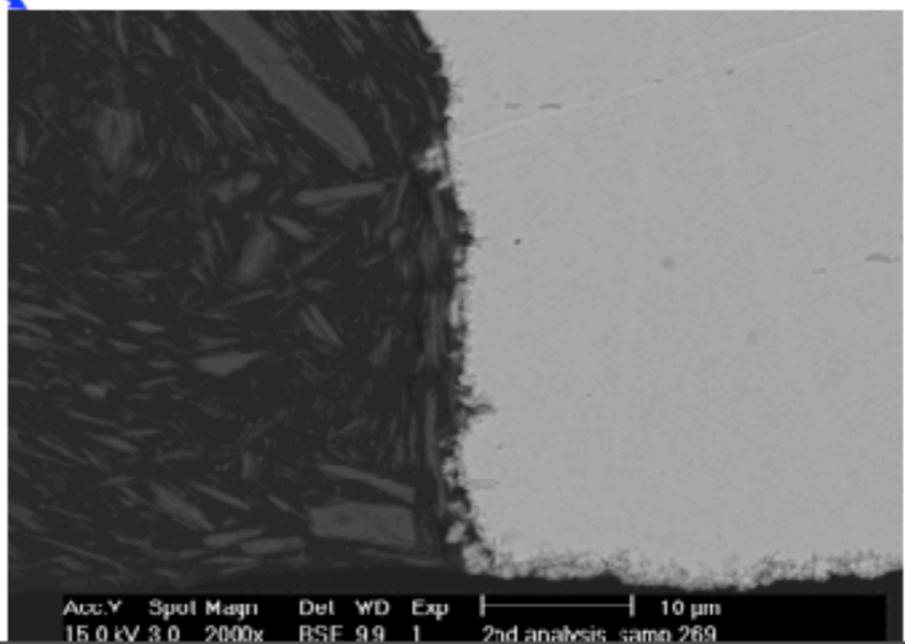
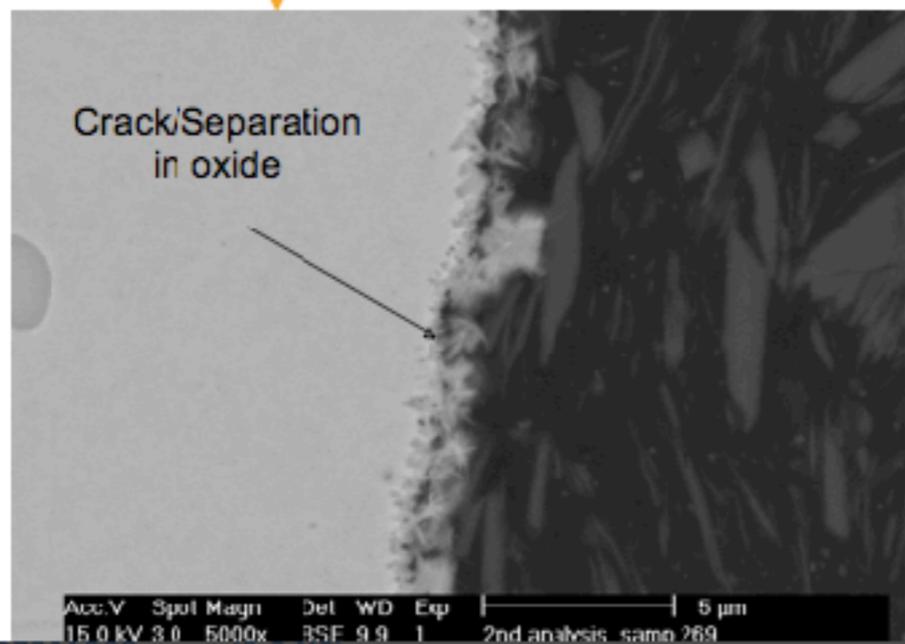
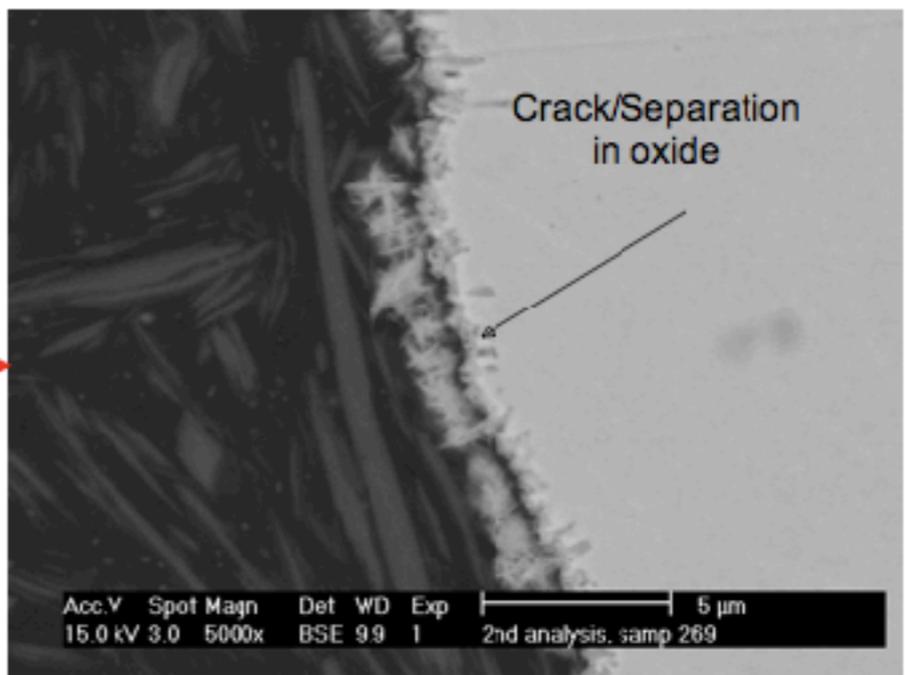
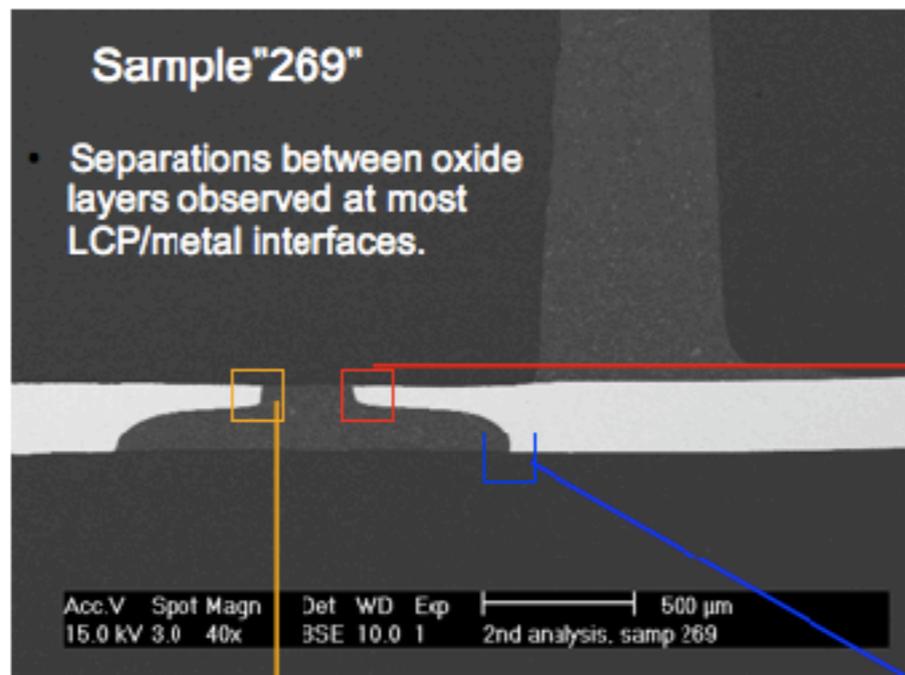


# Crack in Organic Package





# Organic Package- Metallization Failure



07231391.smp (6.8 MB)

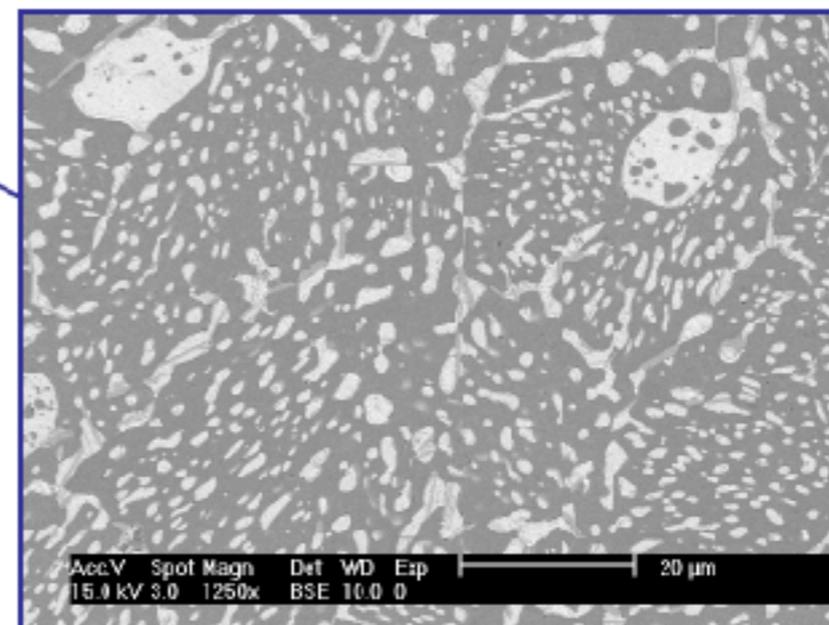
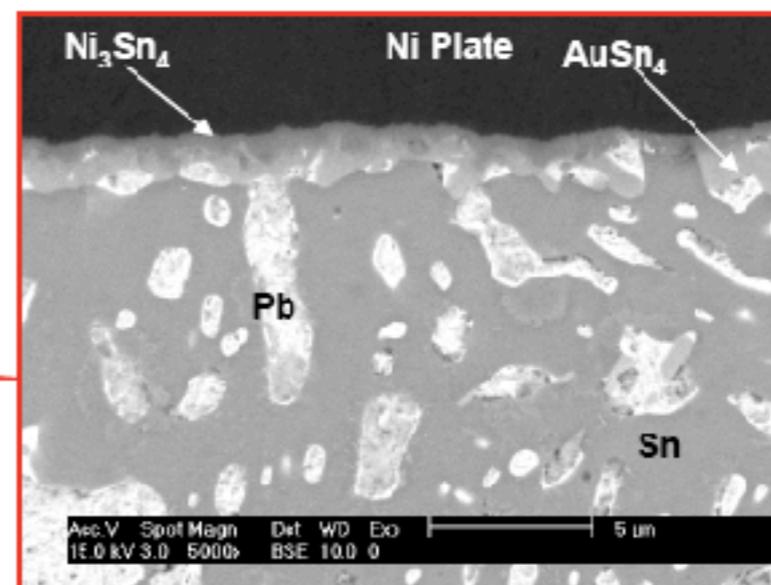
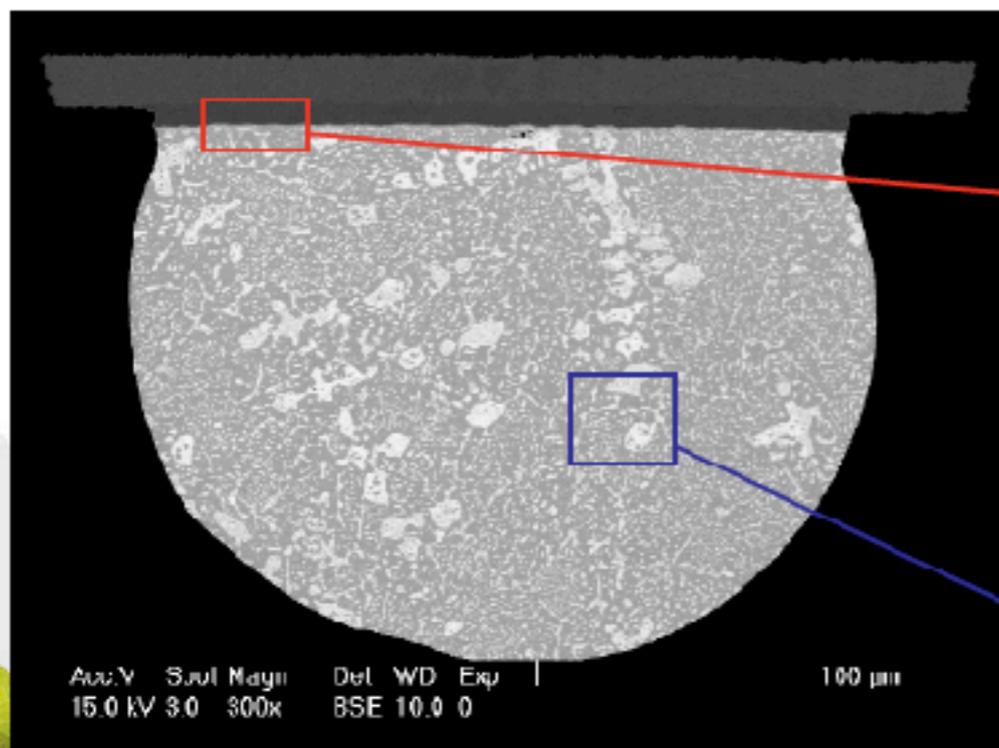


# Microstructure and Secondary Phases



# Phase Distribution in PbSn Solder Ball

SEM Analysis (CMC)

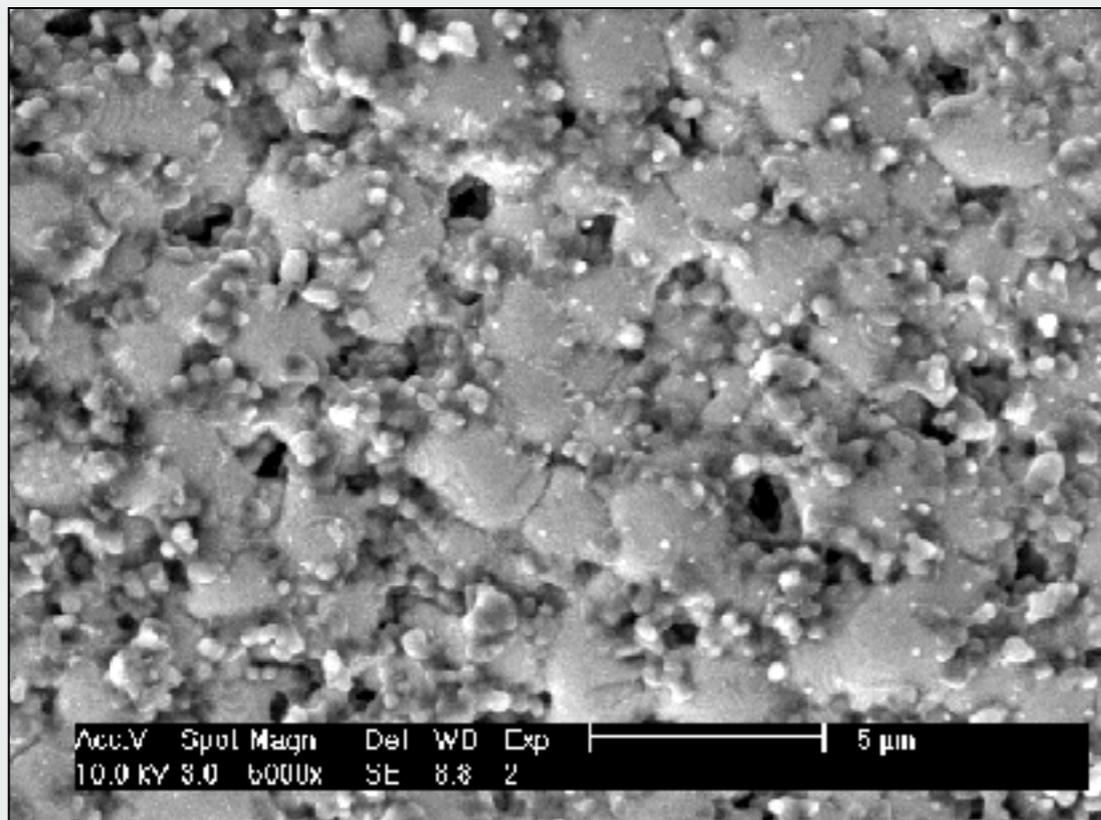


Outsource Your Problems to CMC Interconnect Technologies



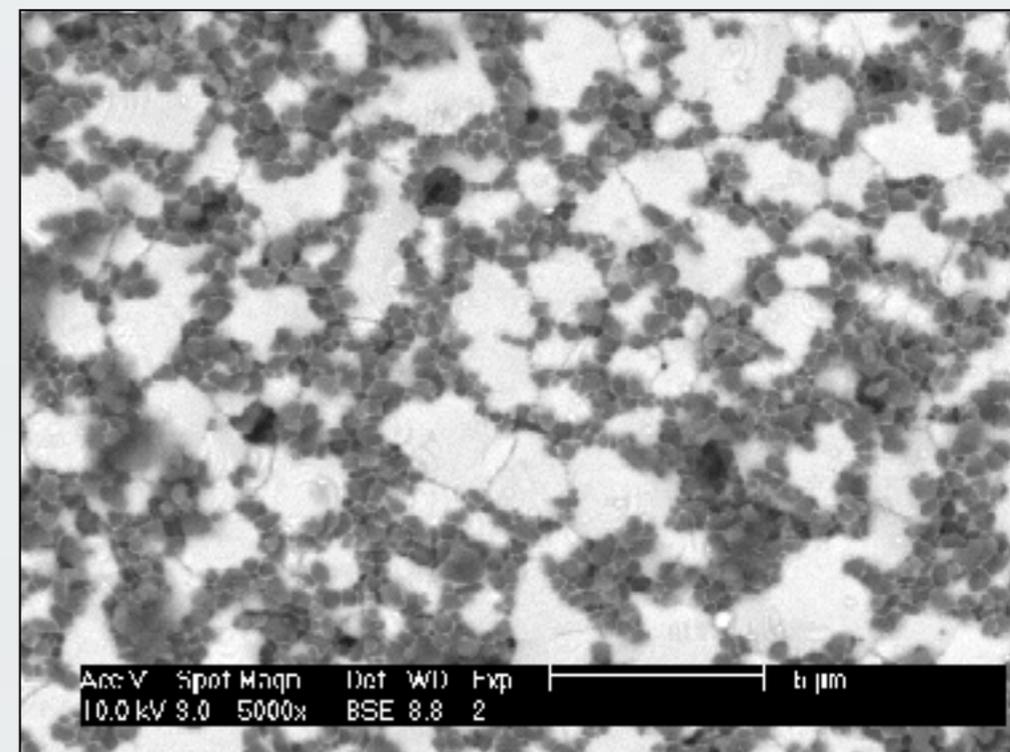
# Ag/Pd Thick Film with Glass Phase

Ag/Pd thick film, with glass phase segregated at surface.



← Secondary Electron Image

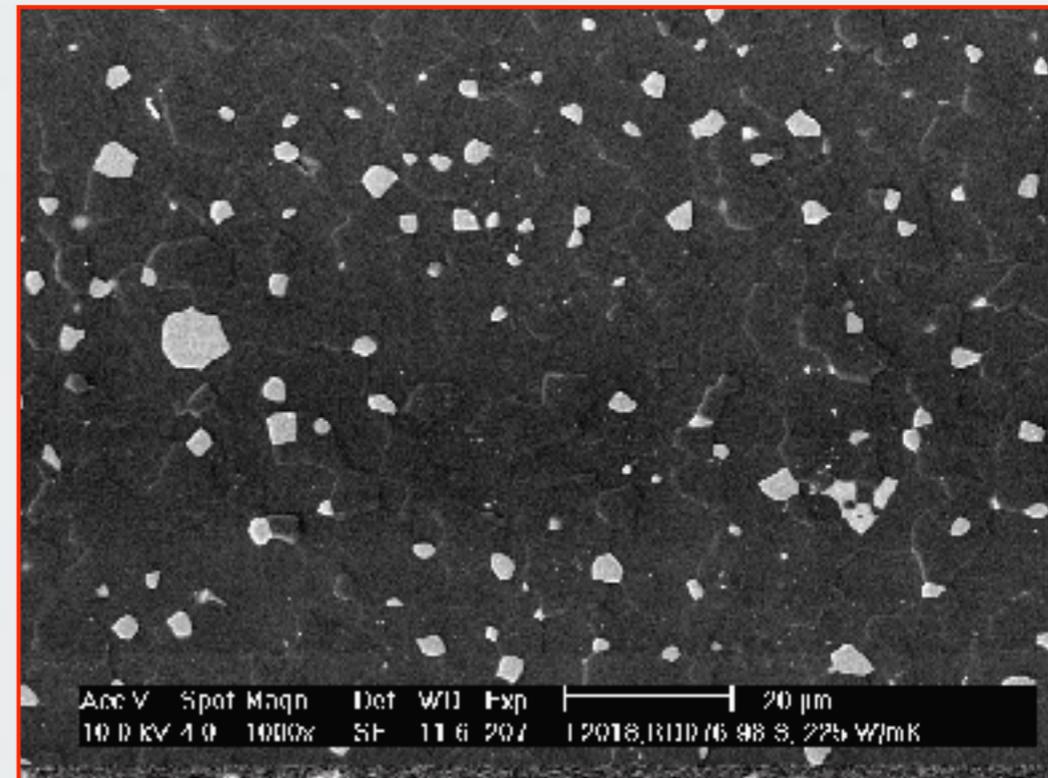
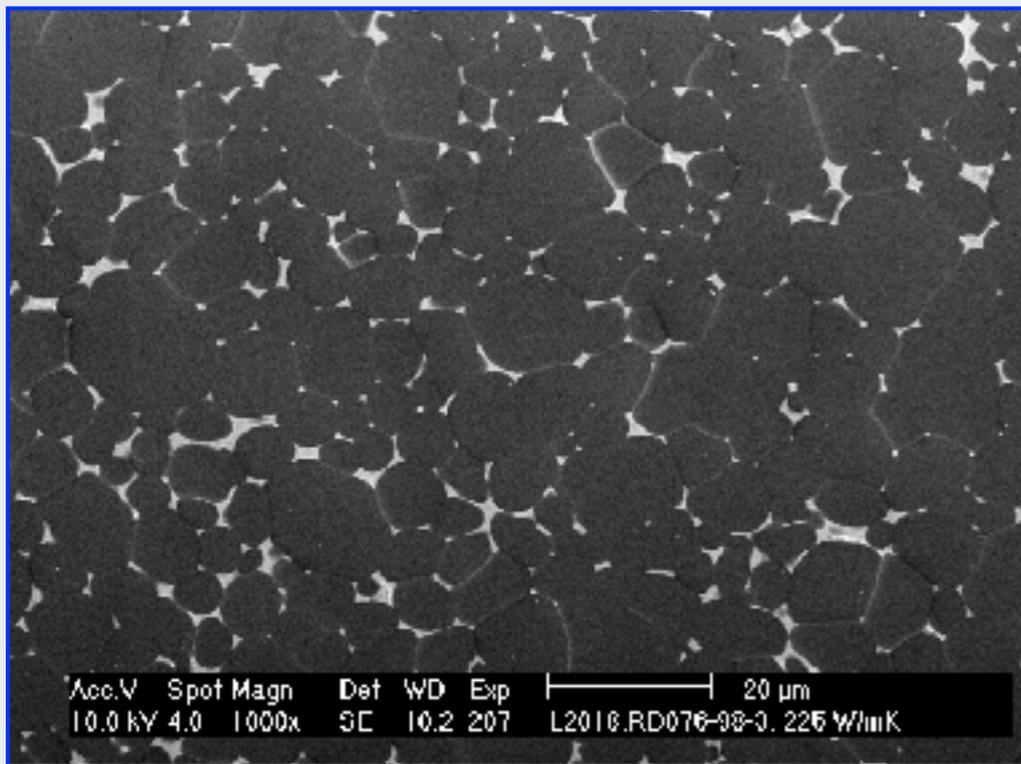
Backscattered Electron Image →





# AlN Microstructure

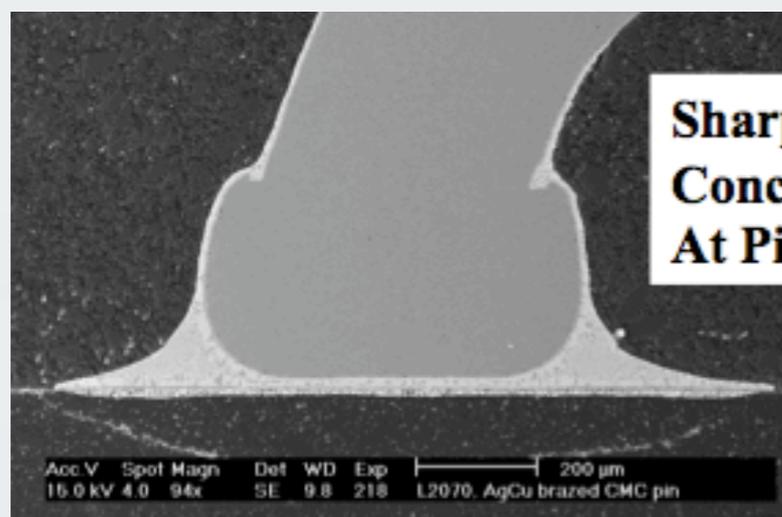
AlN Grains with wetting Y-Al-O phase. Liquid phase sintered microstructure



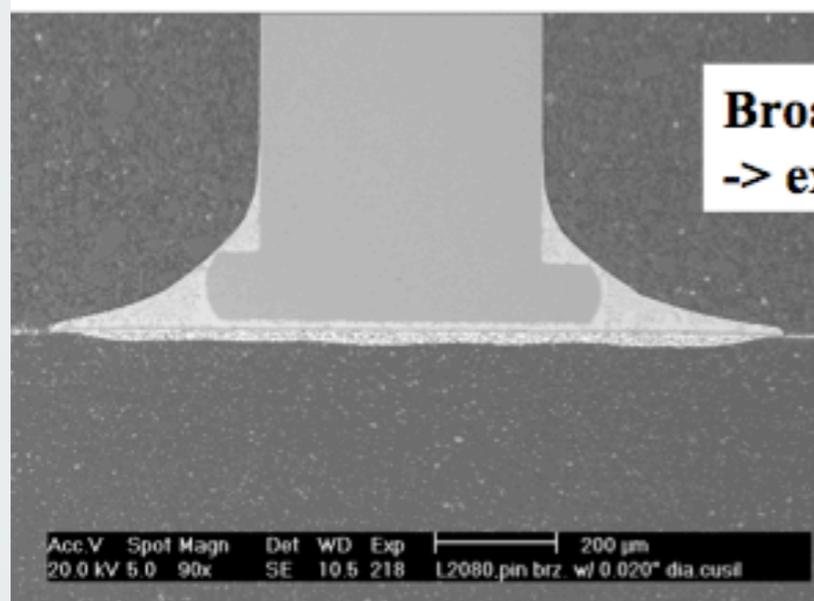
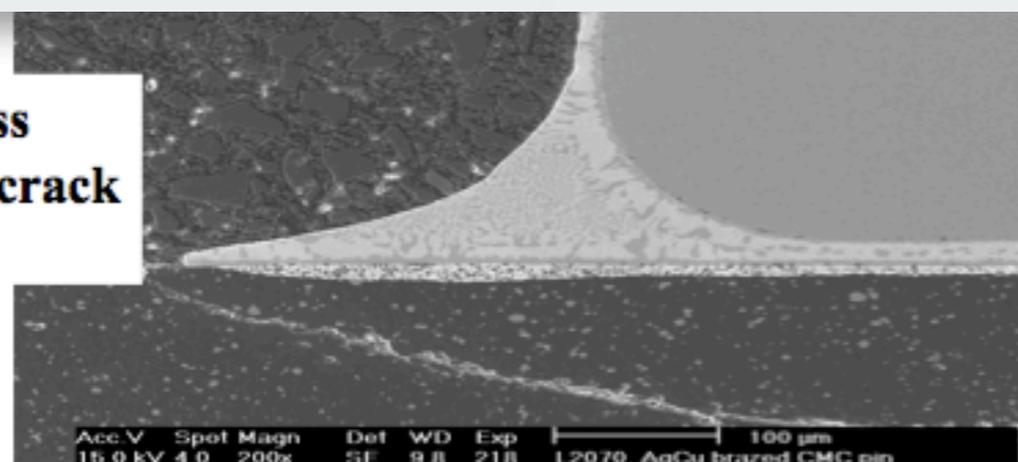
AlN Grains with de-wetting Y-Al-O phase. Solid state sintered microstructure.



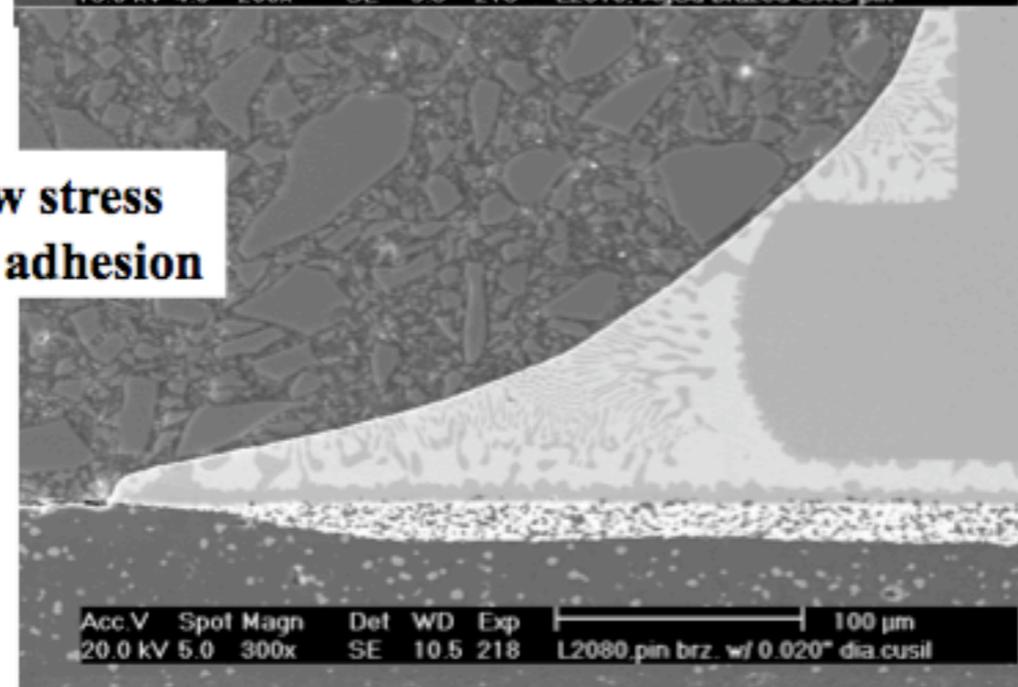
# Eutectic Microstructure- CuAg



**Sharp fillet = stress  
Concentration -> crack  
At Pin base**

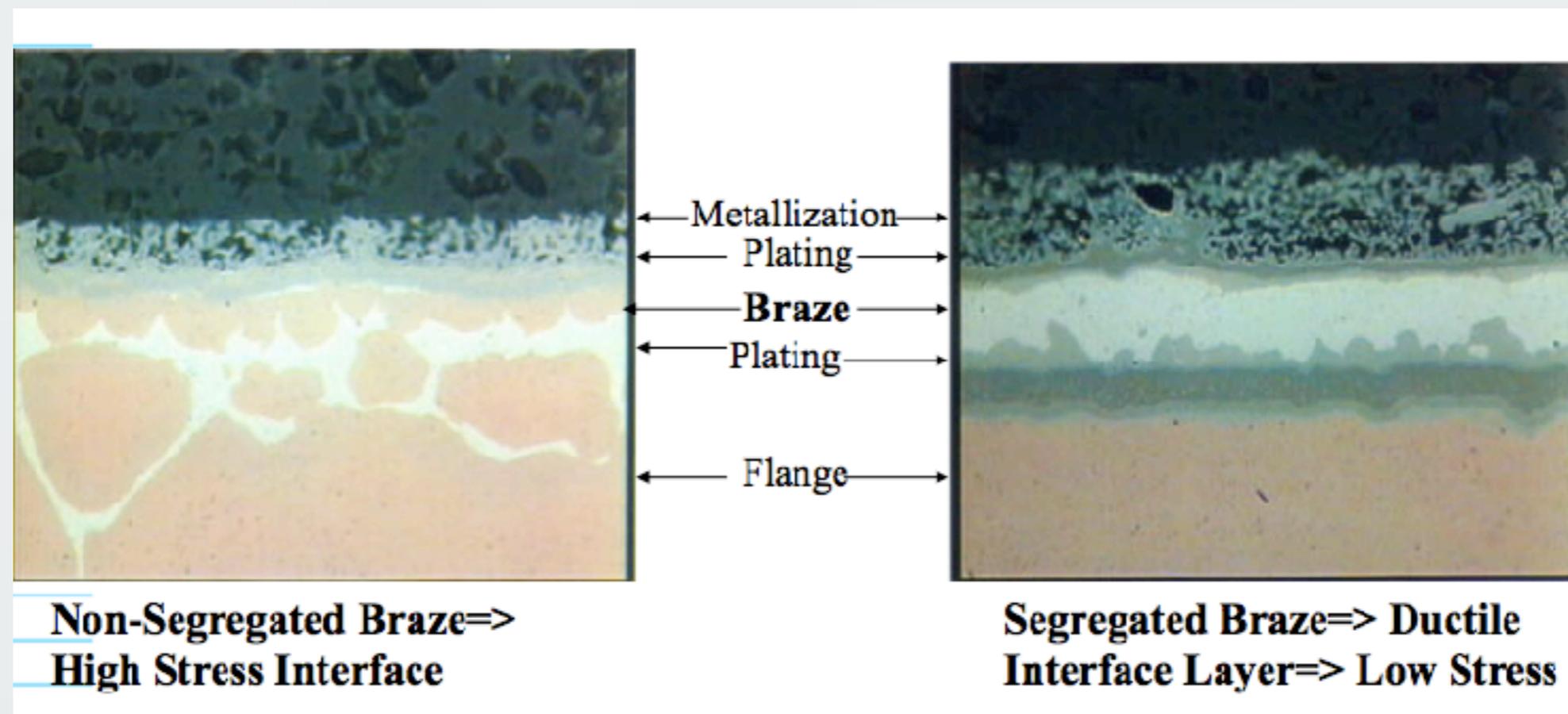


**Broad fillet= low stress  
-> excellent pin adhesion**





# Eutectic Microstructure- CuAg





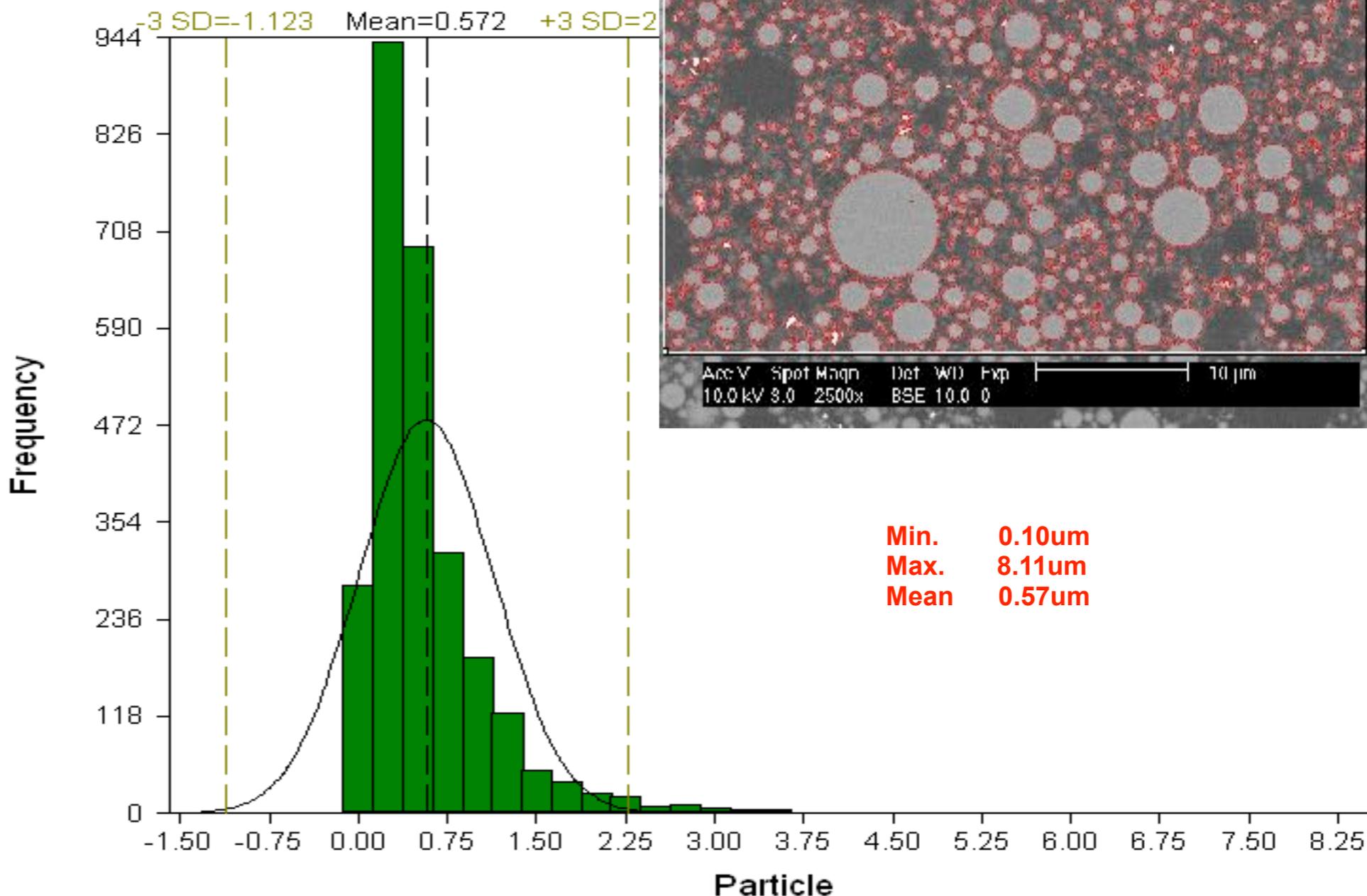
# Grain or Particle Size Image and Analysis



# Underfill Filler Particle Size Characterization

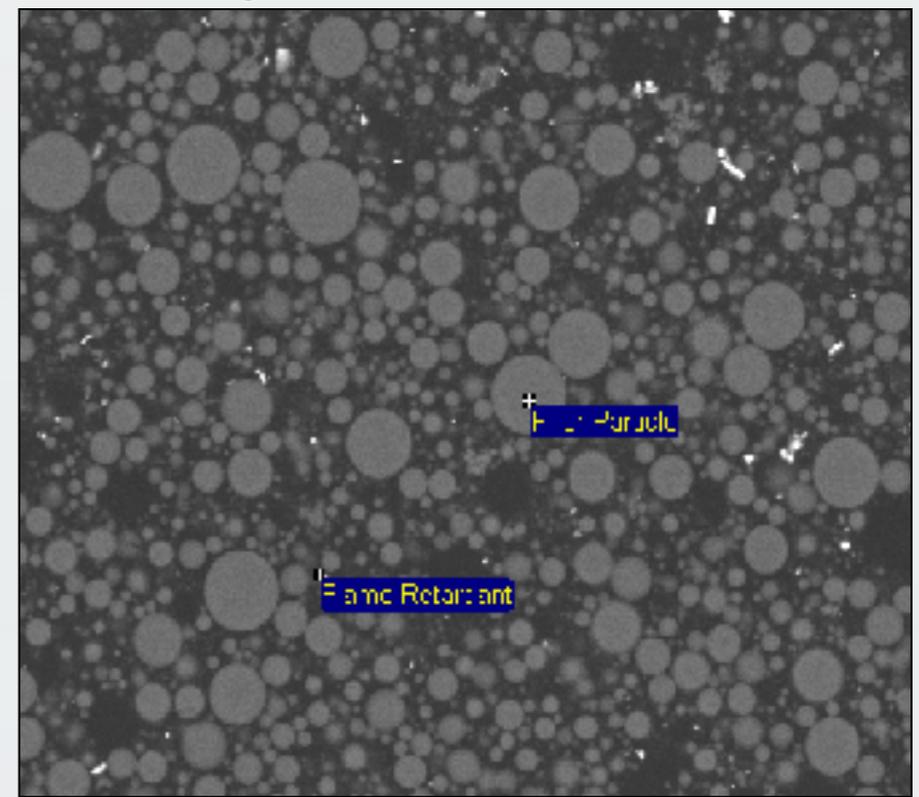
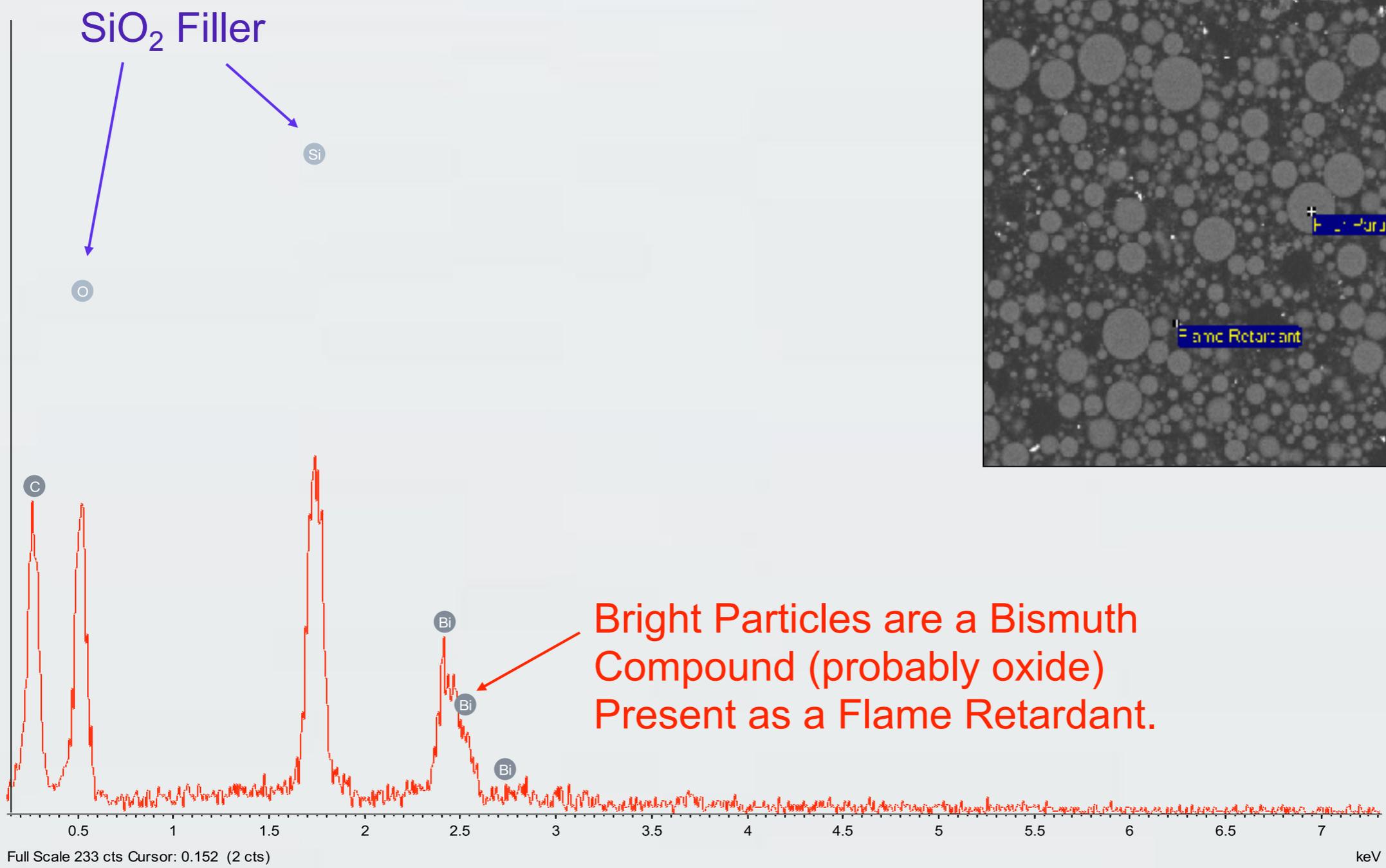
## Process Statistics

Total:	2722
Rows:	All
Cell Width:	0.250
Std Dev:	0.565
Range:	8.01
Skewness:	3.280
Kurtosis:	20.550
PP:	N/A
PR:	N/A
PpM:	N/A
PpK:	N/A
PpU:	N/A
PpL:	N/A
Z-upper (Perf):	N/A
Z-lower (Perf):	N/A
Est % out SL (Perf):	N/A
Act % out of SL:	N/A
Dist:	Normal
Fit Test:	K-S
Fit:	0.201
p-value:	0.0000



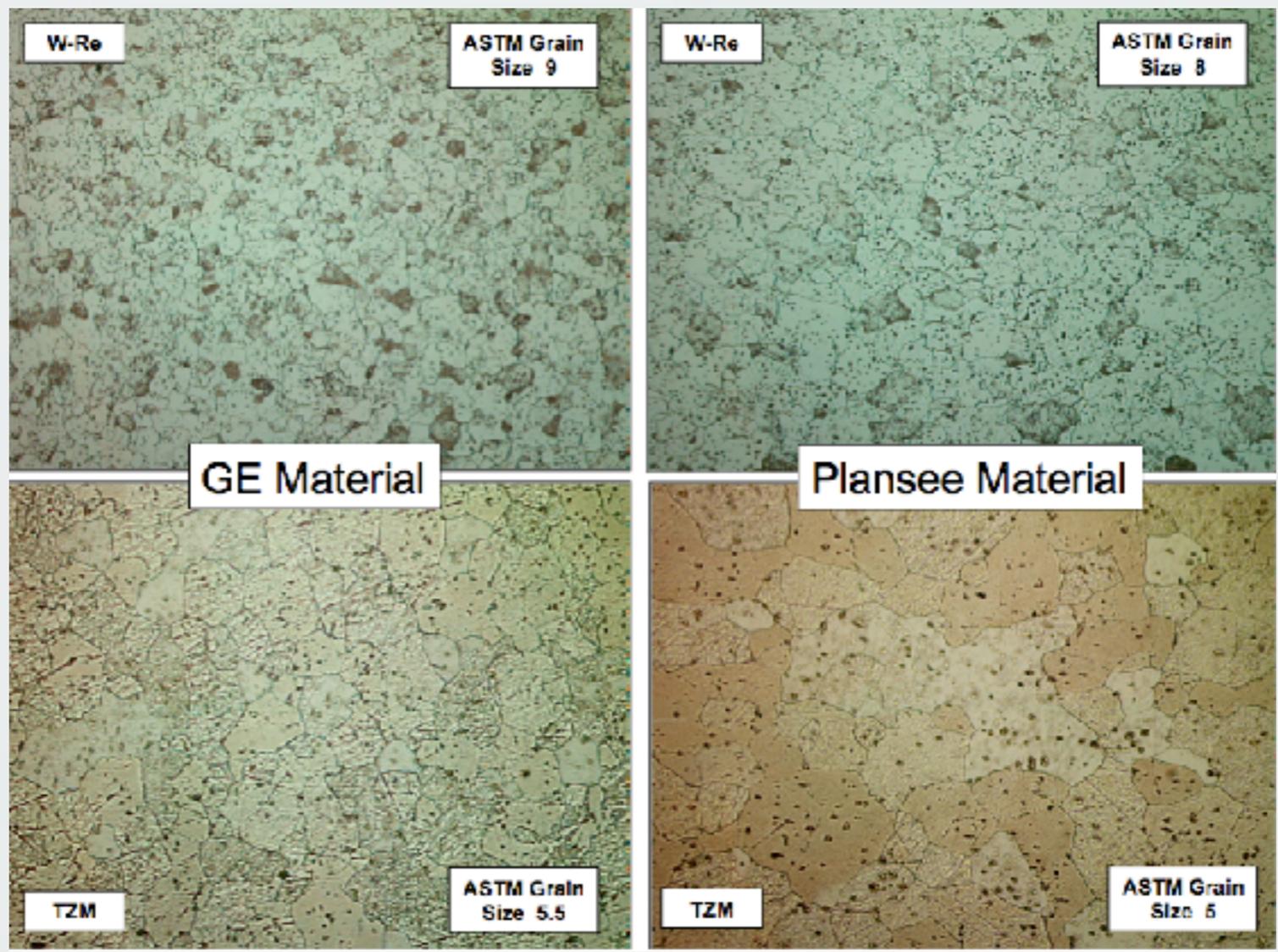


# Analysis of Underfill Components by EDS





# Etching to Reveal Grain Structure and Secondary Phases





# Thin Film Structure



# Thin Film Morphology

- Chemical attack seen in thin film underlayers after plasma cleaning in oxygen
- Thin film structure compared for plasma cleaned and non-plasma cleaned samples
- Oxygen plasma attacked thin film along grains and produced pores which could be seen in cross-section

# Relation of Thin Film Structure and Surface Morphology

