P. Kay Metal Inc.

Lead Free Wave Solder Analysis

Presentation Report

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This data provided by Dr. Erik Severin of P Kay Metal

Technical Information

Pre-Heat #1: 350F/177C
Pre-Heat #2: 615F/324C
Top Side Board Temp: 248 – 266F/120 – 130C
Conveyor Speed: 4 ft/min
Flux: MultiCore MFR301, No Clean, Sustained Activity Flux

After pot reached 1st operating temperature (490F set point) the dross was removed.

Five boards at each condition were run, the last two boards of each run were analyzed.

One flat pin of a dip connector and one round pin of the 6-pin header were cross-sectioned

Board Designations

Board #4 & #5	Pot Temp (set pt): 490F/254C, (actual): **488**F/253C, **No MS2**
Board #19 & #20	Pot Temp (set pt): 490F/254C, (actual): **488**F/253C, **MS2 added** and allowed to mix for 1/2 hour before boards were run.
Board #24 & #25	Pot Temp (set pt): 485F/252C, (actual): **477**F/247C, **MS2 present**
Board #29 & #30	Pot Temp (set pt): 485F/252C, **No MS2** present, all traces cleaned off one week prior, Engent ran their lead-free class between the cleaning and running these boards.

Findings

- **Eight boards, boards 4, 5, 19, 20, 24, 25, 29 and 30, were chosen for cross section analysis of the 6 pin header and a through hole DIP device, . Each of the section were done through the center of the pins so that the solder grain structure could be seen and the intermetallic thickness of the solder to board wall and solder to pin wall could be determined.**
- **The solder structure of the DIP devices was clean and homogeneous. The structure of the header pins had signs of course contamination throughout the solder. This contamination was mainly made up of tin and silver, but showed high levels of oxides and an ionic presence of sulfur and chlorine. It is unknown the reason why this was only seen in the header sites.**
- **Intermetallic thickness varied from 500 nm up 1.5 microns at the solder to plated through hole (PTH) locations and from 900 nm up to 3.2 microns at the solder to pin locations. There was no significant difference in the 482F and 495F temperature differences on the IML thicknesses and no obvious difference could be seen in IML thicknesses from the 4 experimental sets. A table showing this data can be seen on slide 3.**
- **All sections showed acceptable hole fill and solderability to the DIP leads and the header pins.**

Follow on Comments by Dr. Dan Baldwin of Engent
In response to a request for clarification by Larry Kay

- Larry,

  Sorry for the delay in getting back to you on this information. I wanted to do some background work before responding. In reviewing the through hole soldering results, the following observations can be made.

  ## Solder Wetting:
  The results show good solder wetting with joints meeting or exceeding IPC 610C class 3 requirements for boards processed with and without the solder pot additive. Relative to typical production through hole wave solder joints analyzed at Engent for PbSn solders, the joints produced for all of the board assemblies process for P.K. Metals were considerably high quality.

  ## Solder Grain Structure:
  No apparent change is grain structure is found for the boards processed with and without additive. Generally the SnAg intermetallic ranged in size from 1 to 4 microns. This is a typical range for as processed wave solder joints at Engent with the SAC305 alloy. The boards processed without additive generally had more variability in the SnAg grain size then units processed with additive.

  ## Header Joint Contamination:
  The header joints contained an excess of contamination through the majority of boards processed for P.K. Metals. When present, the contaminants were concentrated along the pin in the solder. Density effects tended to result in contaminant layers on the top fillets of the solder joints. The material composition of the contaminants included sulfur, chlorine, and oxygen in addition to the solder metal elements. The structure and composition of the contaminants tends to suggest that they are flux residues, flux compounds, and/or additive residue present in the header solder joints. Moreover, the contamination level in the solder joints did not appear to be reduced by the solder pot additive. *Joints pre and post additive showed similar contamination levels*.

  The DIP joints showed minimum presents of the contaminants being evident only on a few components at the surface of the top solder fillet.

- The general finds are that the solder joints produced with the P.K. Metals additive are very similar to those processed without the additive with the exception of slightly less intermetallic grain size variation.

  I hope this information is helpful in your product development.

  Regards,
  Dan
  Daniel F. Baldwin, Ph.D.
  ENGENT, Inc.

E Mail from Baldwin

Findings

P KAY METALS CROSS-SECTION SUMMARY					
X-Section#	Component Type	Structure	IML Interface Wall to Solder	IML Interface Solder to Pin	Notes
4	3-Pin Header	Good	1 µm	1.10 µm	Lot of solder contamination
4	Dip	Good	900 nm	1.35 µm	No voids
5	3-Pin Header	Good	900 nm	900 nm	A little bit of voids
5	Dip	Good	1 µm	2 µm	
19	3-Pin Header	Good	1 µm	3.20 µm	Lot of solder contamination
19	Dip	Good	500 nm	1.50 µm	No voids
20	3-Pin Header	Good	680 nm	860 nm	Lot of solder contamination
20	Dip	Good	550 nm	1.40 µm	
24	3-Pin Header	Good	1 µm	1 µm	OK
24	Dip	Good	1.60 µm	1.33 µm	OK
25	3-Pin Header	Good	1.20 µm	3 µm	Lot of solder contamination
25	Dip	Good	620 nm	2.5 µm	No voids
29	3-Pin Header	Good	1 µm	1.60 µm	Lot of solder contamination
29	Dip	Good	2 µm	2.5 µm	Unclear IML at solder-pin interface
30	3-Pin Header	Good	900 nm	2.3 µm	Homogeneous Structure
30	Dip	Good	667 nm	2.0 µm	Some small voids in lower part

LEGEND:
IML = Intermetallic Layer

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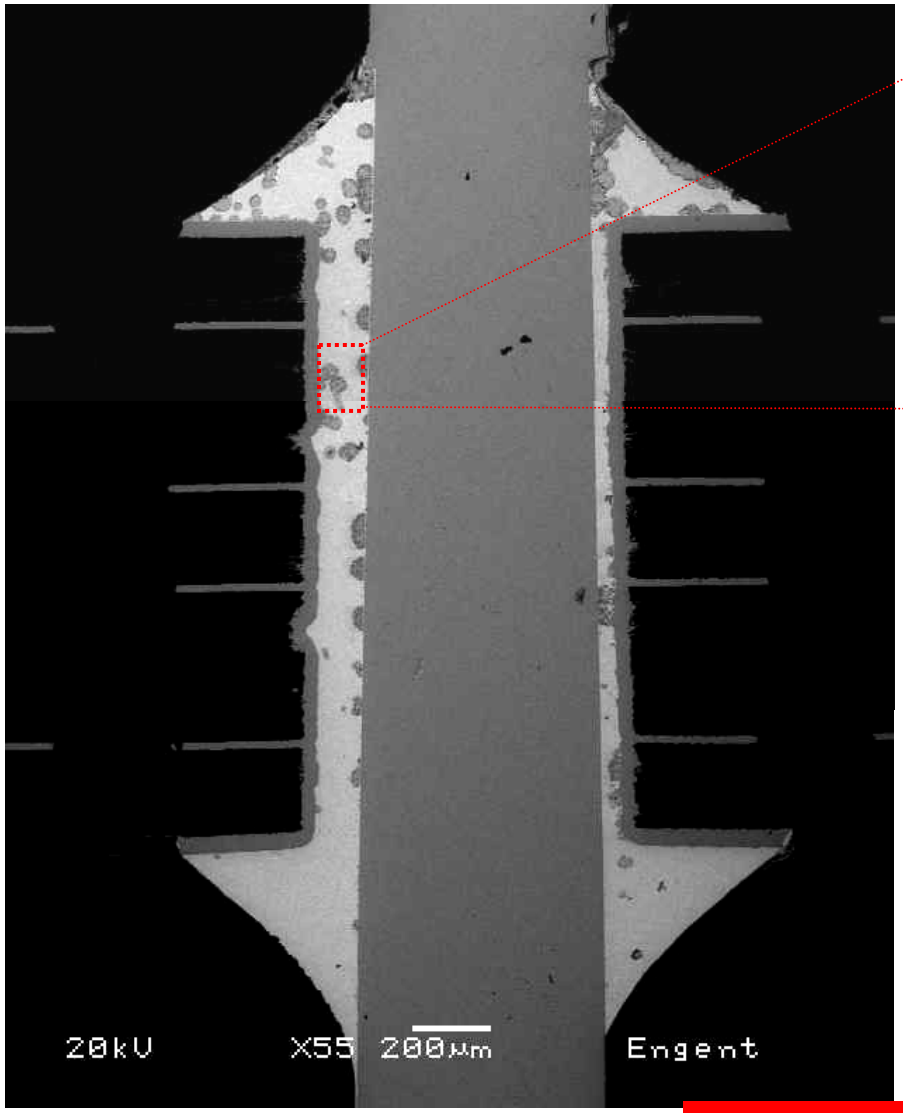
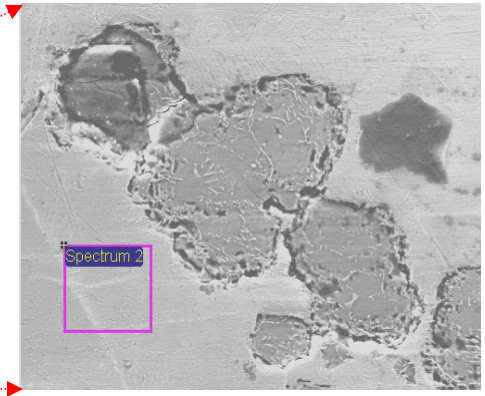
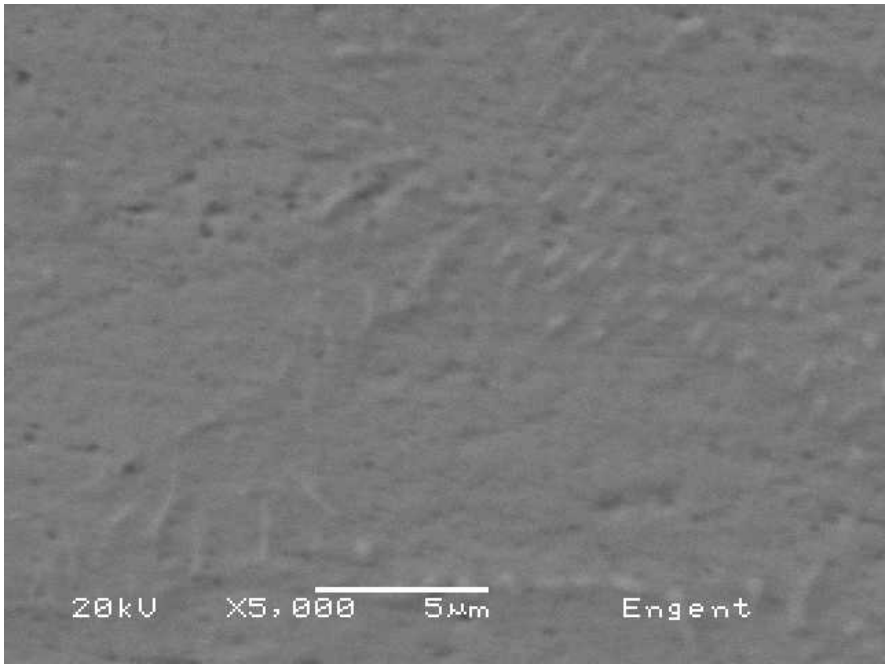
Board # 4

EJS note: 488 F actual T, No MS2

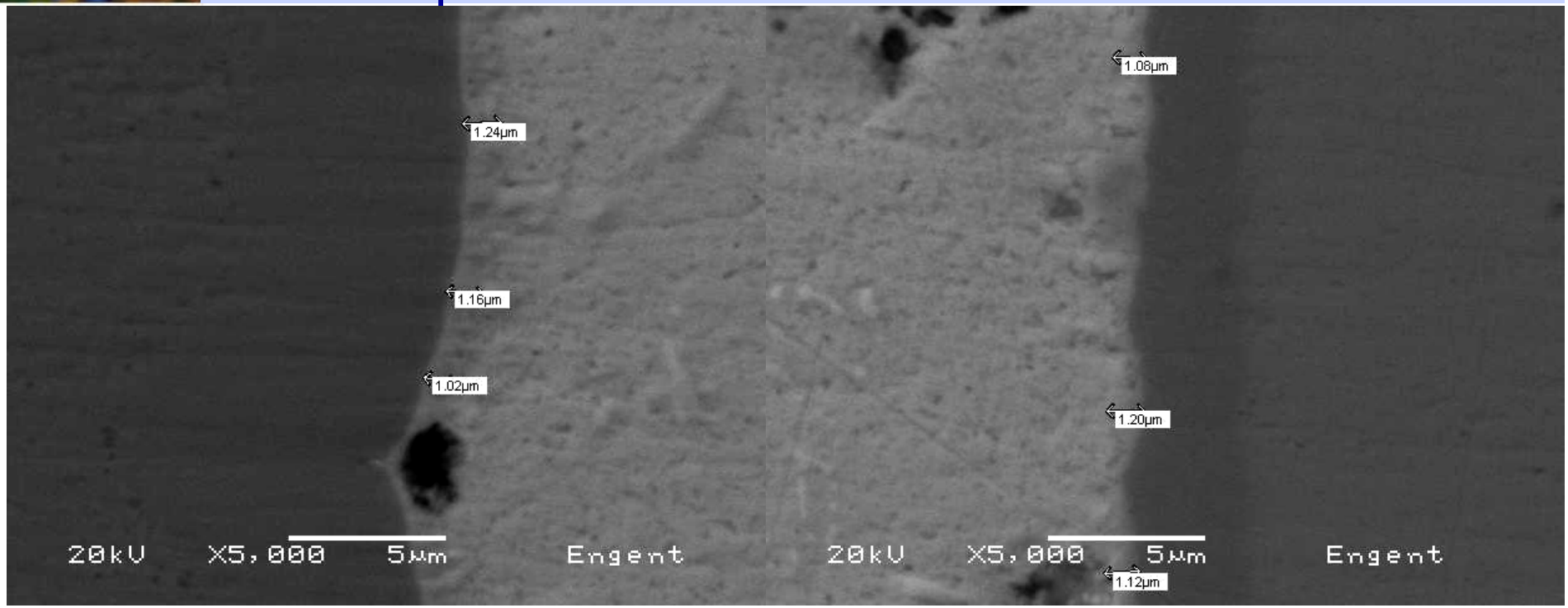
Board 4 showing overall image of Header Pin and solder grain structure







Board 4 showing intermetallic layer (IML) thickness at solder/pin and solder/board interface



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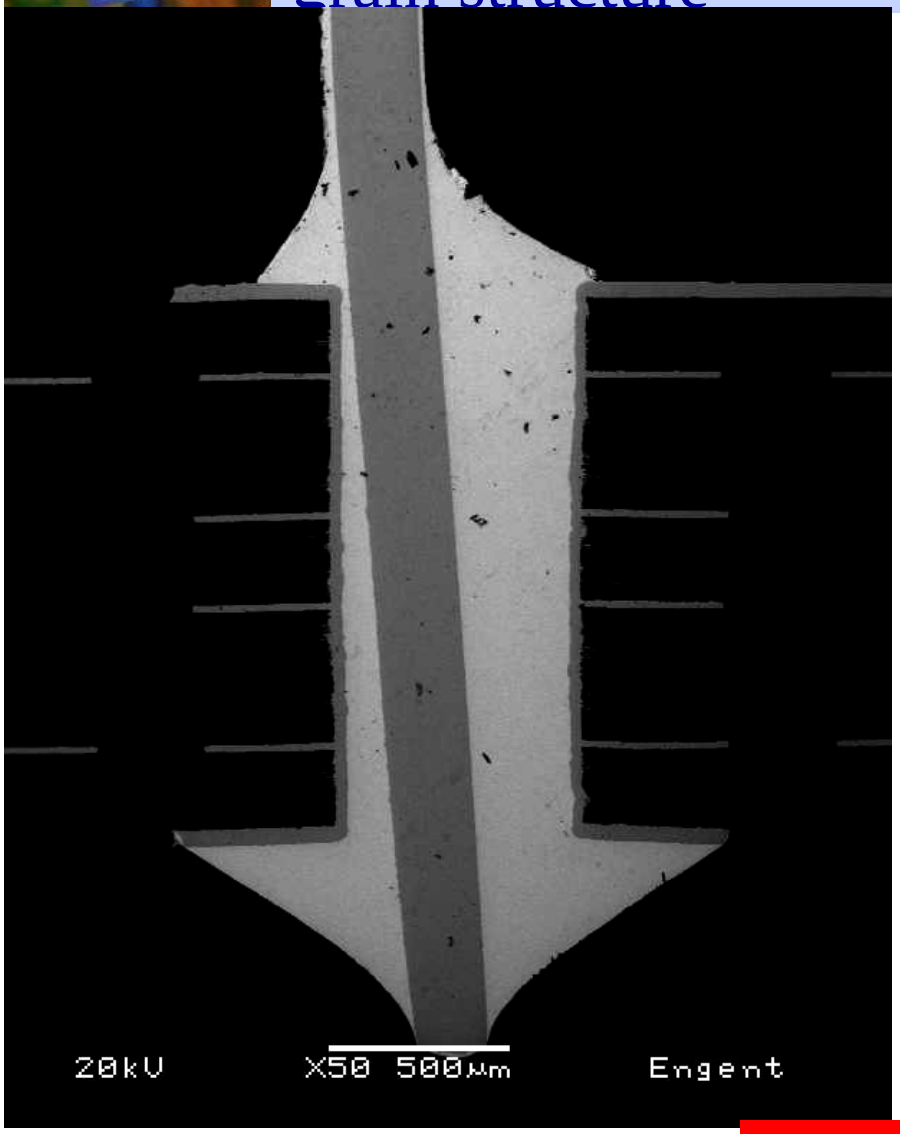
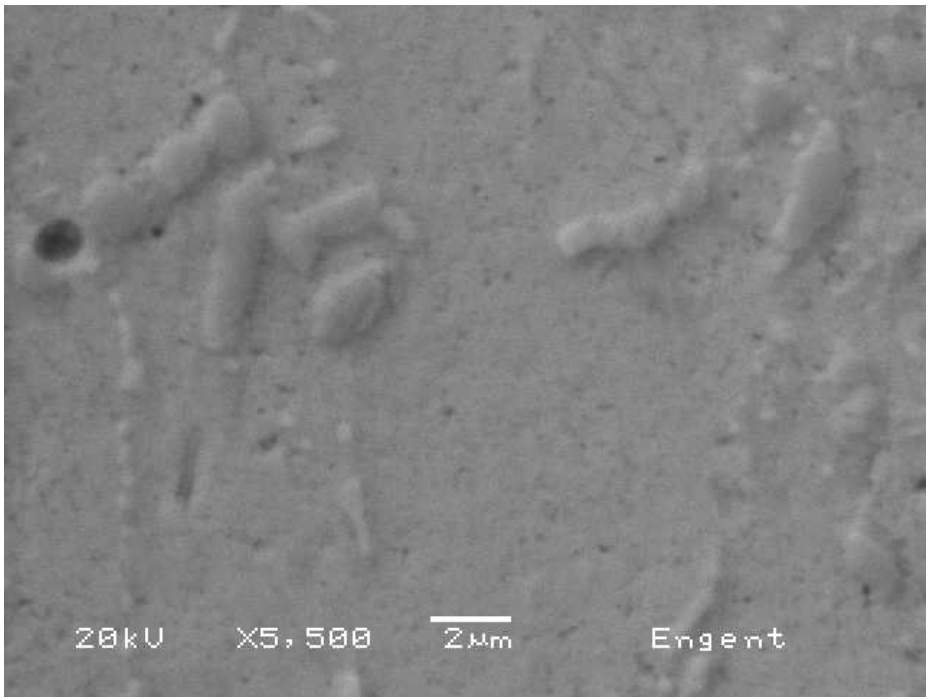
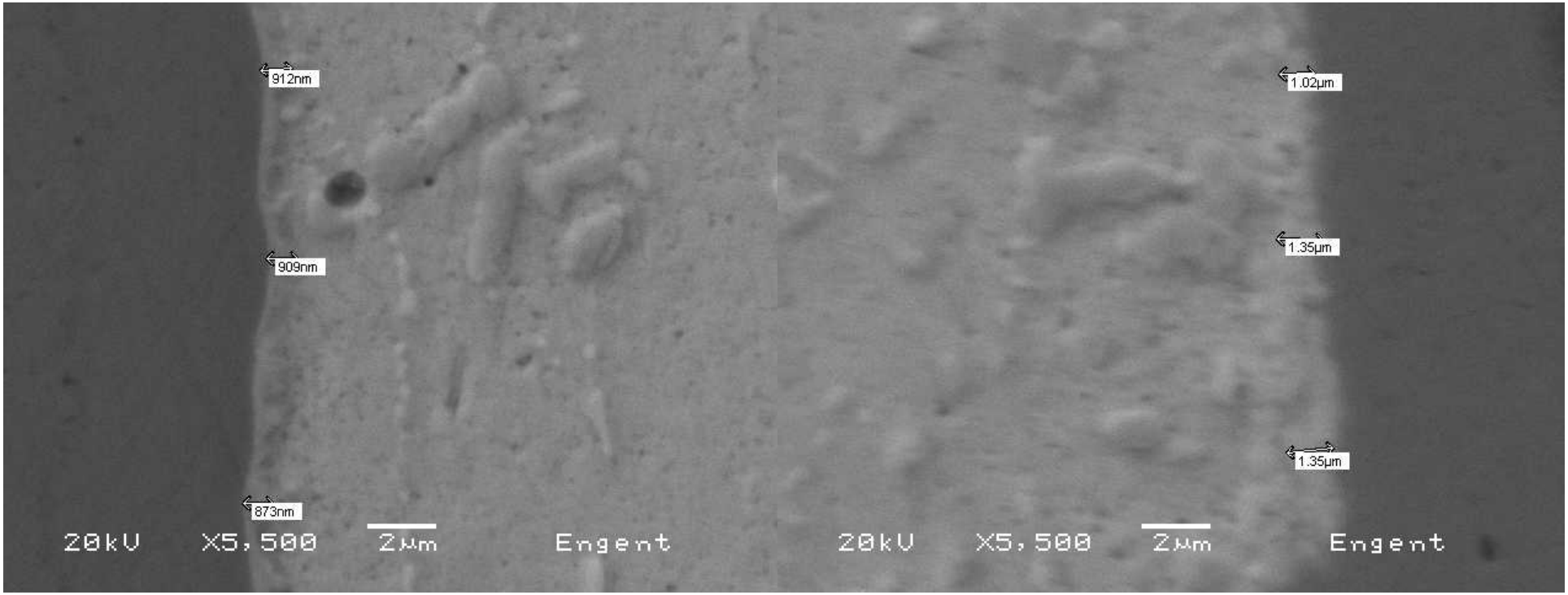
Board 4 showing overall image of DIP Pin and solder grain structure

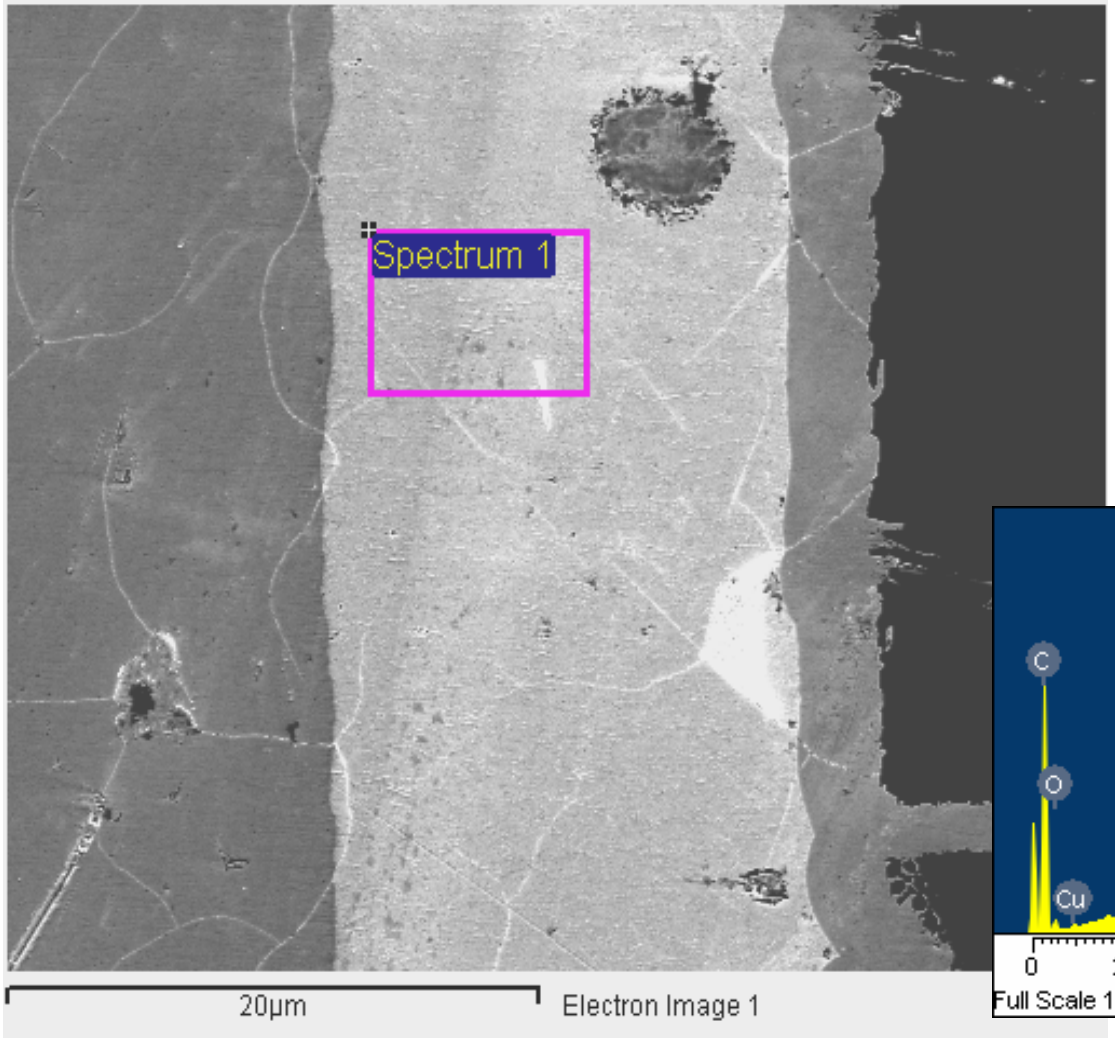




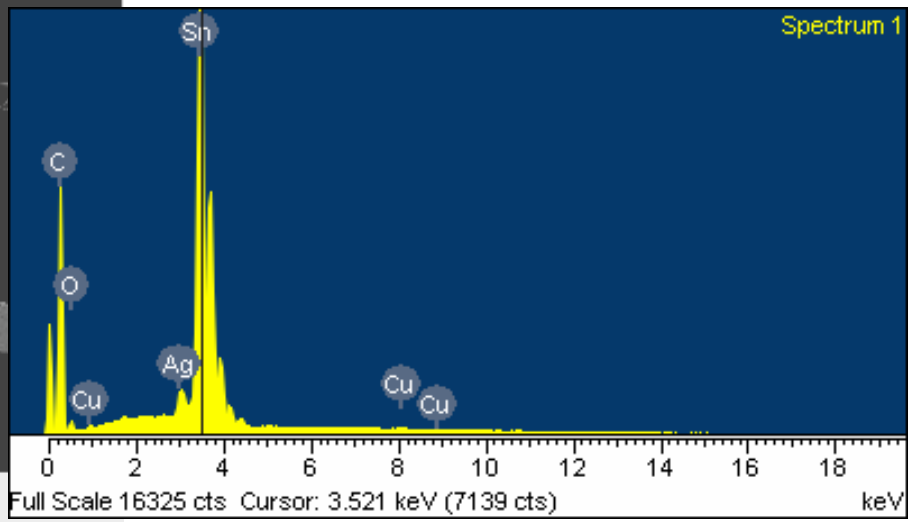
Board 4 showing intermetallic layer (IML) thickness at solder/pin and solder/board interface of DIP pin



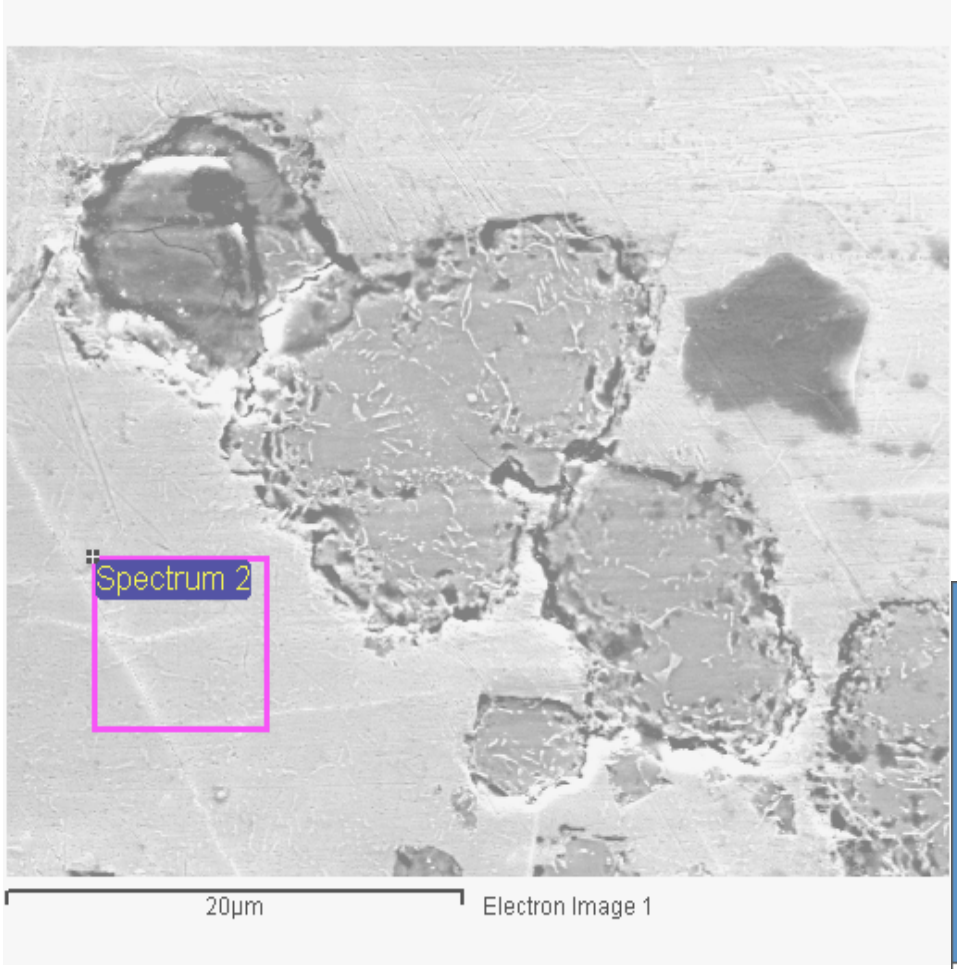
Board 4 pin showing area spectrum of bulk solder



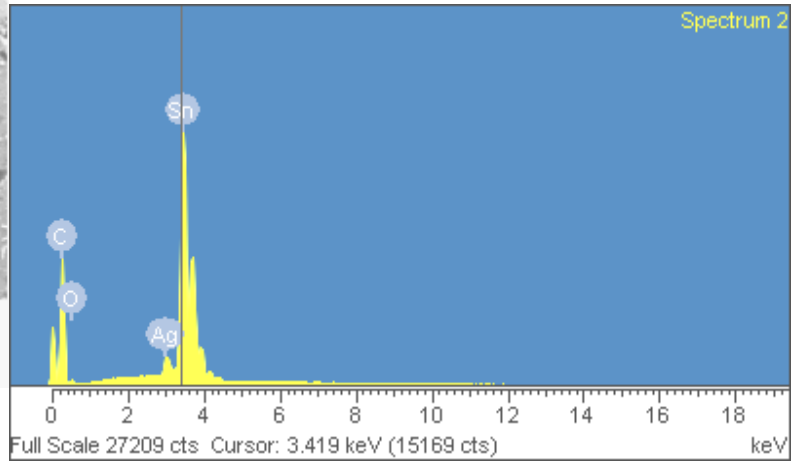
Element	Weight%	Atomic%
O K	6.83	34.99
Cu K	0.78	1.01
Ag L	2.37	1.80
Sn L	90.02	62.20
Totals	100.00	



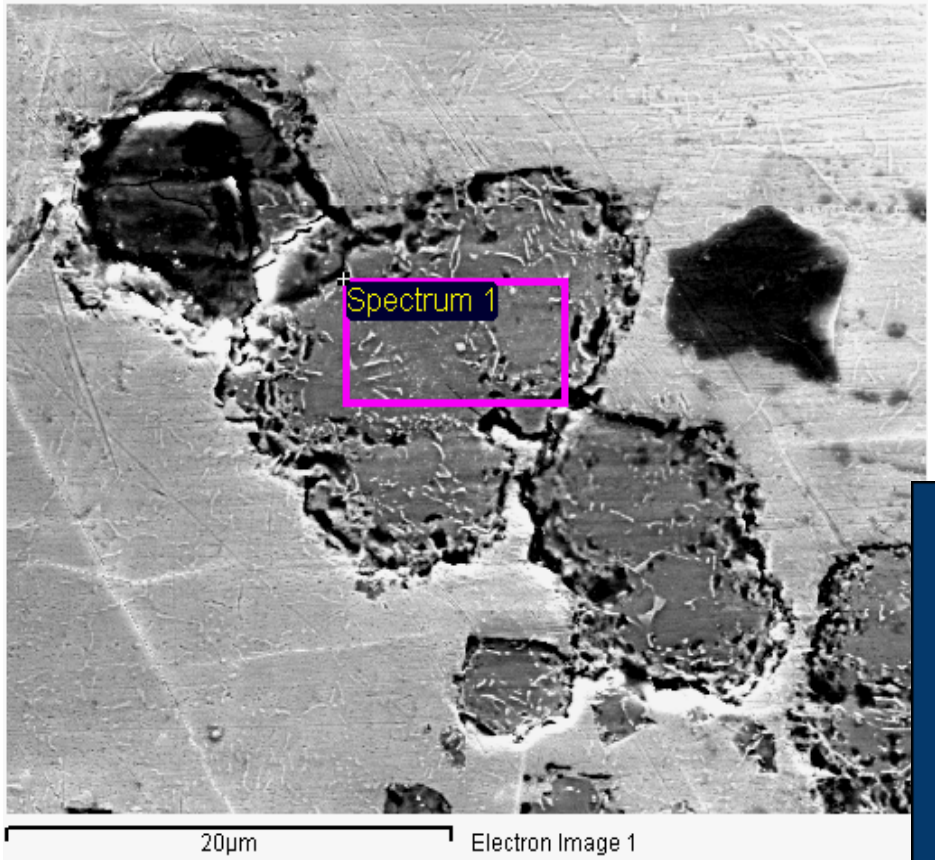
Board 4 pin showing area spectrum of bulk solder



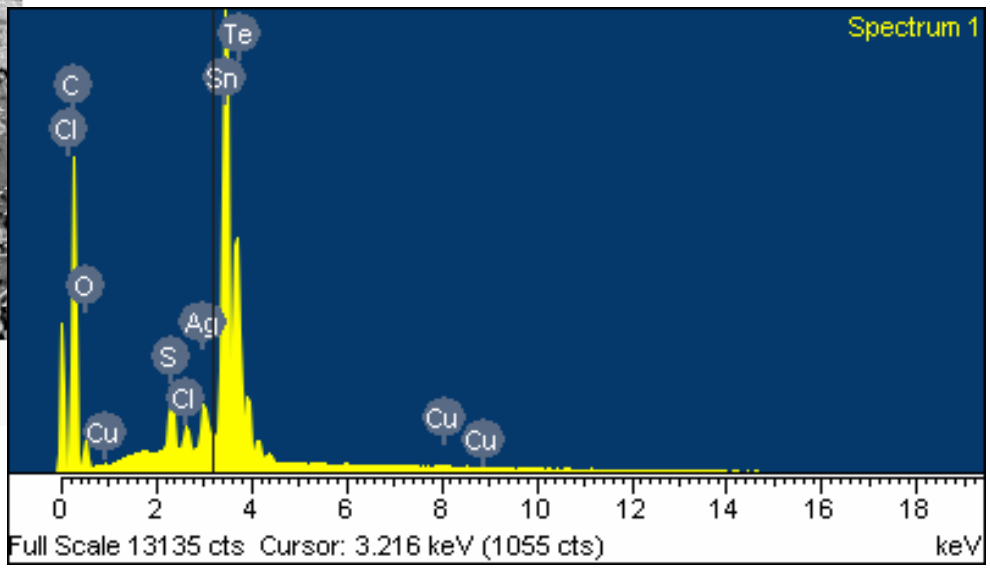
Element	Weight%	Atomic%
O K	6.04	32.19
Ag L	3.78	2.99
Sn L	90.18	64.82
Totals	100.00	



Board 4 pin showing spectrum of dark spots in bulk solder



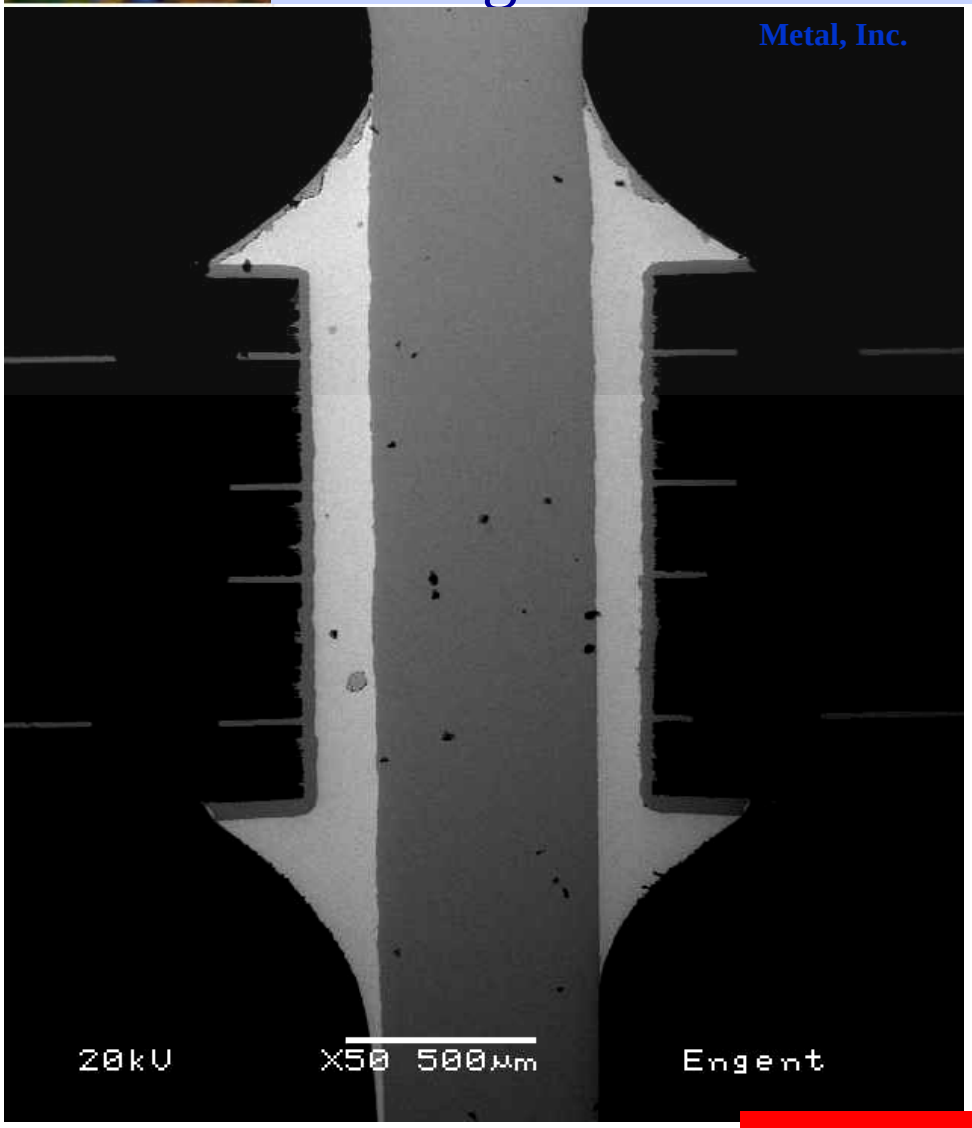
Element	Weight%	Atomic%
O K	14.30	52.39
S K	2.37	4.32
Cl K	1.43	2.36
Cu K	0.67	0.62
Ag L	4.68	2.54
Sn L	75.12	37.10
Te L	1.43	0.66
Totals	100.00	

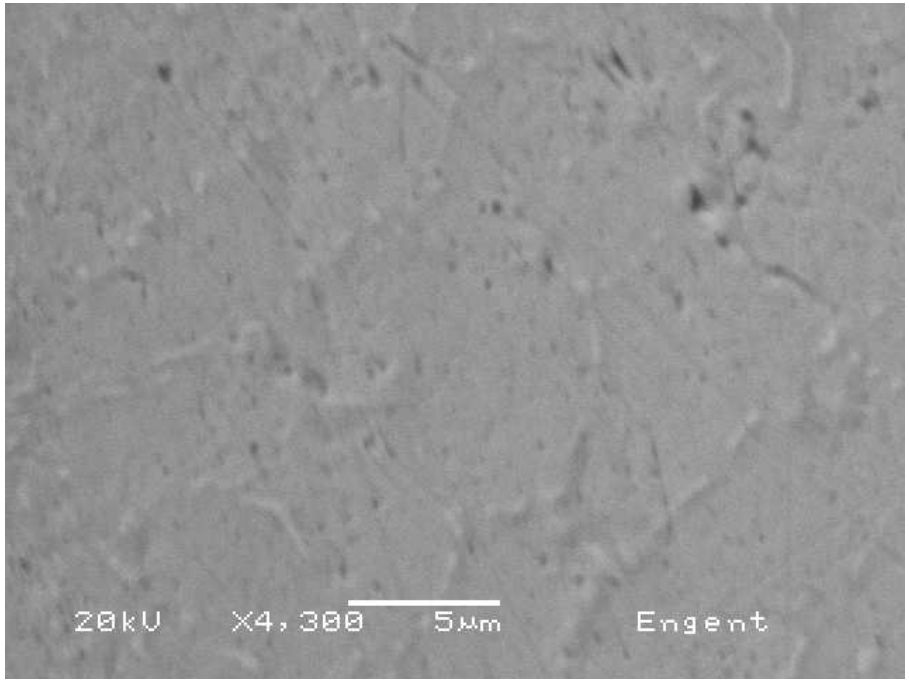


Board # 5

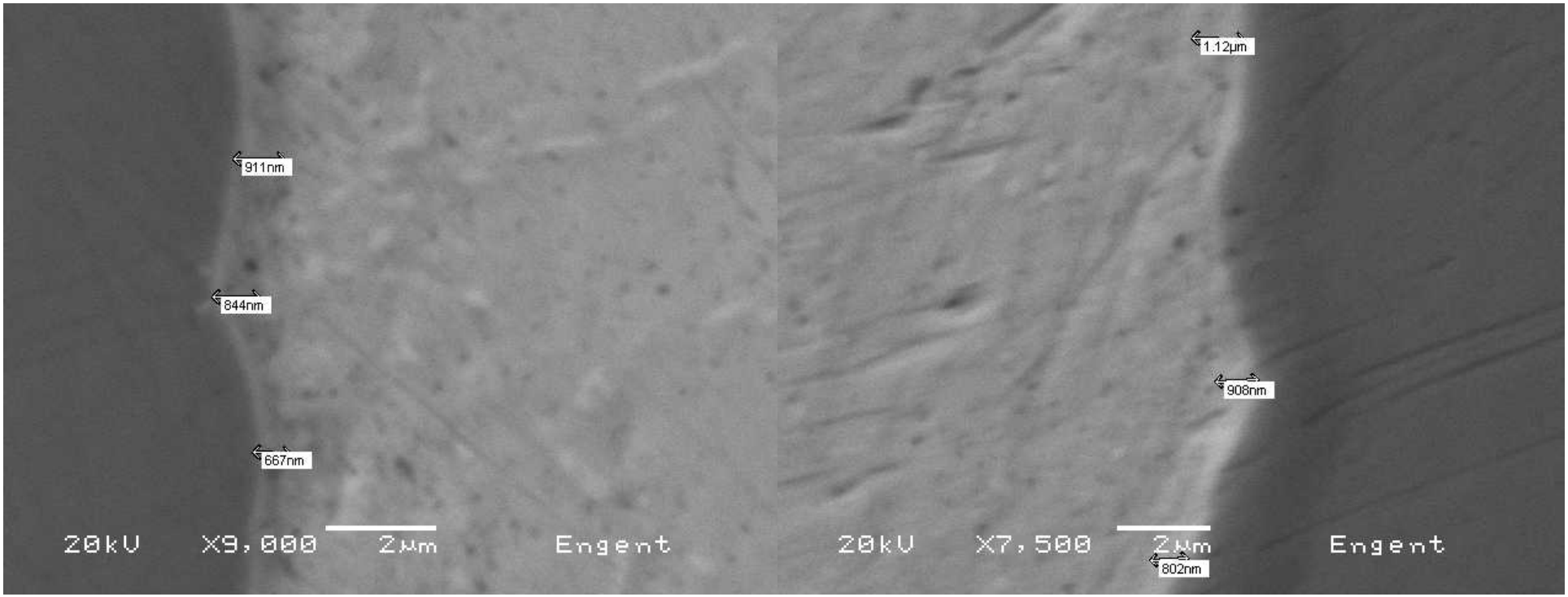
EJS note: 488 F actual T, No MS2

Board 5 showing overall image of Header Pin and solder grain structure

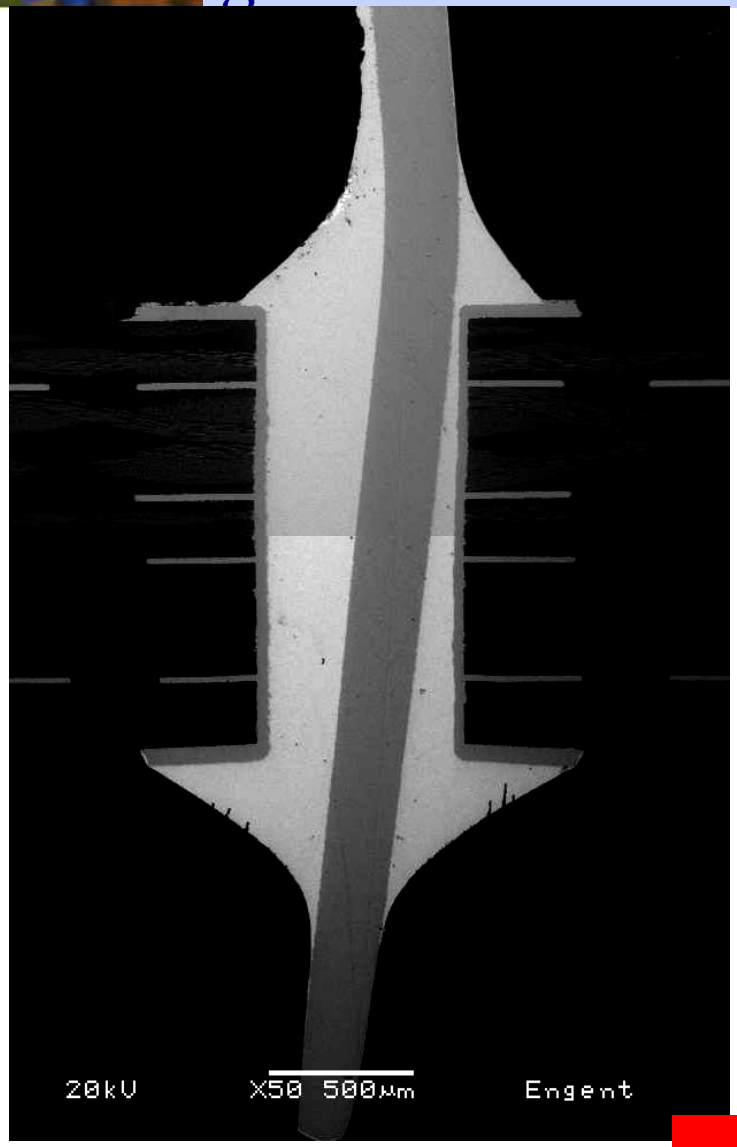


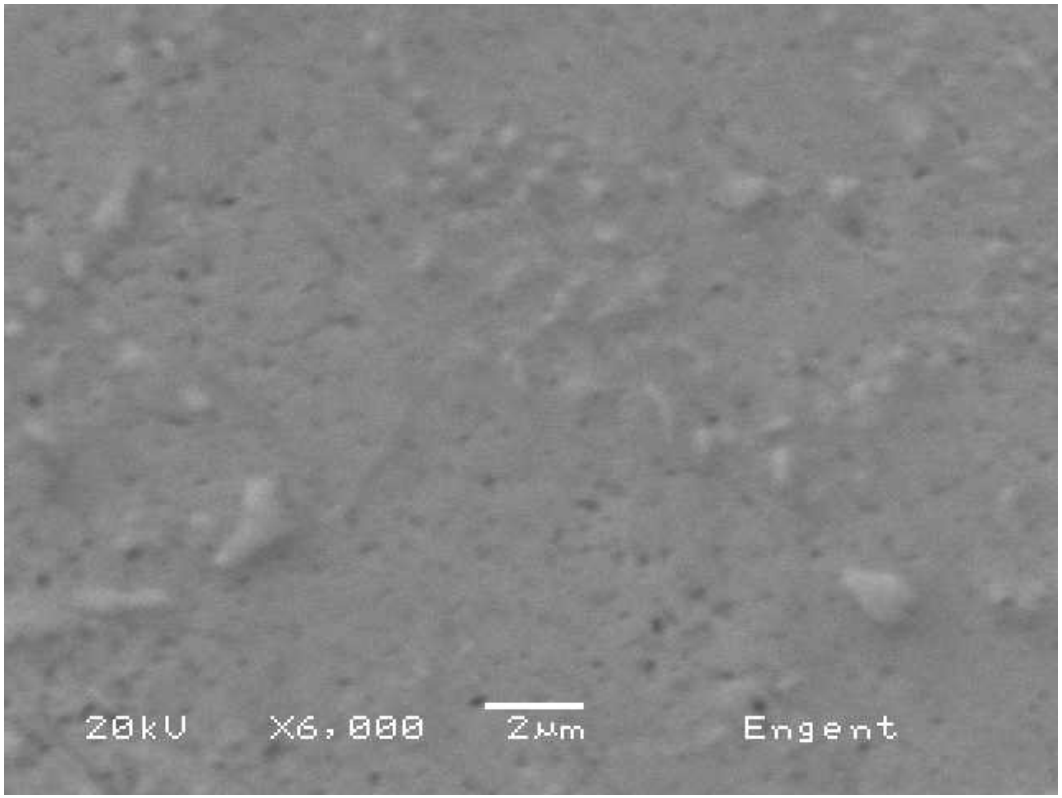


Board 5 showing intermetallic layer (IML) thickness at solder/pin and solder/board interface of Header pin

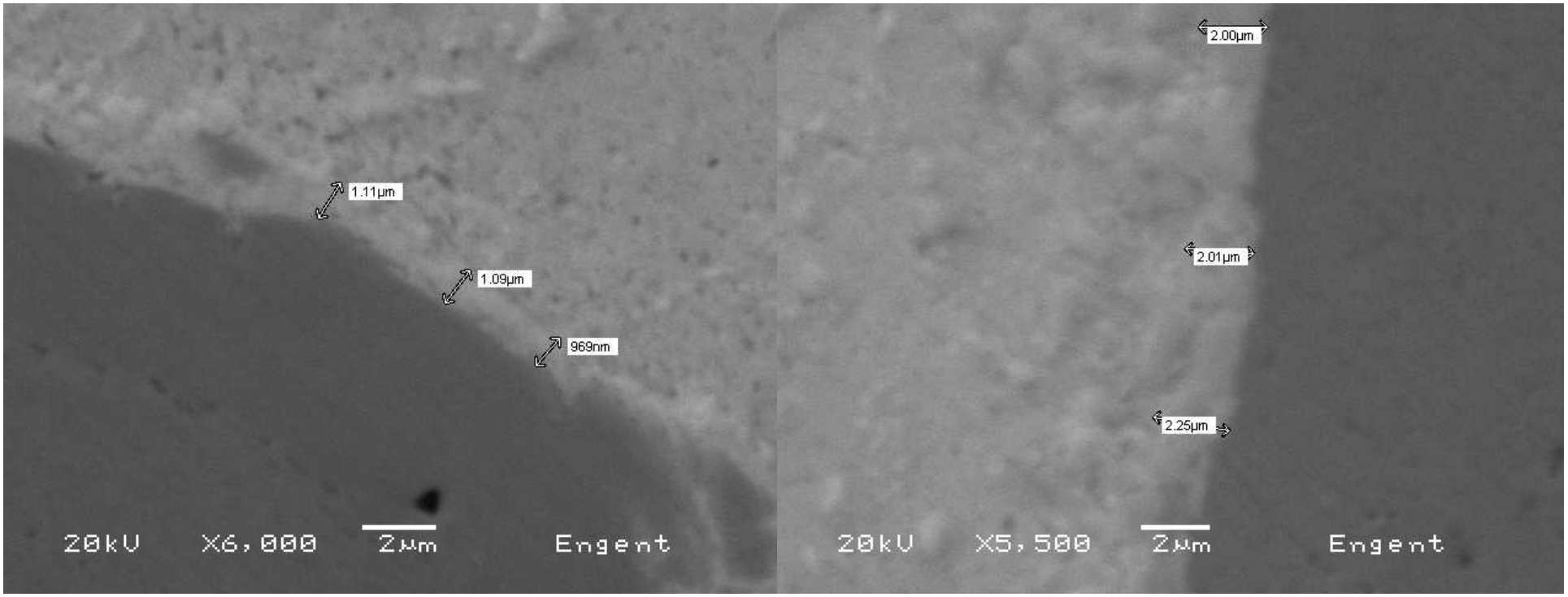


Board 5 showing overall image of DIP Pin and solder grain structure





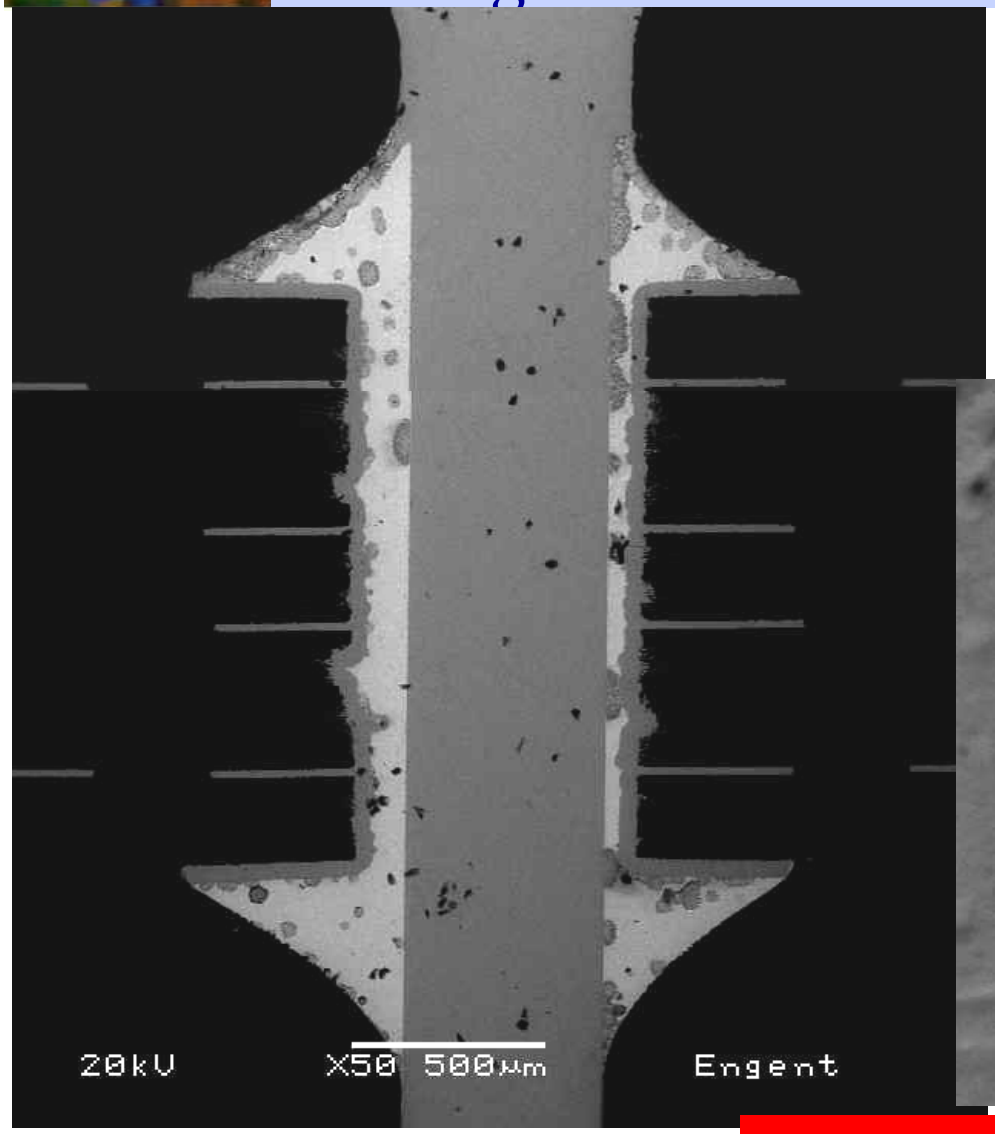
Board 5 showing intermetallic layer (IML) thickness at solder/pin and solder/board interface of DIP pin

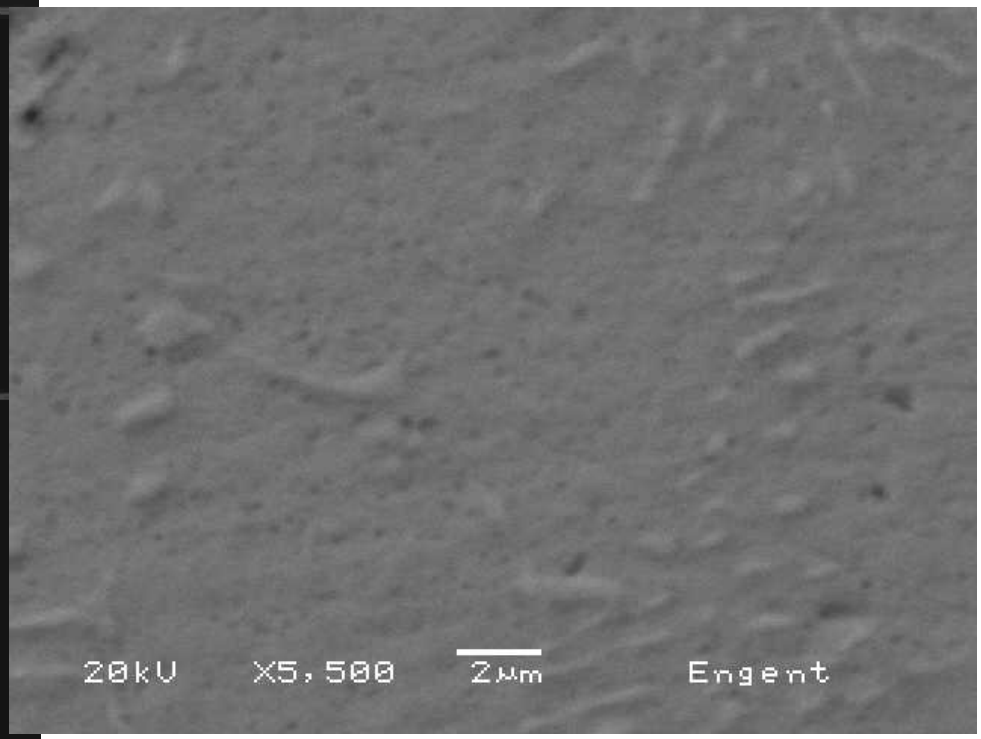


Board # 19

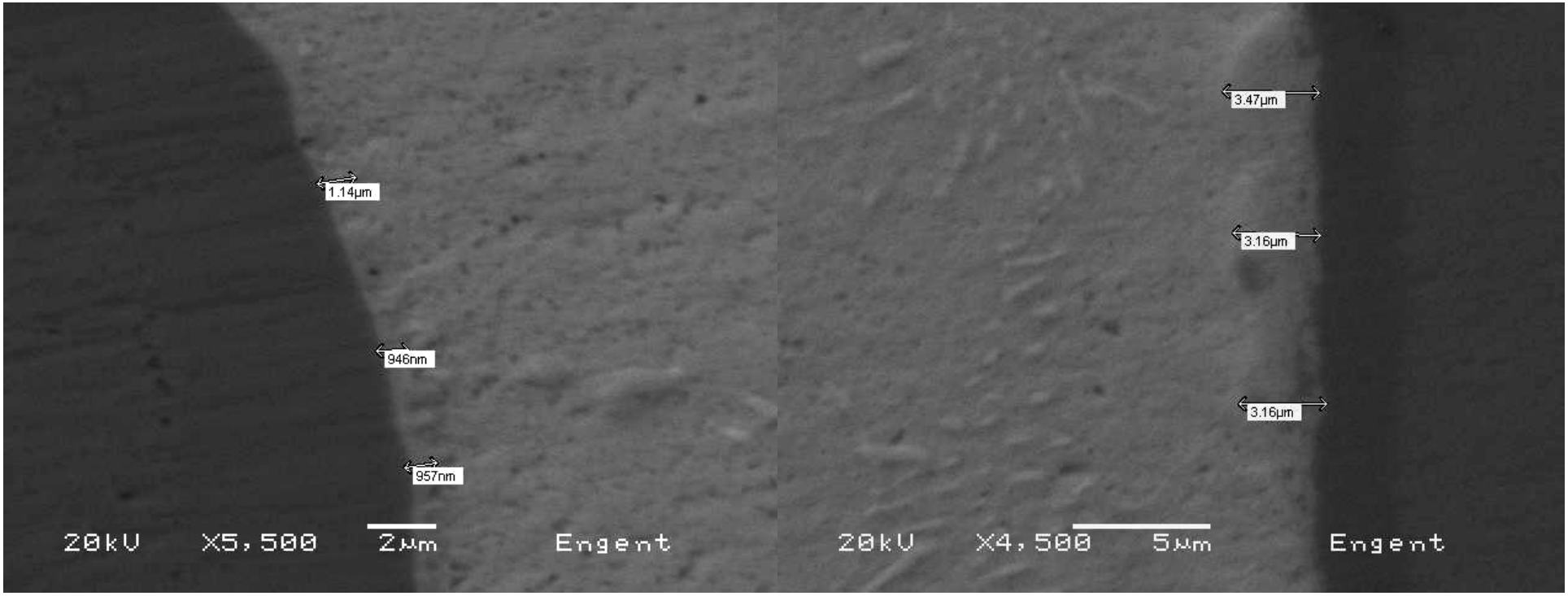
EJS note: 488 F actual T, MS2 present

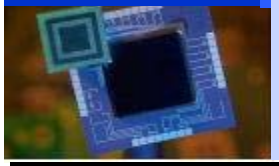
Board 19 showing overall image of Header Pin and solder grain structure



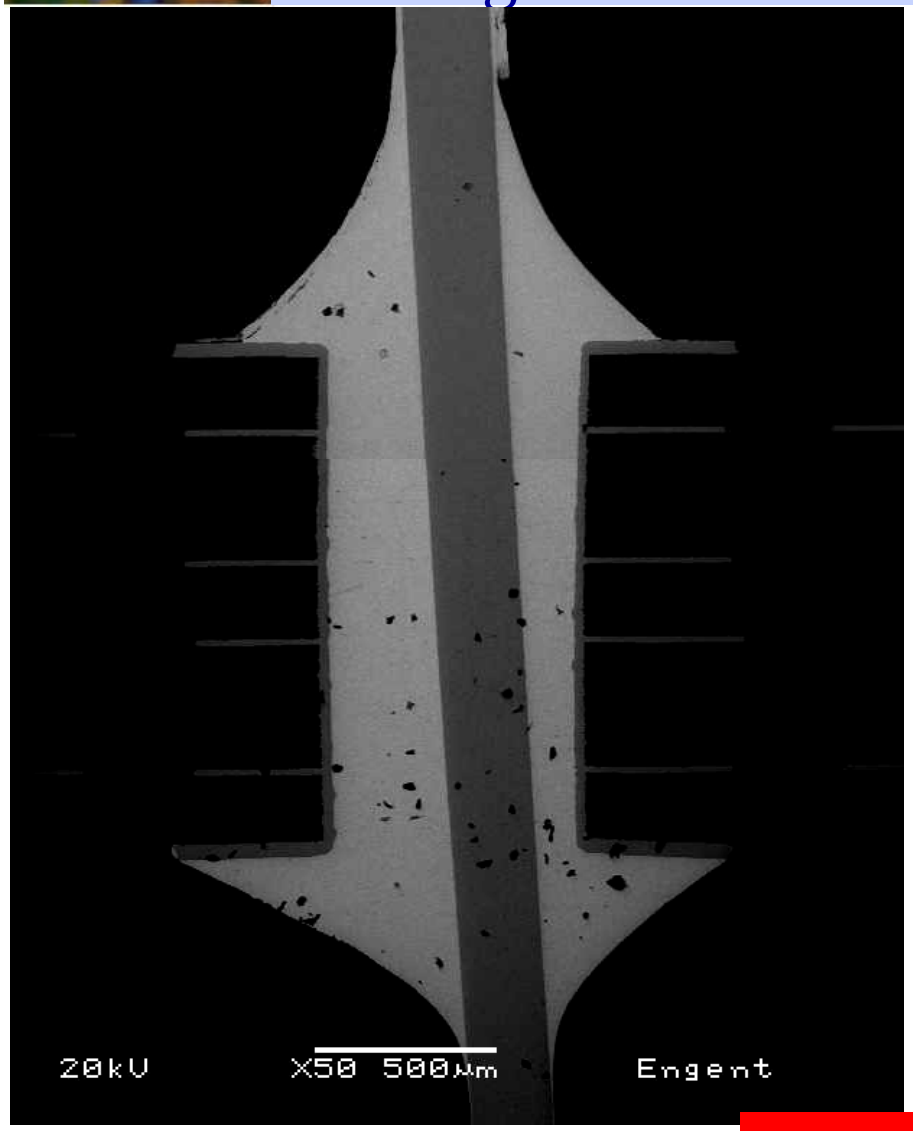


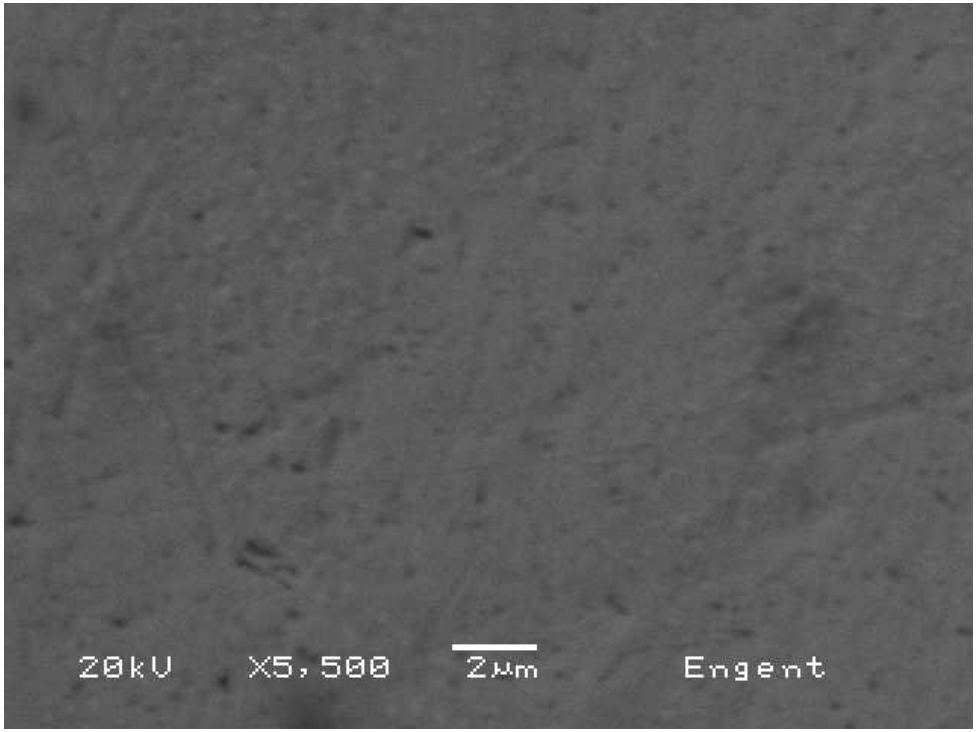
Board 19 showing intermetallic layer (IML) thickness at solder/pin and solder/board interface of Header pin



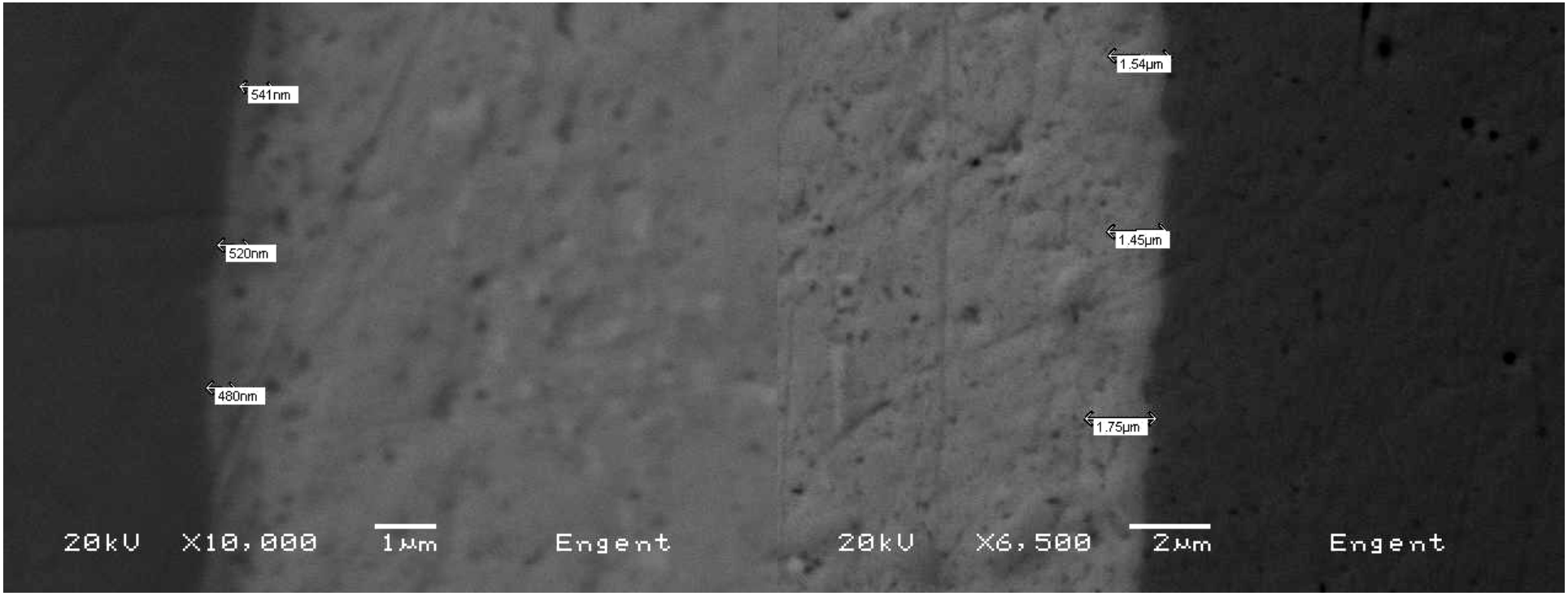


Board 19 showing overall image of DIP Pin and solder grain structure

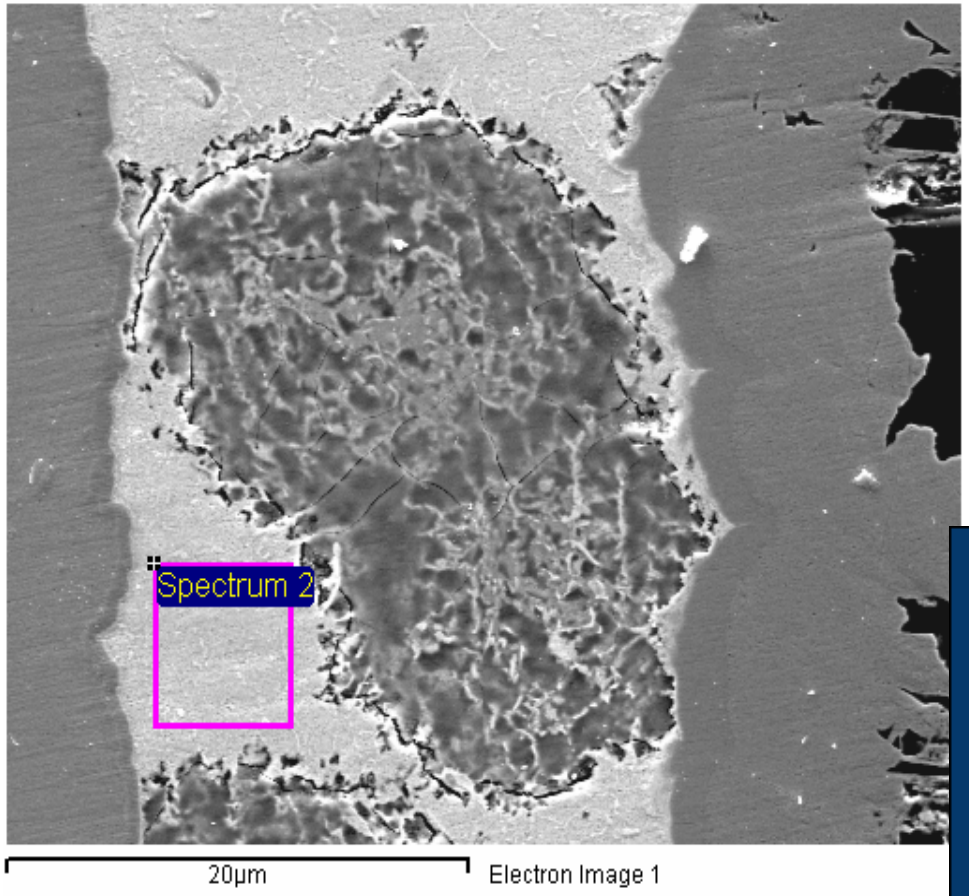




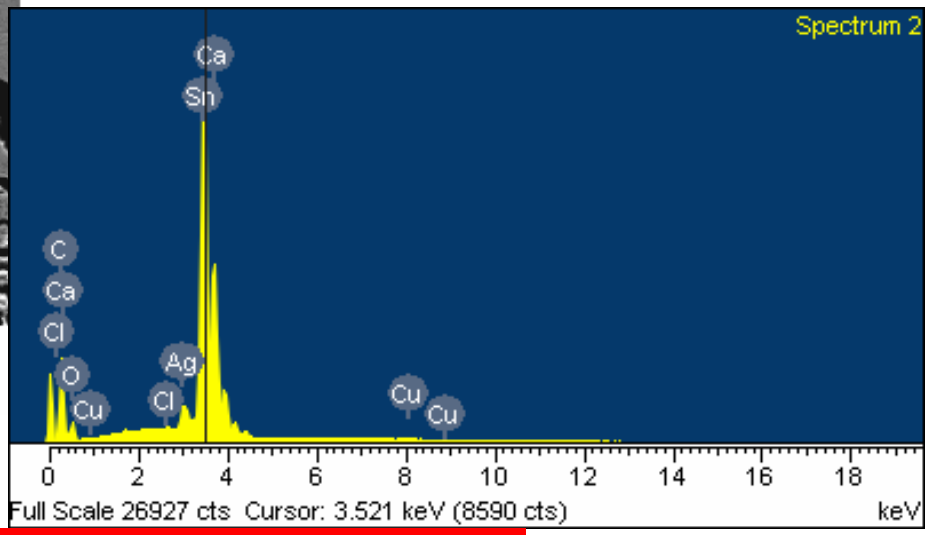
Board 19 showing intermetallic layer (IML) thickness at solder/pin and solder/board interface of DIP pin



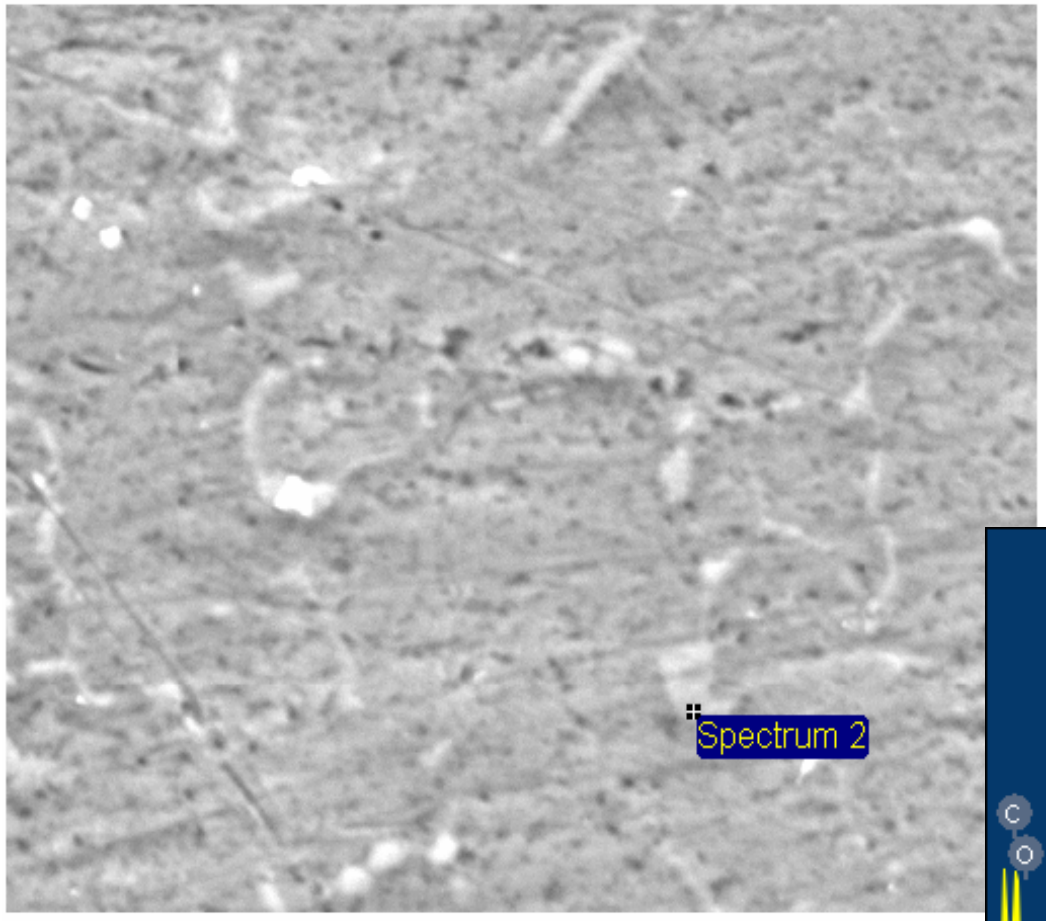
Board 19 showing bulk solder of header pin



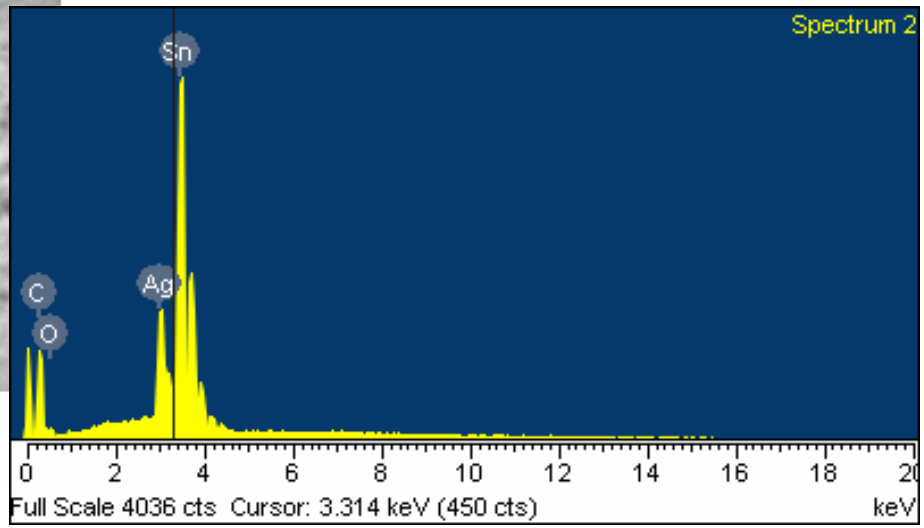
Element	Weight%	Atomic%
O K	12.78	51.41
Cl K	0.25	0.44
Ca K	0.46	0.73
Cu K	0.69	0.70
Ag L	3.18	1.90
Sn L	82.65	44.82
Totals	100.00	



Sample 19 showing point spectrum in bulk solder



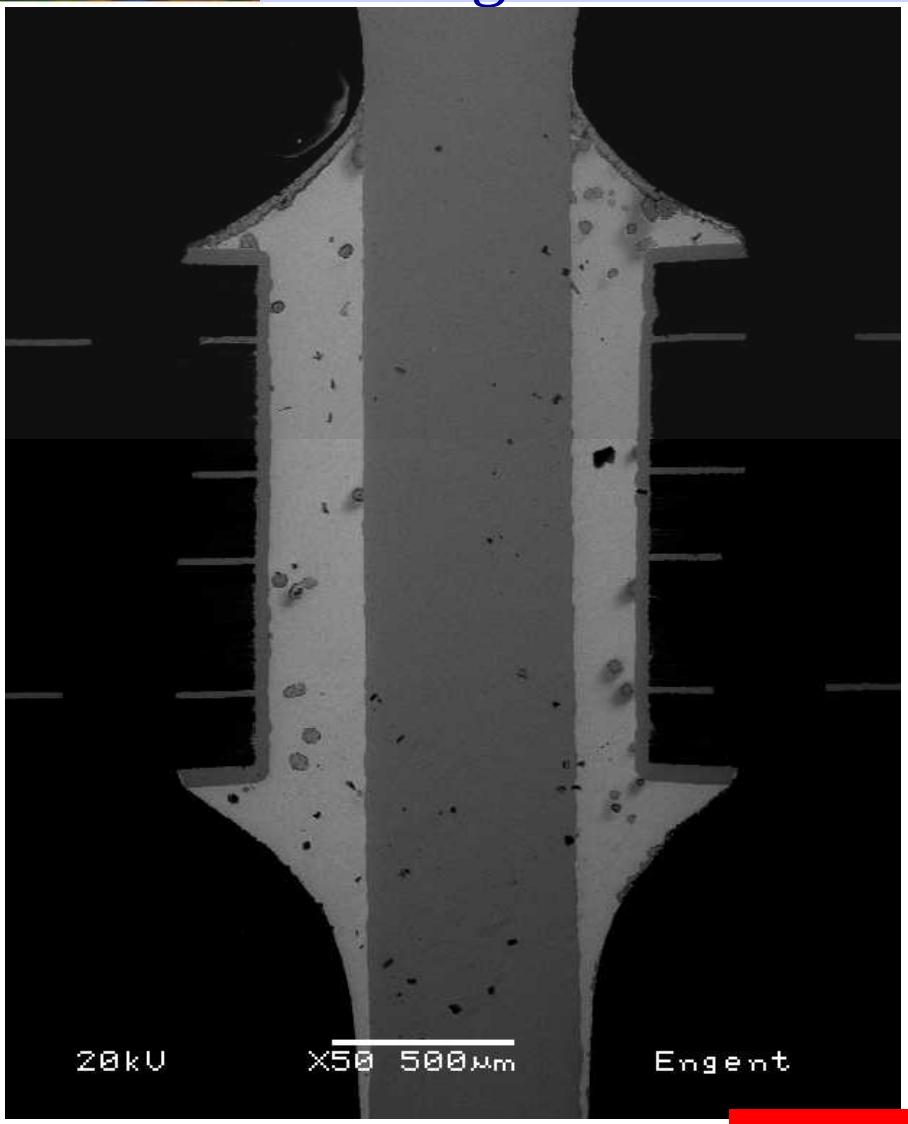
Element	Weight%	Atomic%
O K	7.57	37.38
Ag L	16.62	12.17
Sn L	75.81	50.45
Totals	100.00	

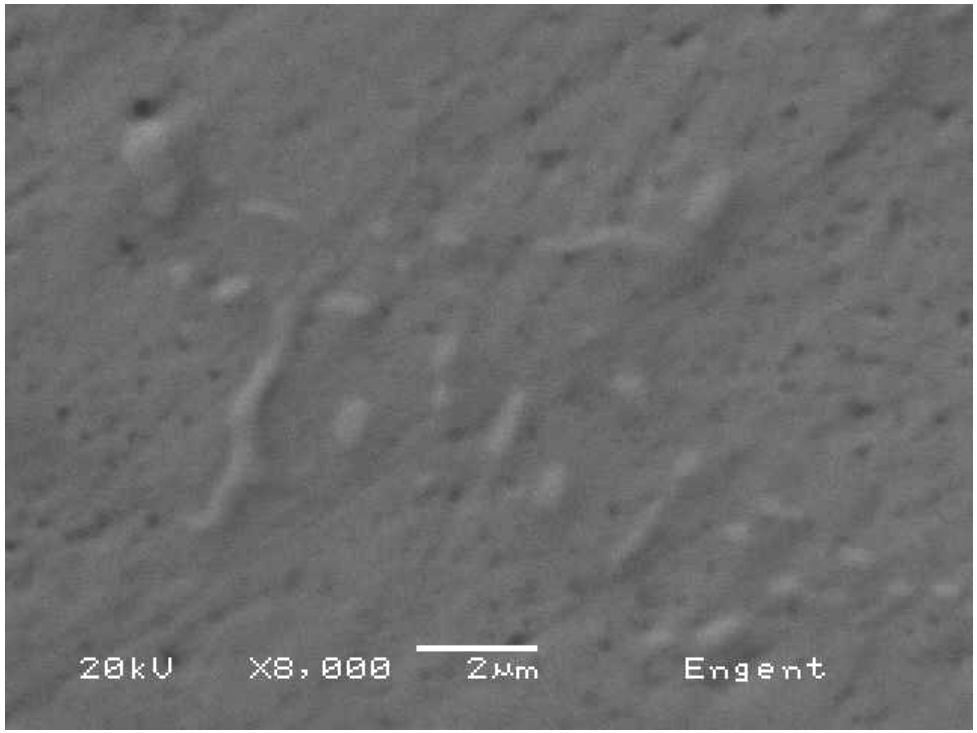


Board # 20

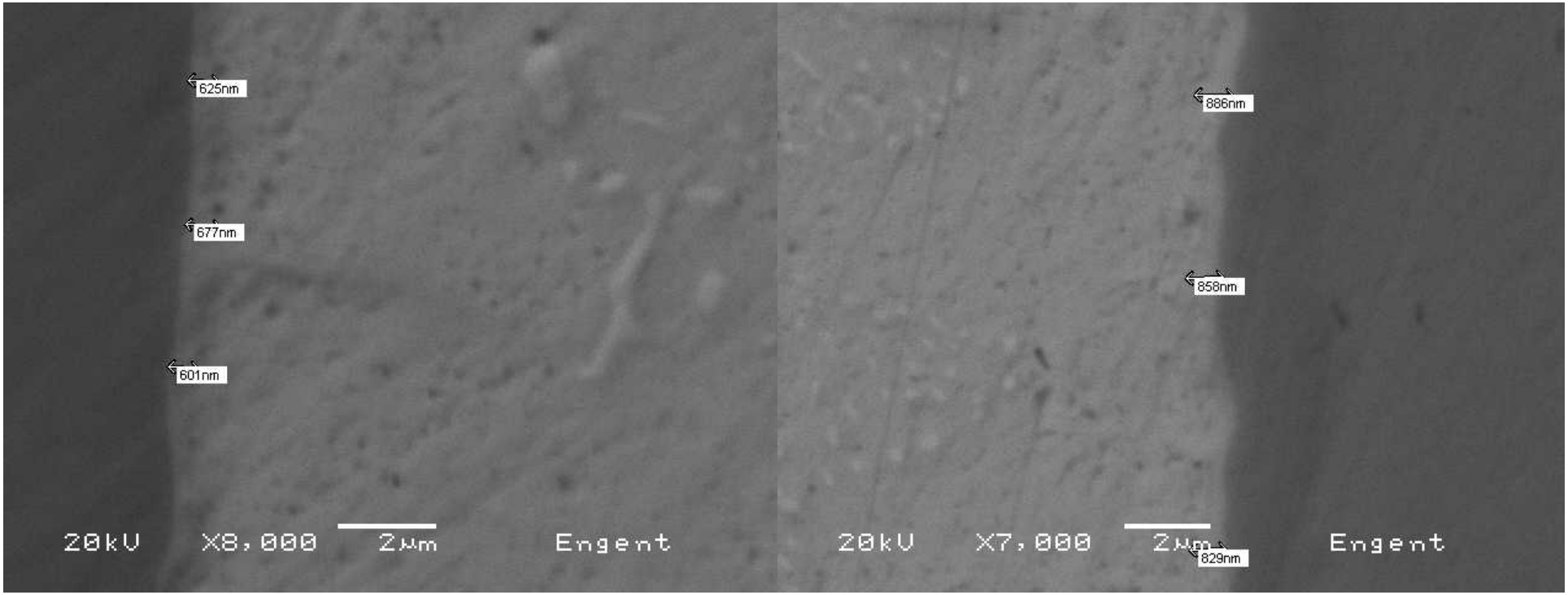
EJS note: 488 F actual T, MS2 present

Board 20 showing overall image of Header Pin and solder grain structure

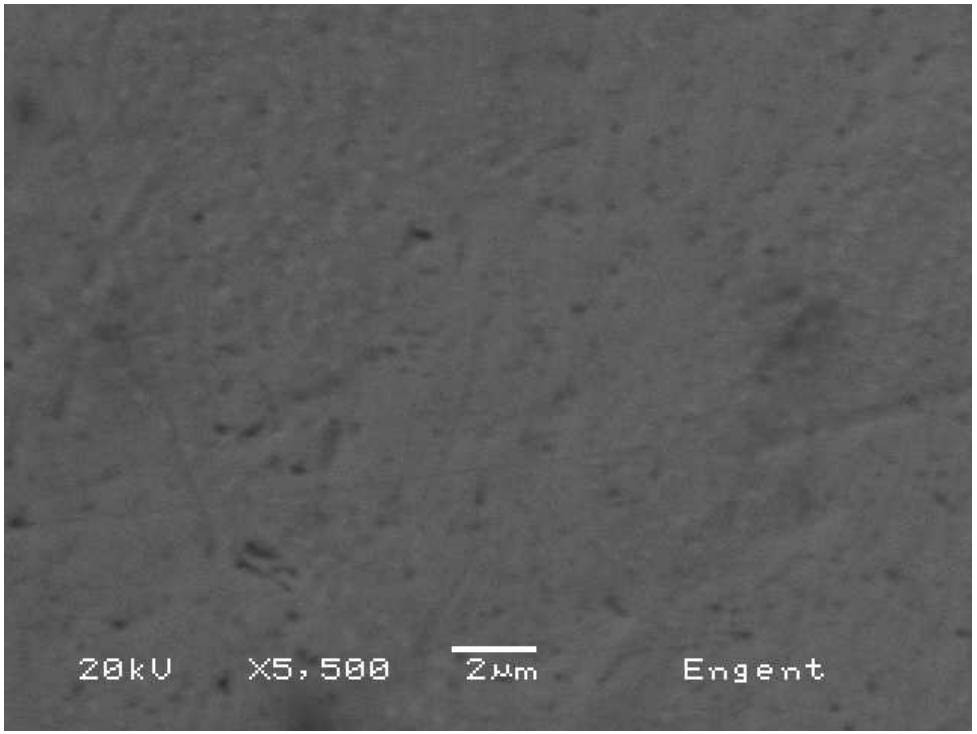




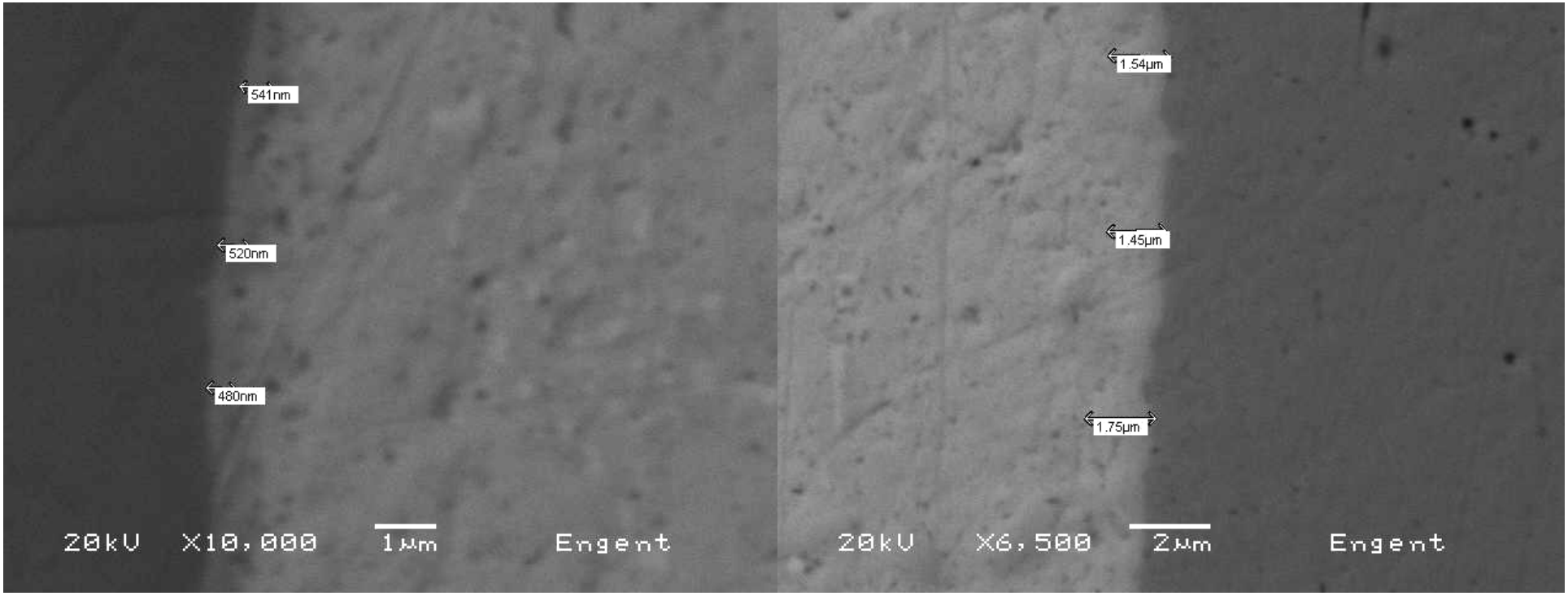
Board 20 showing intermetallic layer (IML) thickness at solder/pin and solder/board interface of Header pin



Board 20 showing overall image of DIP Pin and solder grain structure



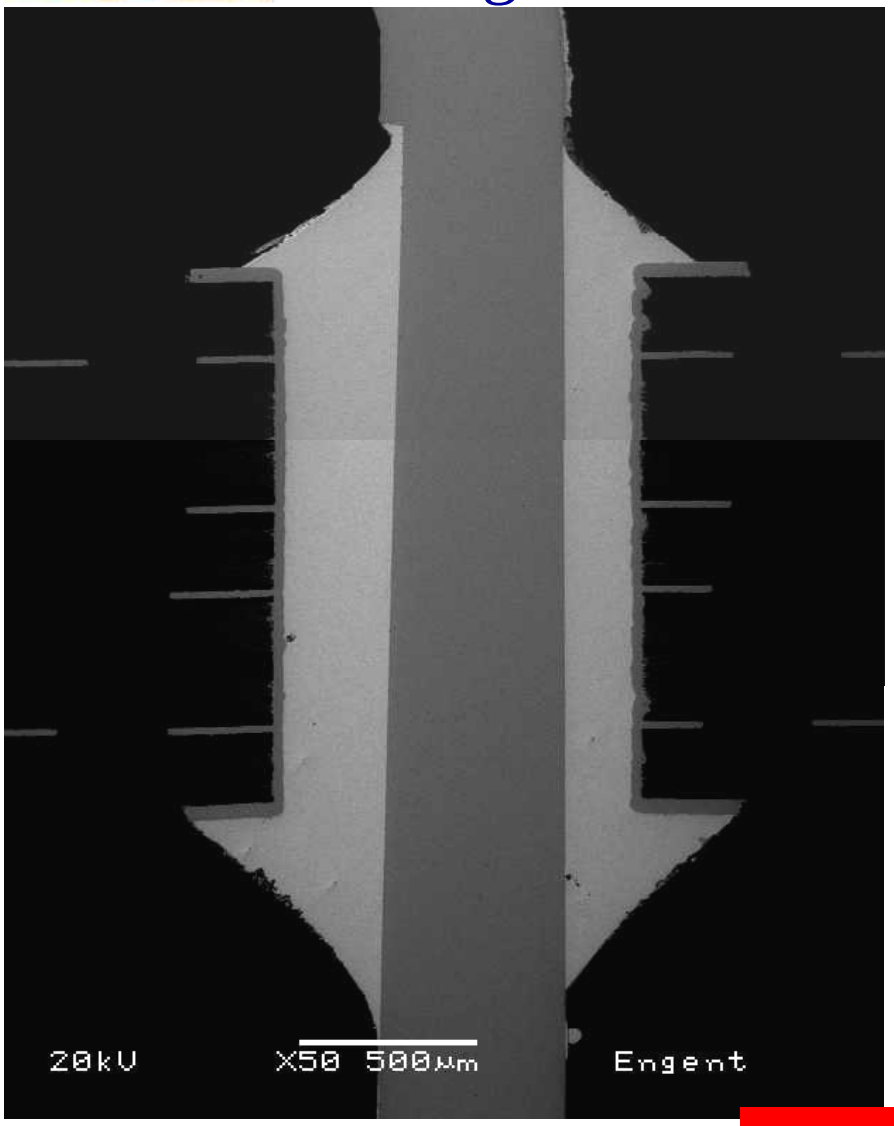
Board 20 showing intermetallic layer (IML) thickness at solder/pin and solder/board interface of DIP pin

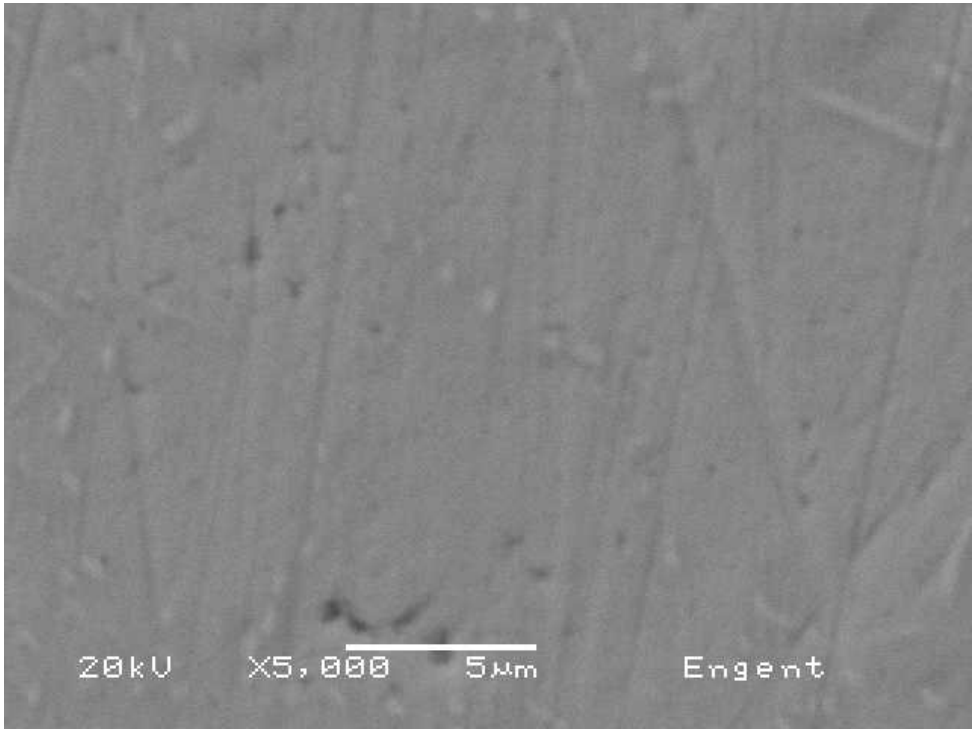


Board # 24

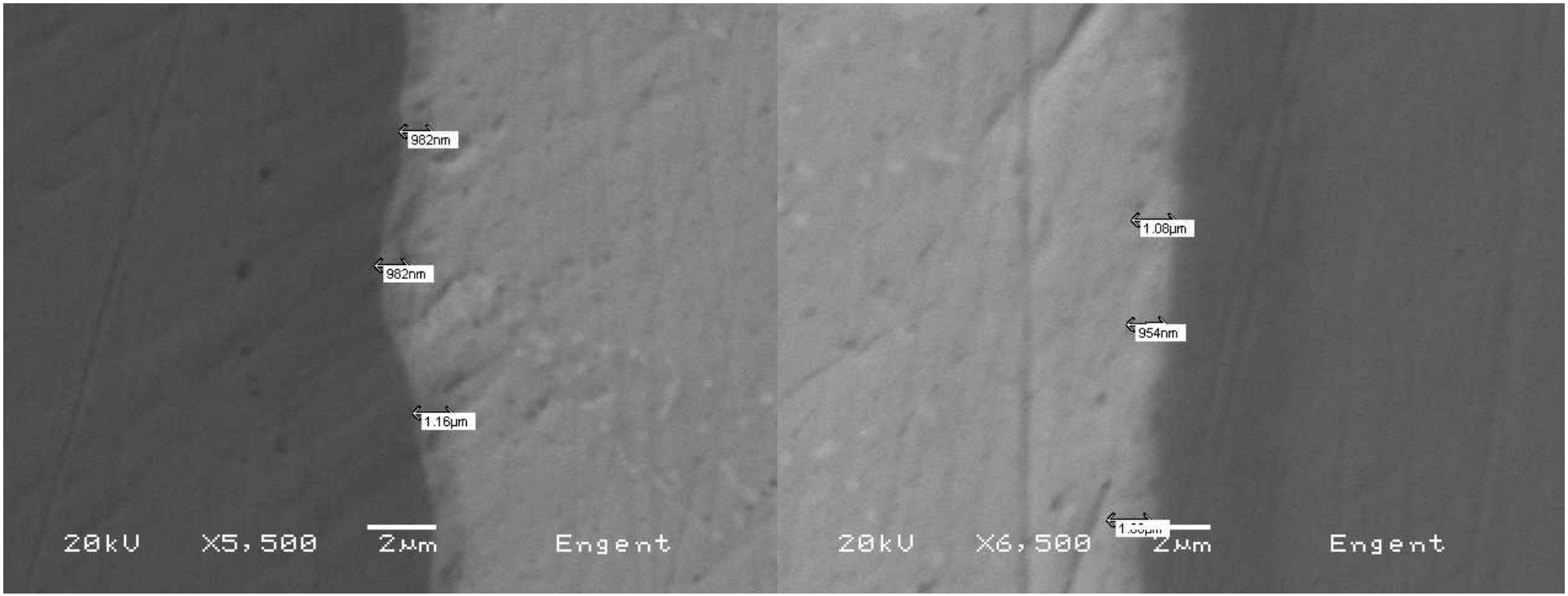
EJS note: 477 F actual T, MS2 present

Board 24 showing overall image of Header Pin and solder grain structure

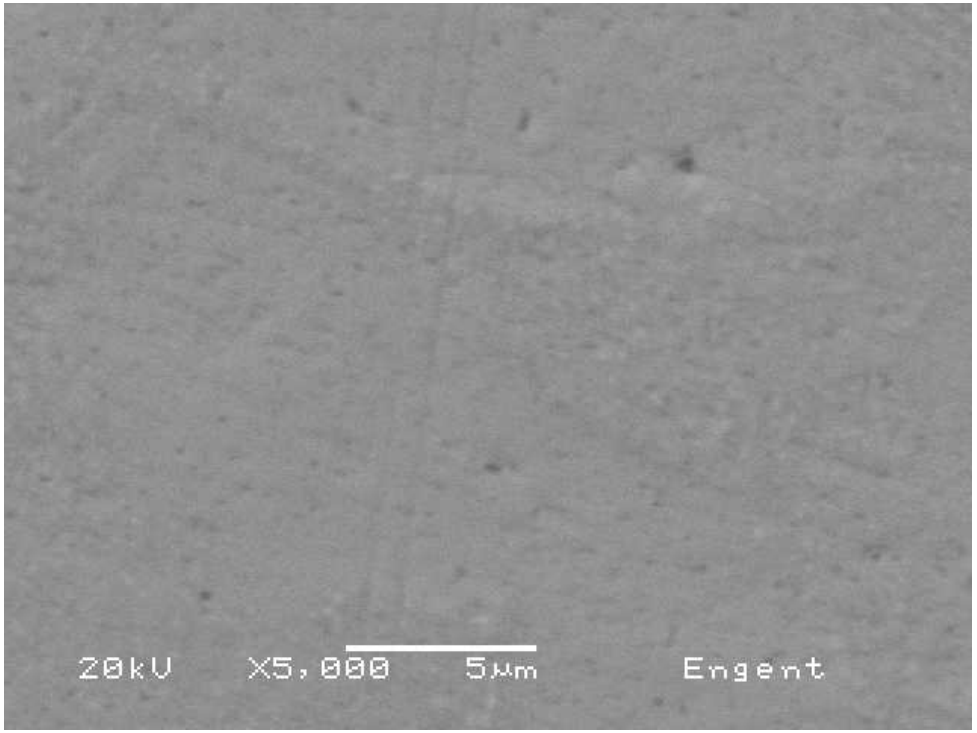




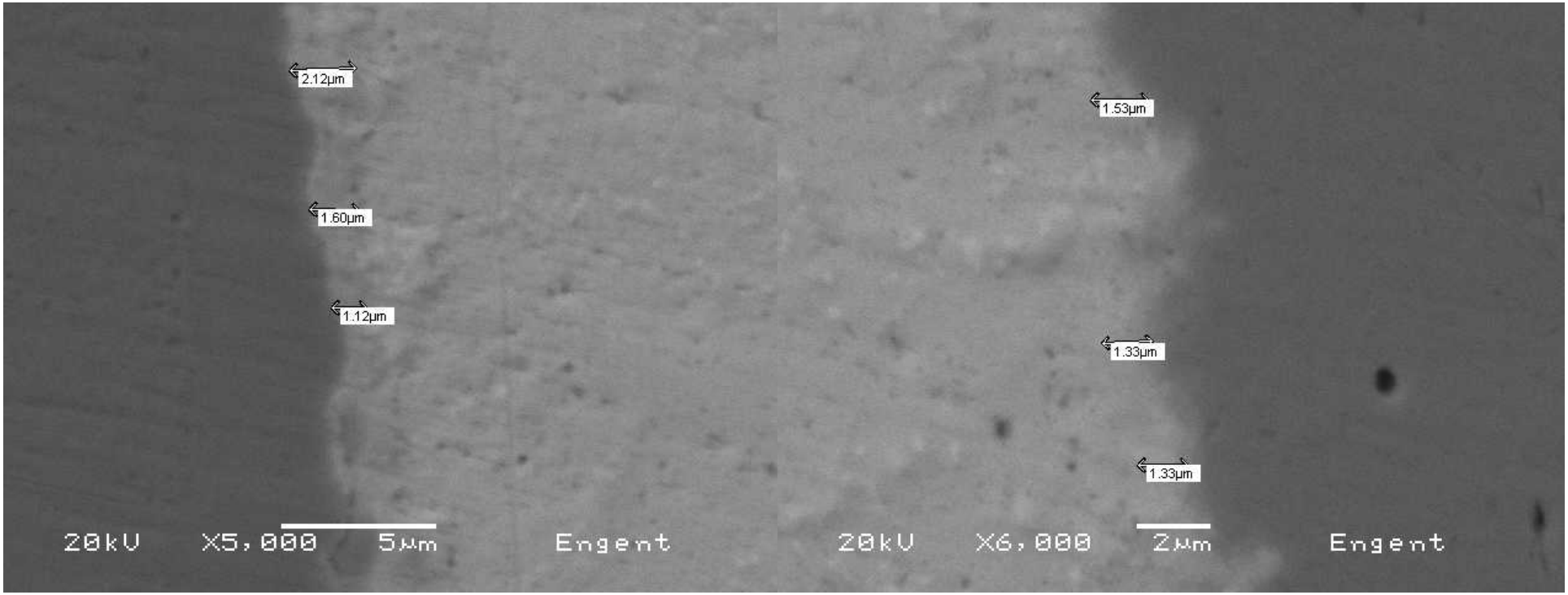
Board 24 showing intermetallic layer (IML) thickness at solder/pin and solder/board interface of Header pin



Board 24 showing overall image of DIP Pin and solder grain structure



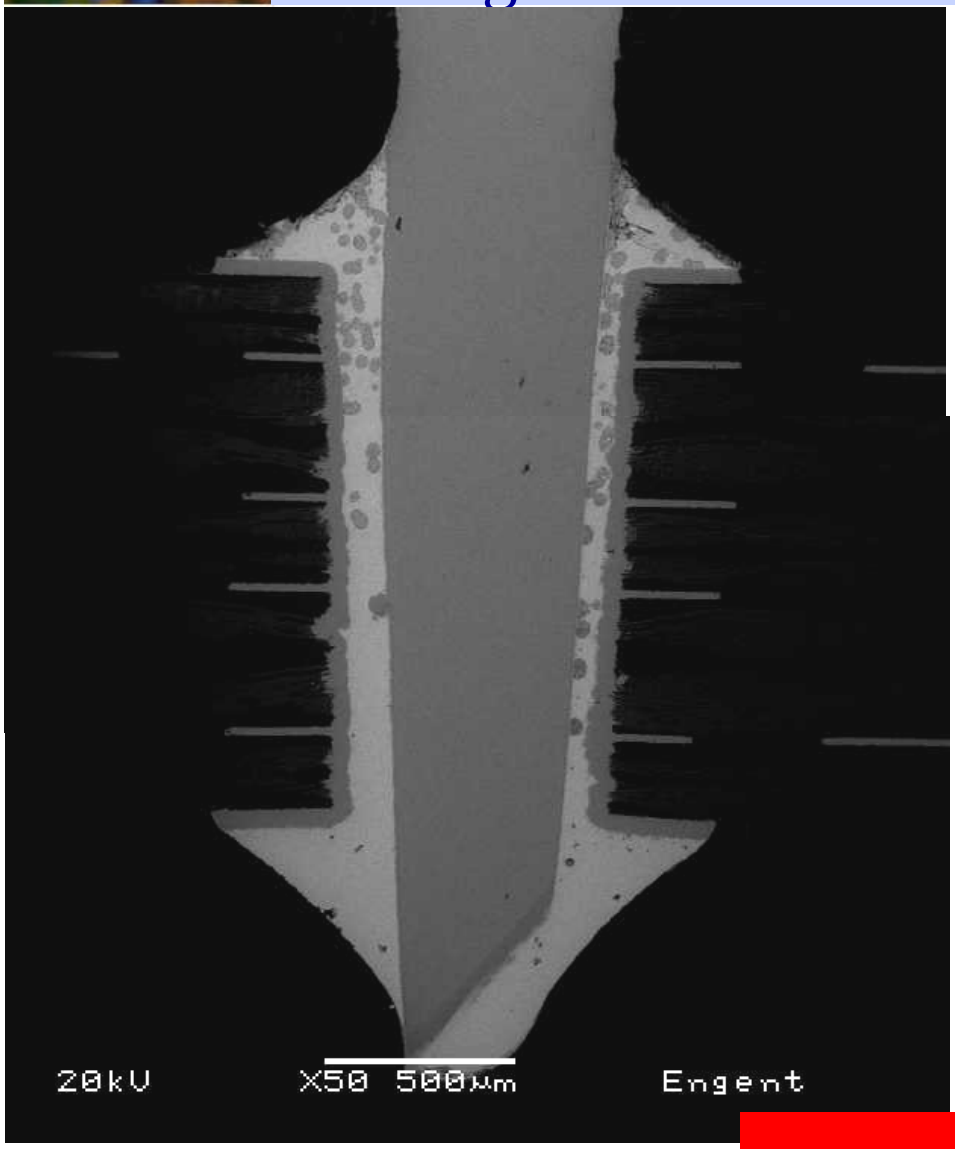
Board 24 showing intermetallic layer (IML) thickness at solder/pin and solder/board interface of DIP pin

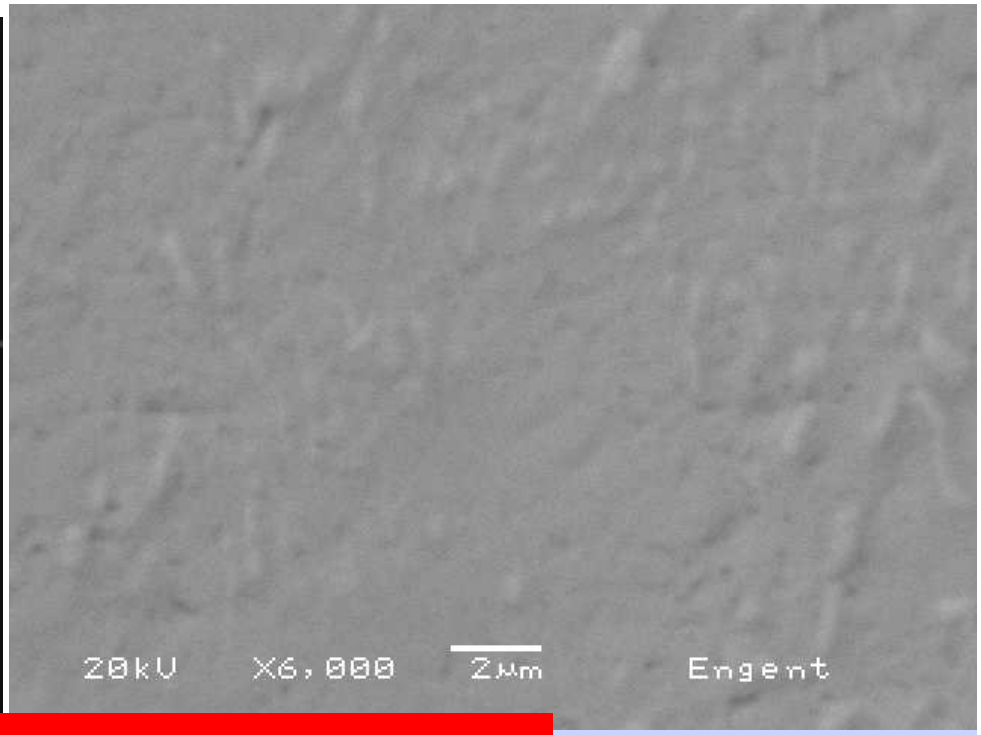


Board # 25

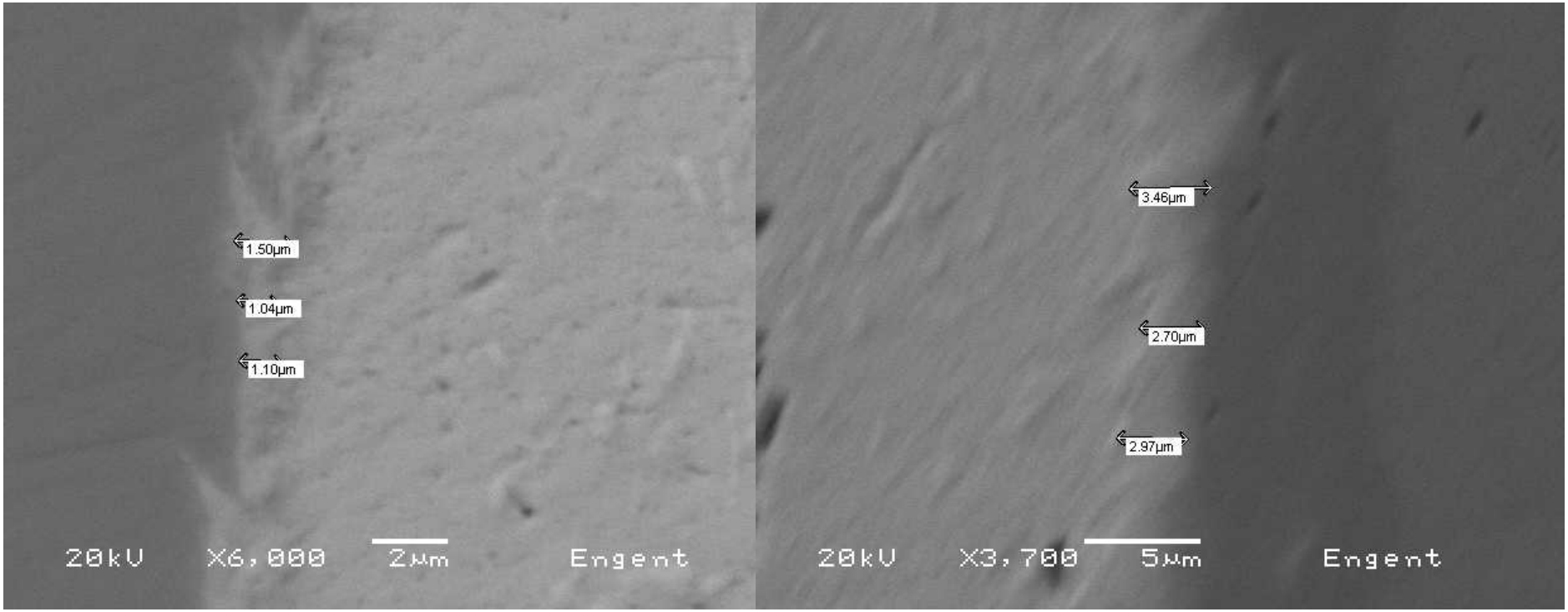
EJS note: 477 F actual T, MS2 present

Board 25 showing overall image of Header Pin and solder grain structure

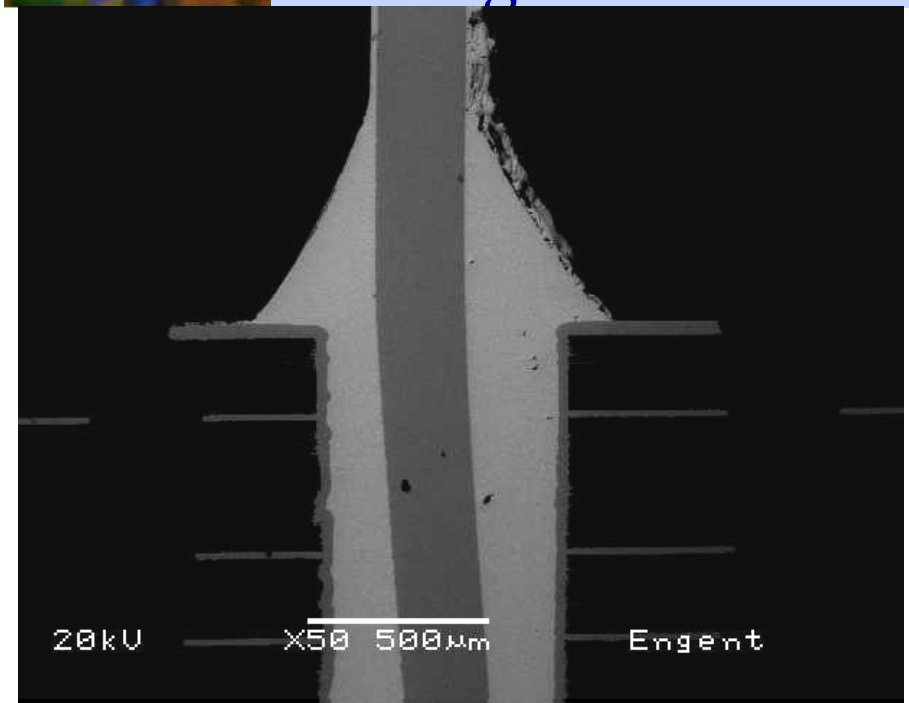


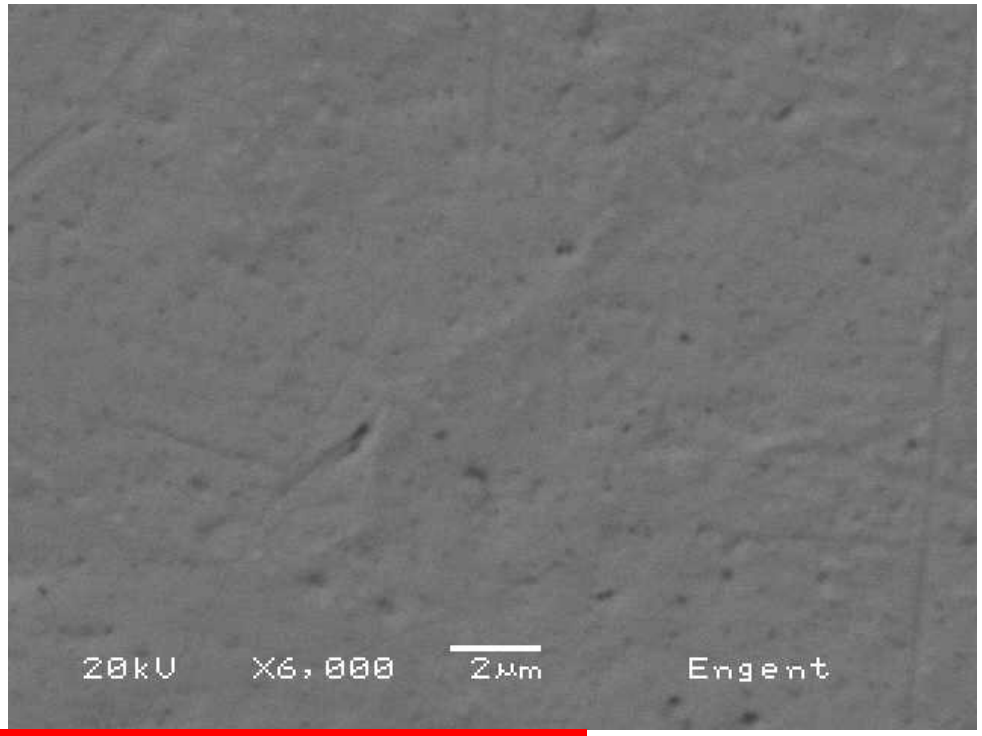


Board 25 showing intermetallic layer (IML) thickness at solder/pin and solder/board interface of Header pin

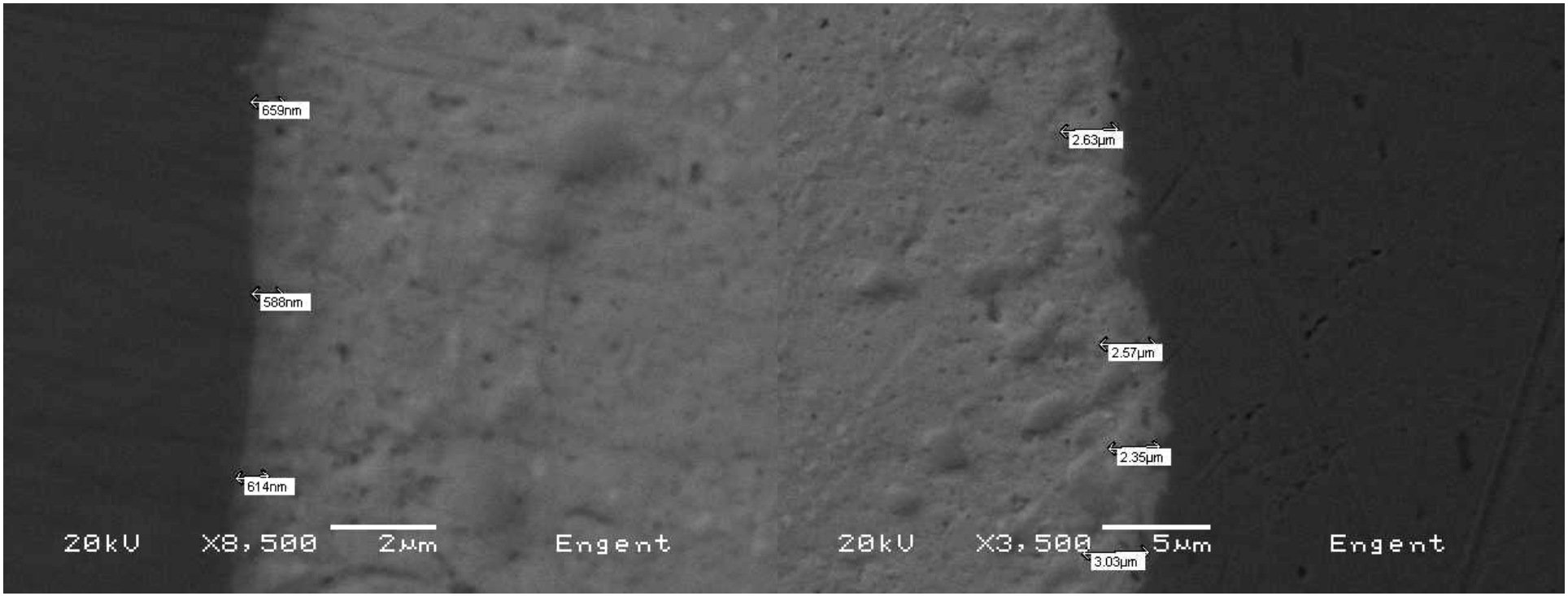


Board 25 showing overall image of DIP Pin and solder grain structure





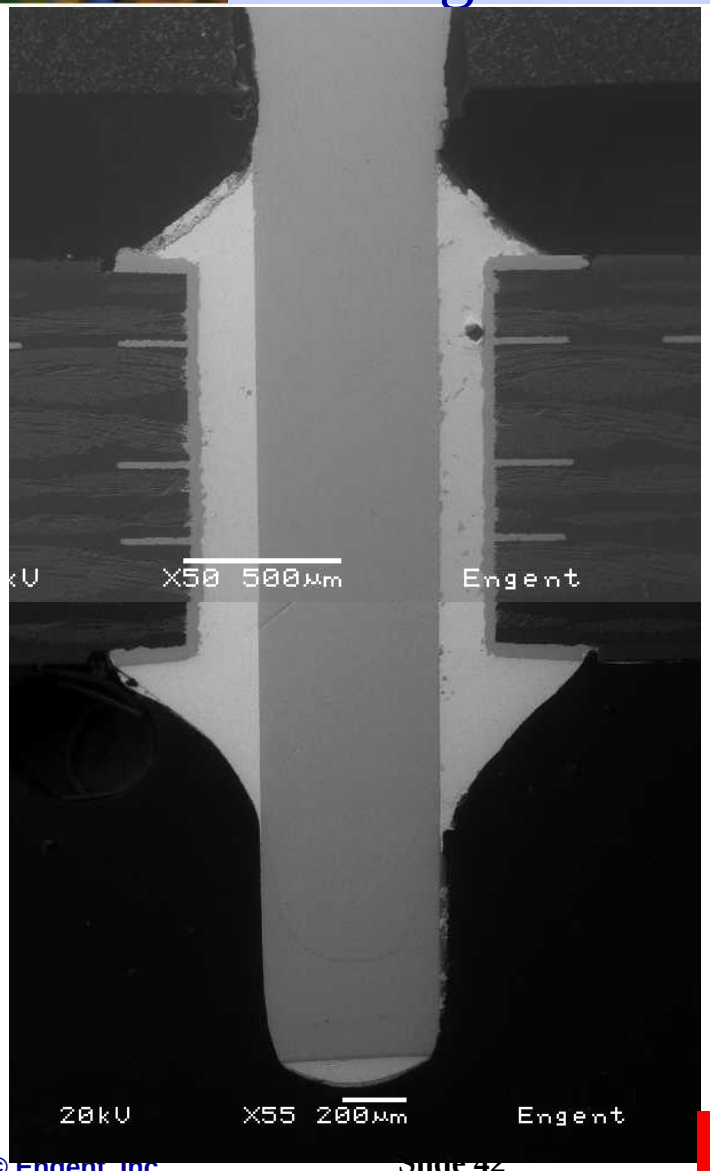
Board 25 showing intermetallic layer (IML) thickness at solder/pin and solder/board interface of DIP pin

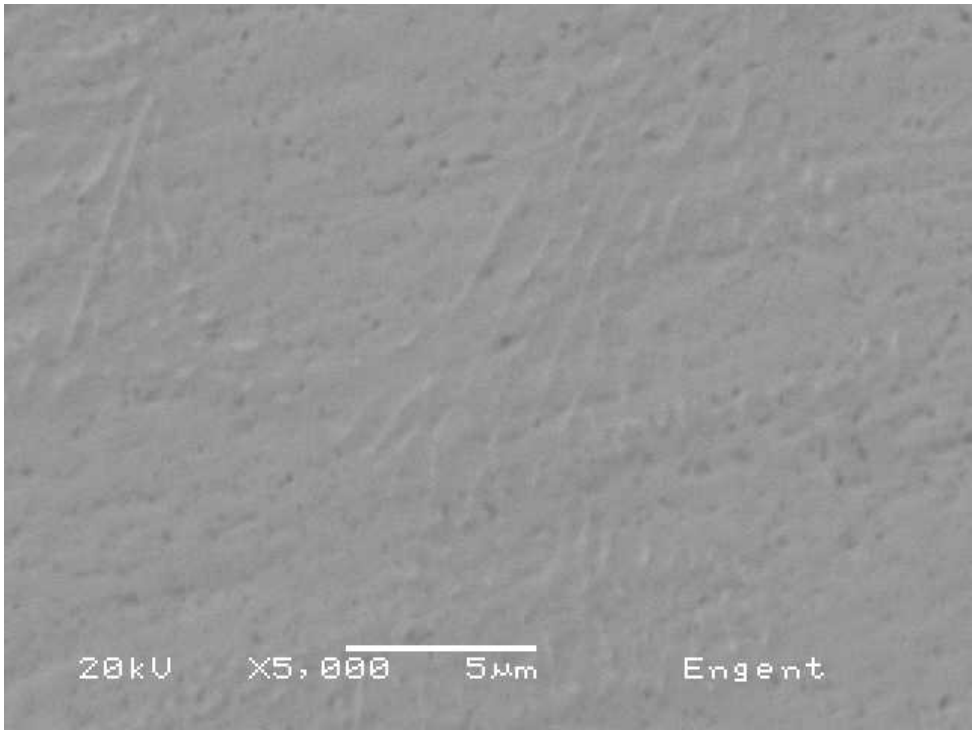


Board # 29

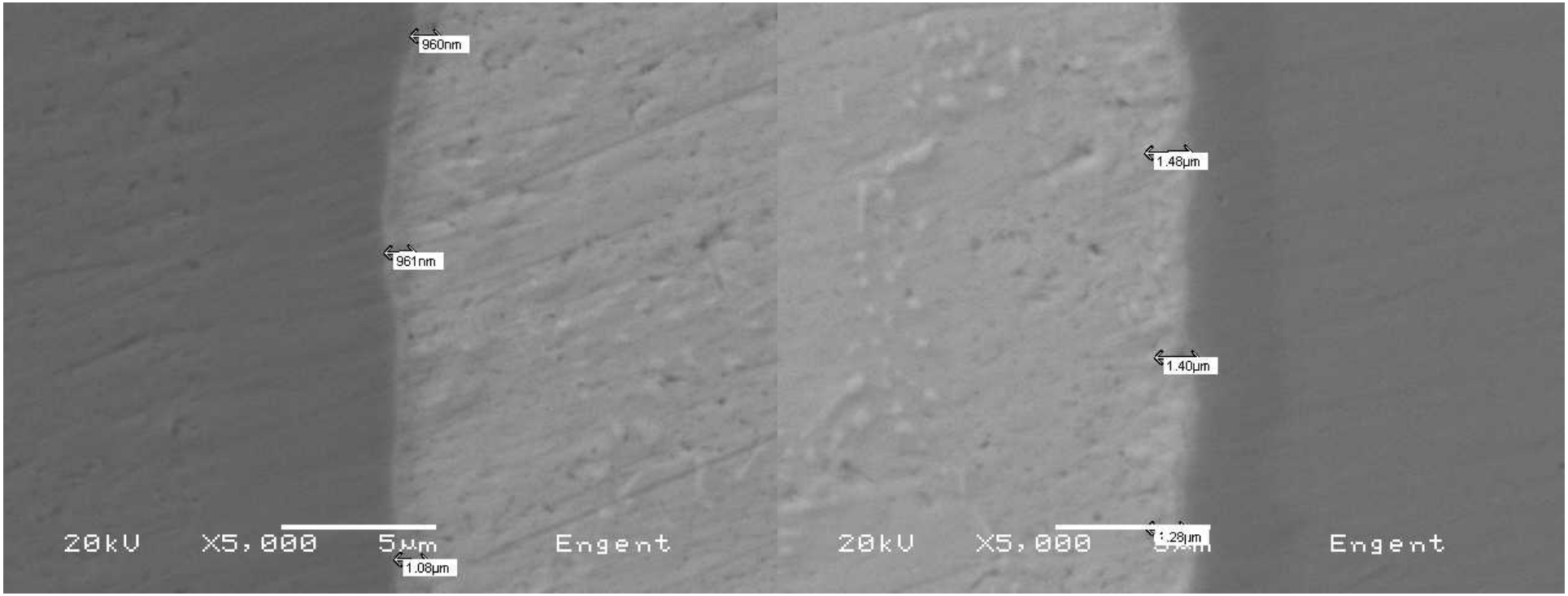
EJS note: 485 F set point T, one week later, No MS2

Board 29 showing overall image of Header Pin and solder grain structure

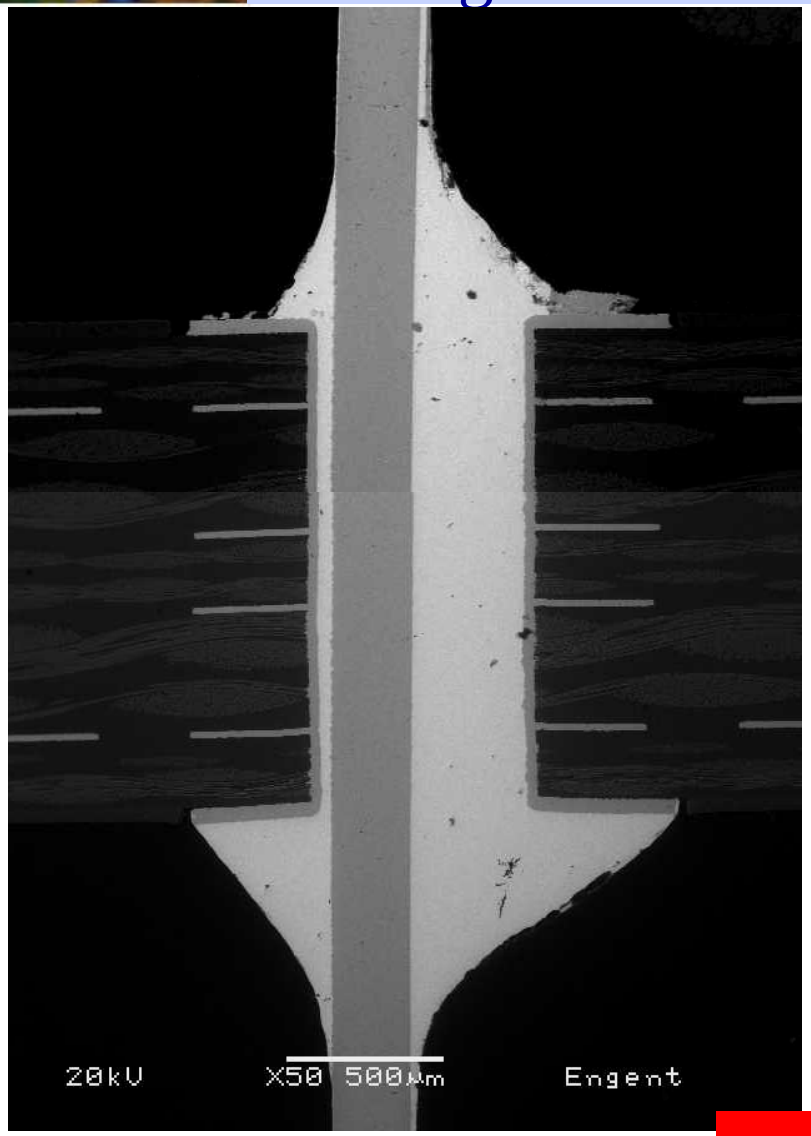


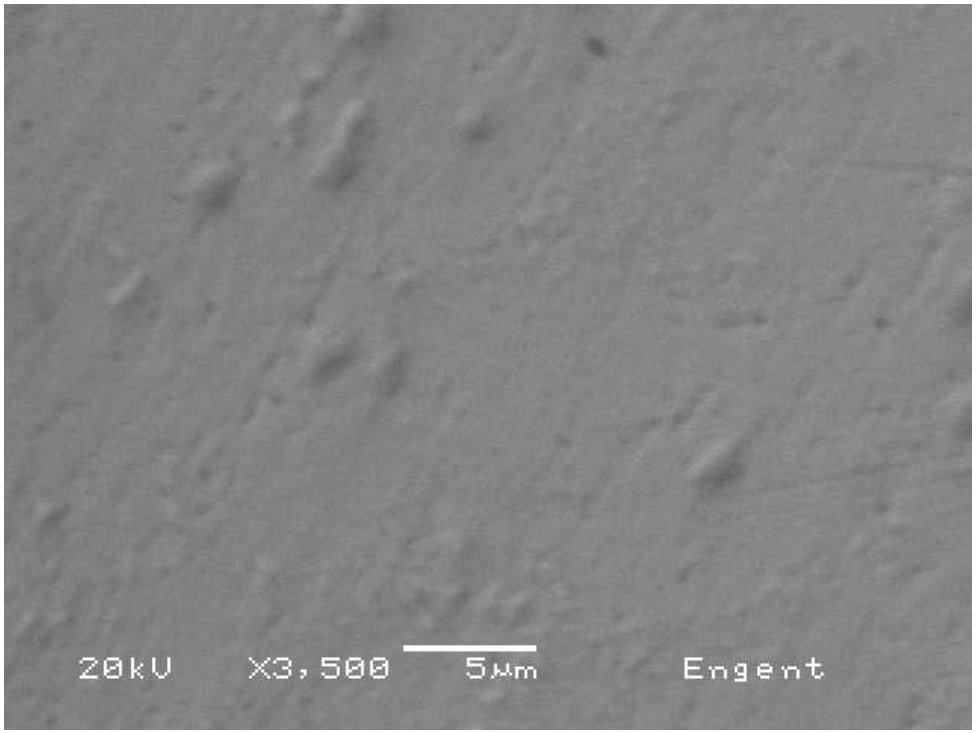


Board 29 showing intermetallic layer (IML) thickness at solder/pin and solder/board interface of Header pin

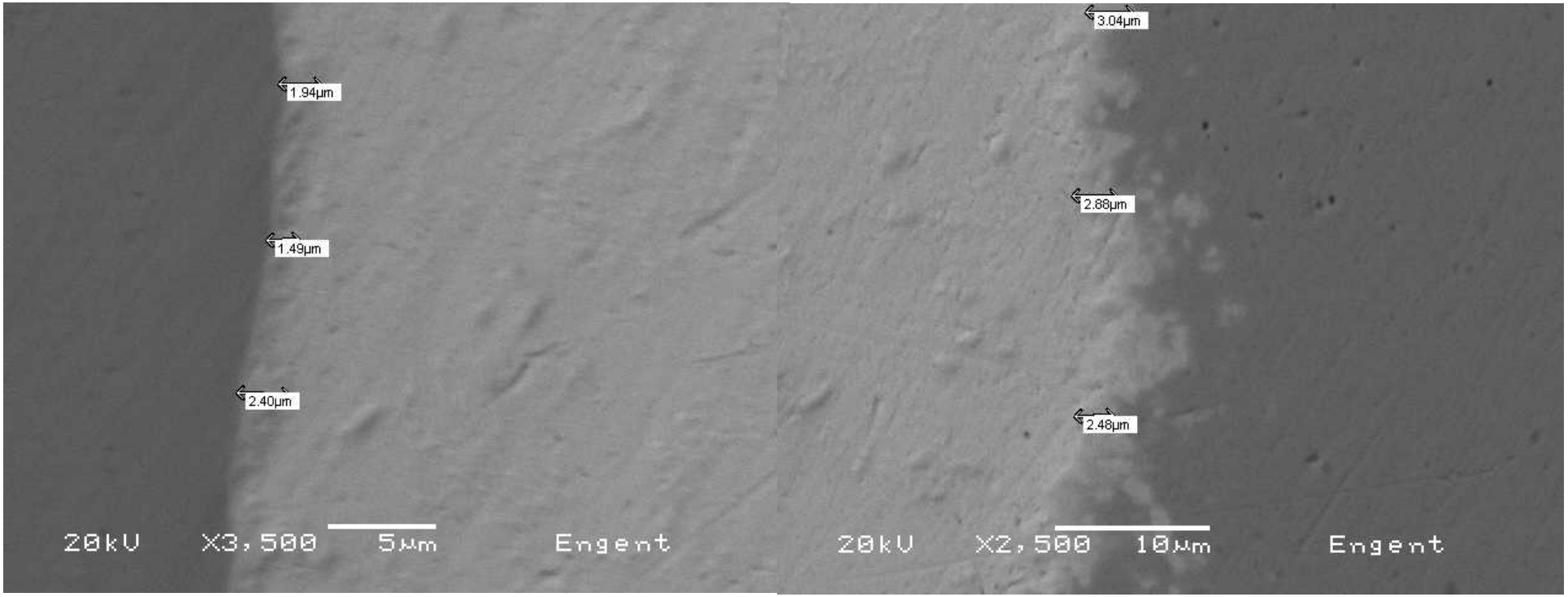


Board 29 showing overall image of DIP Pin and solder grain structure





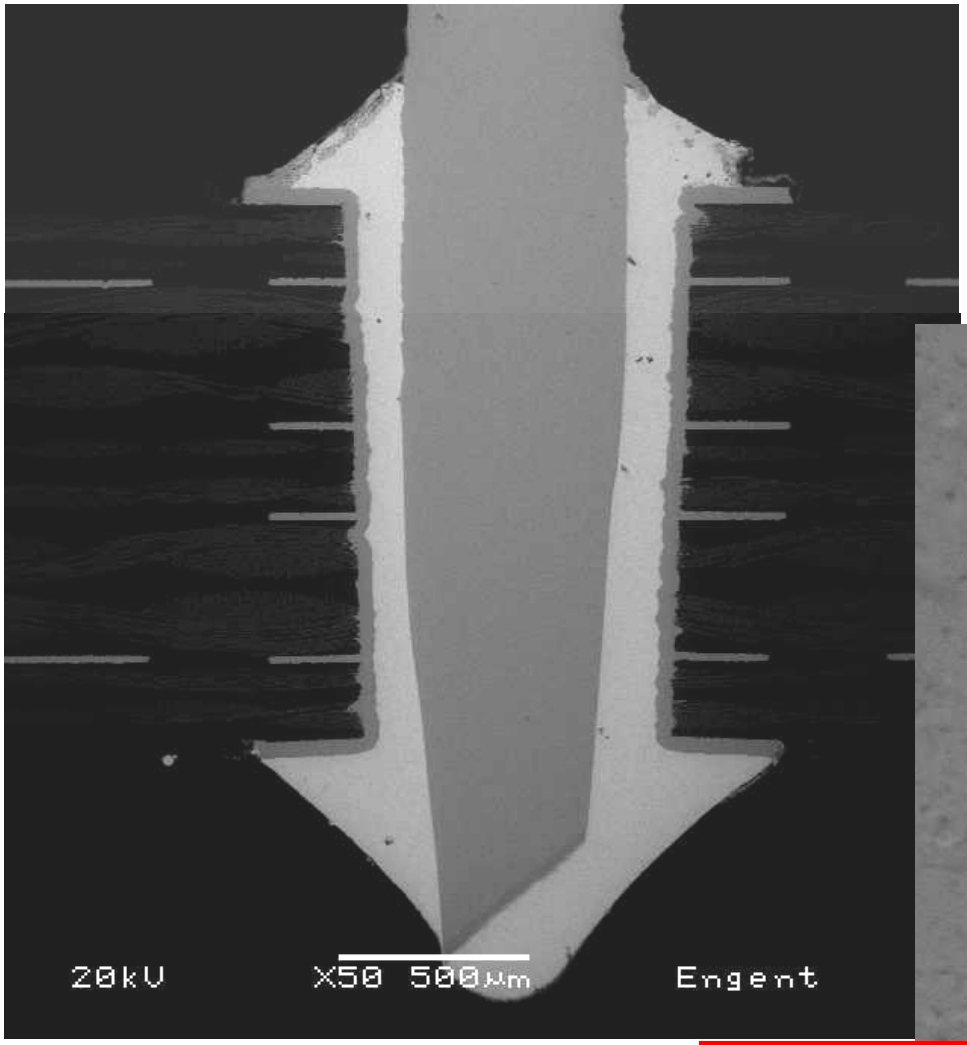
Board 29 showing intermetallic layer (IML) thickness at solder/pin and solder/board interface of DIP pin

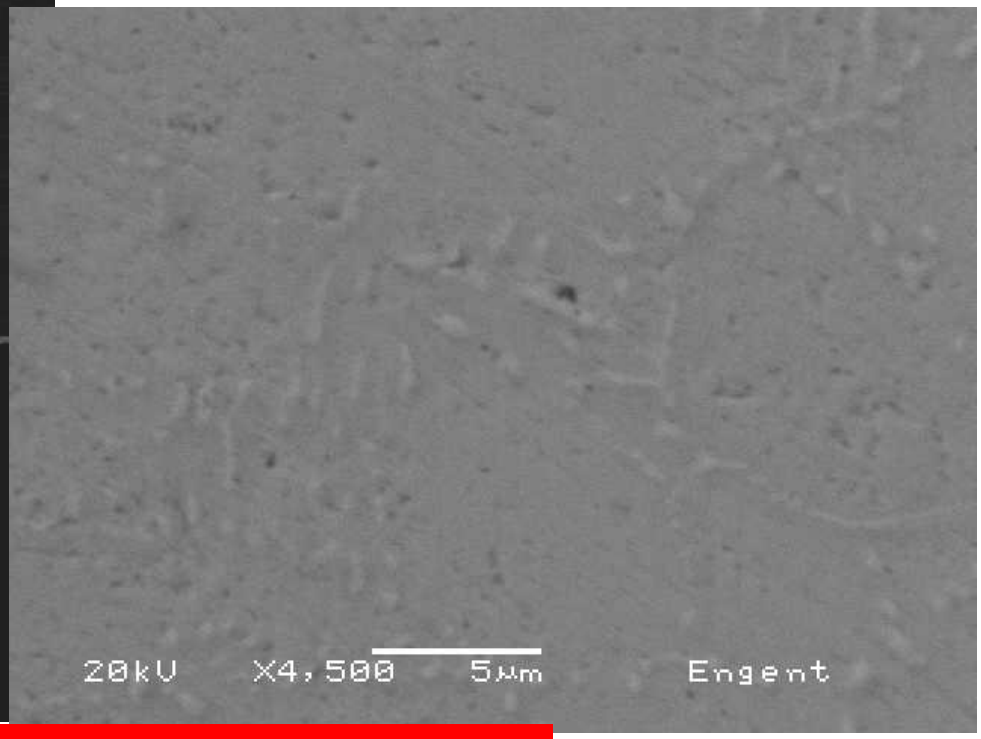


Board # 30

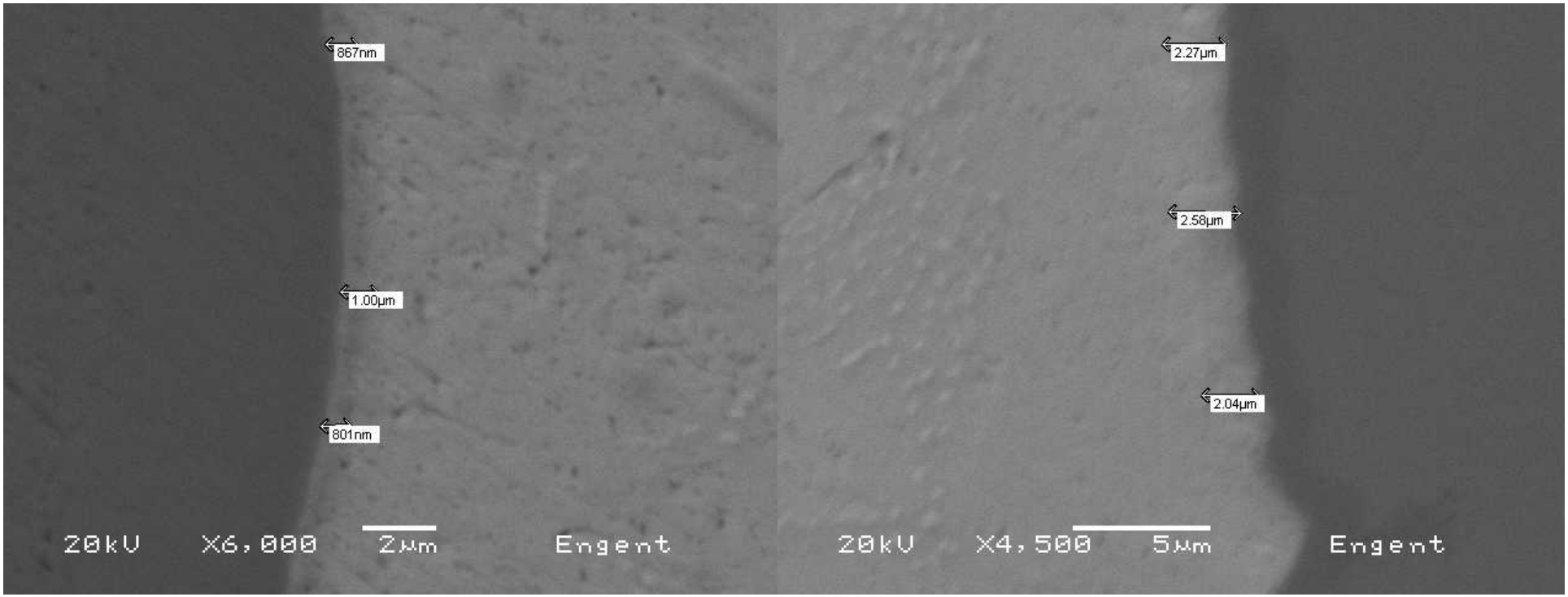
EJS note: 485 F set point T, one week later, No MS2

Board 30 showing overall image of Header Pin and solder grain structure

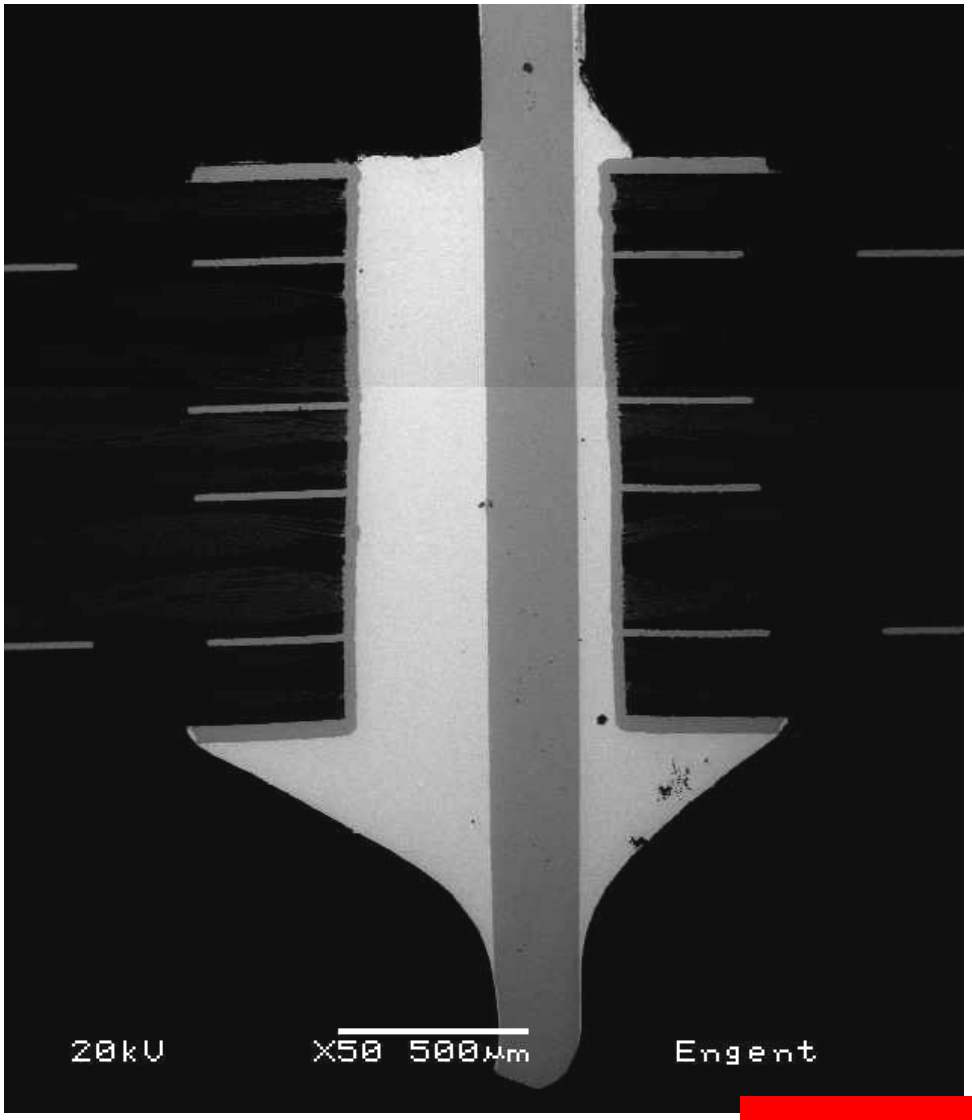


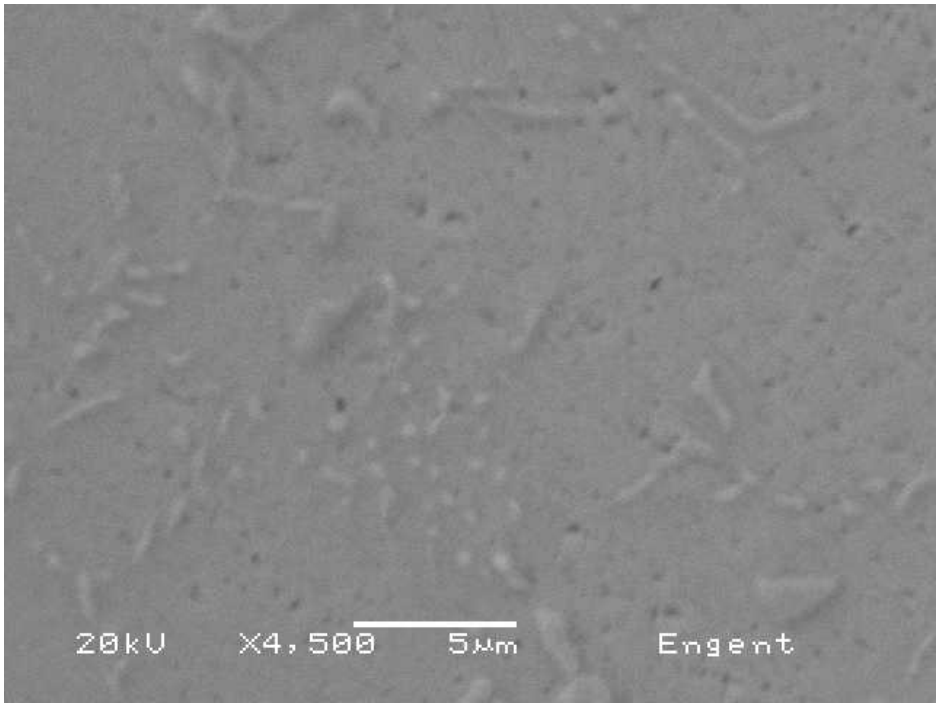


Board 30 showing intermetallic layer (IML) thickness at solder/pin and solder/board interface of Header pin

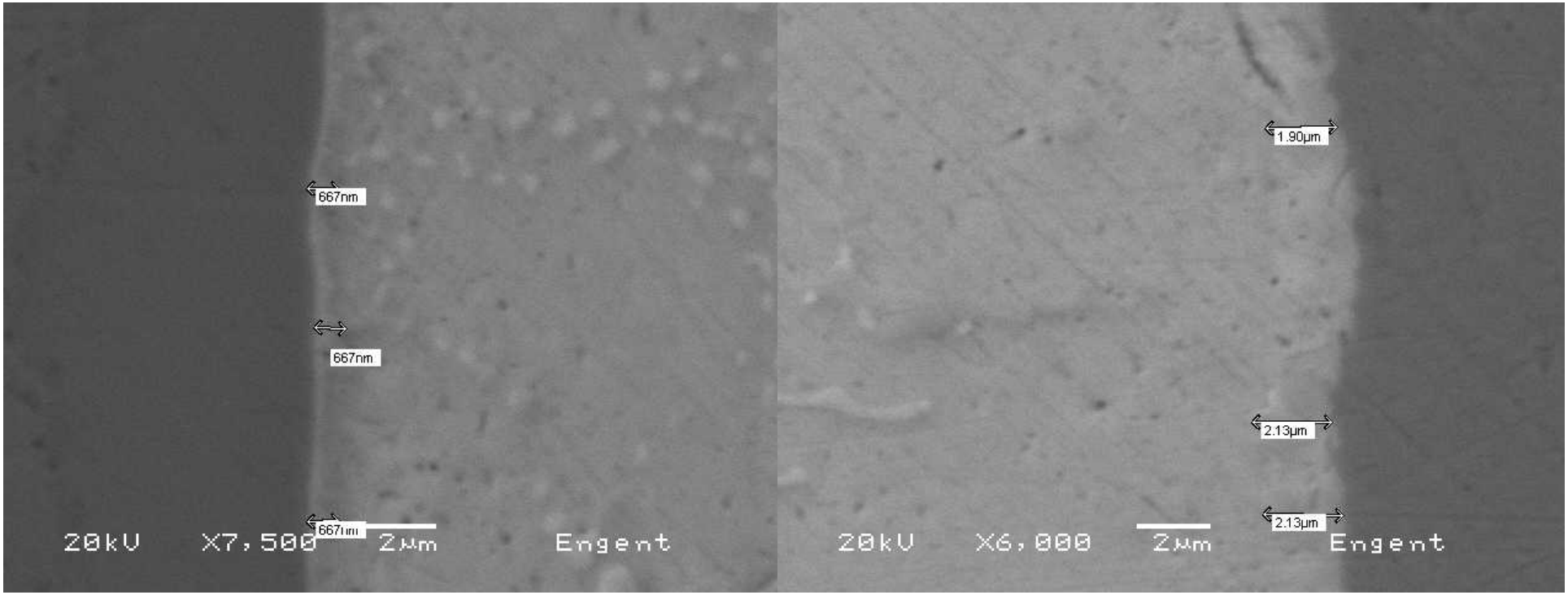


Board 30 showing overall image of DIP Pin and solder grain structure

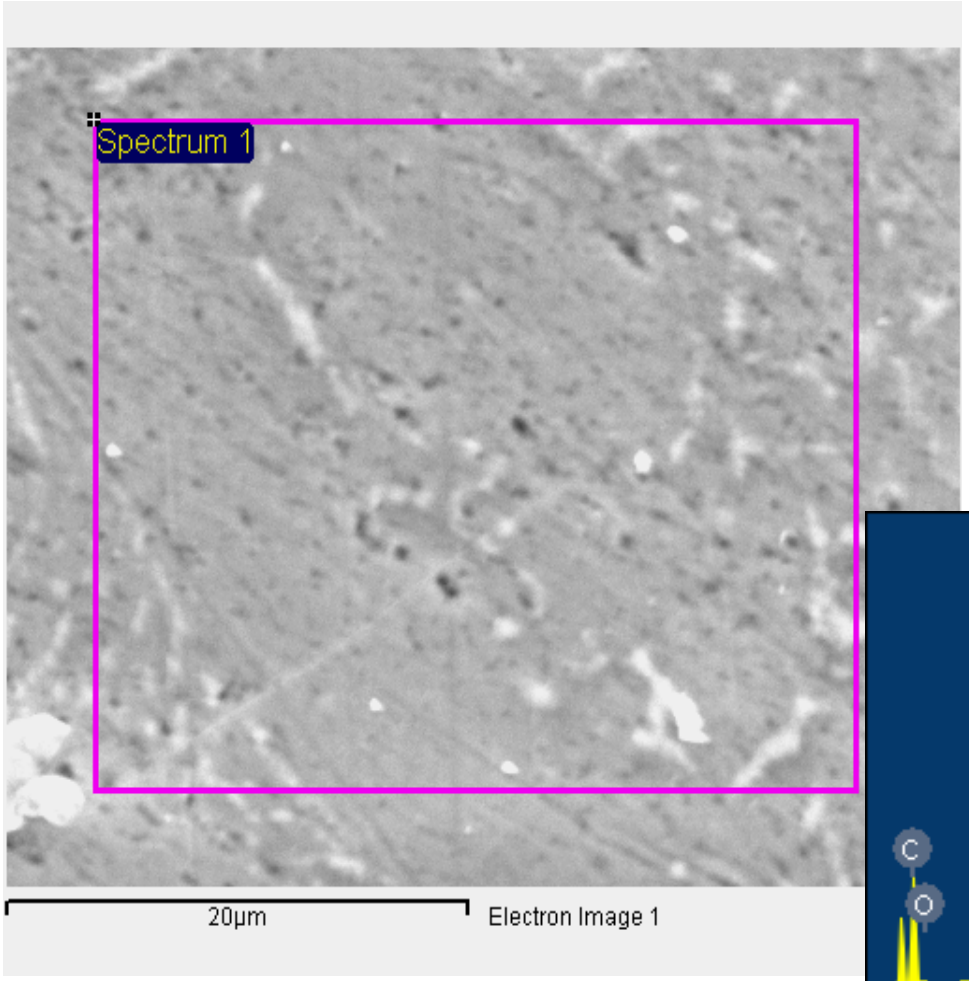




Board 30 showing intermetallic layer (IML) thickness at solder/pin and solder/board interface of DIP pin



Sample 30 showing area spectrum of bulk solder



Element	Weight%	Atomic%
O K	5.81	31.32
Ag L	2.99	2.39
Sn L	91.20	66.29
Totals	100.00