

Construction Analysis

SGS-Thomson L4990 Controller

Report Number: SCA 9710-560



INTEGRATED CIRCUIT ENGINEERING

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INTRODUCTION

This report describes a construction analysis of the SGS-Thomson L4990 controller. Five devices were supplied, encapsulated in 16-pin Dual-In-Line plastic packages (DIP). Devices were date coded 9531.

MAJOR FINDINGS

Questionable Items:¹ None.

Special Features:

- BiCMOS with N+ buried layer, N-epi, P-wells in a P substrate.

¹ These items present possible quality or reliability concerns. They should be discussed with the manufacturer to determine their possible impact on the intended application.

TECHNOLOGY DESCRIPTION

Assembly:

- Devices were encapsulated in 16-pin plastic Dip's.
- Lead-locking provisions (anchors and holes) were present at all pins.
- Thermosonic ball bond method employing 1.0 mil O.D. gold wire.
- Silver-filled epoxy die attach.
- Sawn dicing (full depth).

Die Process and Design

- Fabrication process: Selective oxidation BiCMOS process employing N+ buried layer, N-epi in a P substrate. All devices were formed in N-epi with N+ buried layer. N-channel devices were formed in a P well within the N-epi and N+ buried layer.
- Final passivation: Three layers of passivation were employed. A layer of nitride over two layers of silicon-dioxide. The first layer of silicon-dioxide was very thin.
- Metallization: Two levels of silicon-doped aluminum defined by dry-etch techniques. No caps or barriers were employed. Standard contacts and vias (no plugs).
- Interlevel dielectric: Interlevel dielectric consisted of two layers of silicon-dioxide. The first layer appeared to have been subjected to an etchback.
- Pre-metal glass: A layer of reflow glass over densified oxides was used. Reflow was done prior to contact cuts.

TECHNOLOGY DESCRIPTION (continued)

- Polysilicon: Single layer of dry-etched polysilicon (no silicide) was used to form all MOS gates on the die. Sidewall spacers were not employed.
- CMOS devices: Standard N+ and P+ implanted diffusions formed the sources/drains for these transistors. No LDD process was used. N-channel devices were located in P-wells within the N-epi/N+ buried layer. P-channel devices were located in the N-epi/N+ buried layer.
- Bipolar devices: Standard N+ diffusions (S/D) were used for emitters and collectors of NPN's and base contacts of PNP devices. Standard P+ diffusions (S/D) were also used on the PNP devices at the collector and emitter contacts for better ohmic contact. The base diffusions on the NPN device were a deep P+ diffusion (emitter and collector on PNP's). All bipolar devices were located in the N-epi and N+ buried layers.
- No buried contacts were employed.
- Isolation: Local oxide isolated MOS devices and P+ isolation diffusions (up and down) separated the N-epi islands.

ANALYSIS RESULTS I

Assembly:

Figures 1 - 4

Note: Package analysis was not required. The following data was obtained by observation and is given here as general information.

Questionable Items:¹ None.

Special Features:

- Bond pads were oversized (6.3 x 6.3 mils)

General Items:

- Devices were packages in 16-pin plastic Dip's.
- Package markings and date codes were clear and easy to read.
- Overall package quality: Normal. No defects were noted on the external portions of the package. Deflash was of normal quality and workmanship. Lead form was of normal quality and tinning was complete. No problems were found.
- Die placement: Die was centered on the header and silver-epoxy die attach was of good quantity and quality. No problems were found.
- Lead-locking provisions (anchors and holes) were present at all pins.

¹ These items present possible quality or reliability concerns. They should be discussed with the manufacturer to determine their possible impact on the intended application.

ANALYSIS RESULTS I (continued)

- Wirebonding: Thermosonic ball bond method using 1.0 mil O.D. gold wire. No bond lifts occurred and bond pull strengths were good (see page 9). Wire spacing and placement was good.
- Die dicing: Die separation was by full depth sawing with good quality workmanship.

ANALYSIS RESULTS II

Die Process and Design:

Figures 5 - 26

Questionable Items:¹ None.

Special Features:

- BiCMOS with N+ buried layer, N-epi, in a P substrate.

General Items:

- Fabrication process: Selective oxidation BiCMOS process employing N+ buried layer, N-epi in a P substrate. All devices were formed in N-epi with N+ buried layer. N-channel devices were formed in a P well within the N-epi and N+ buried layer.
- Design and layout: Die layout was clean and efficient. No problems were noted.
- Die surface defects: None. No contamination or processing defects were noted.
- Final passivation: The passivation consisted of a layer of nitride over two layers of silicon-dioxide. The first layer glass was very thin. Passivation integrity test indicated defect free passivation. Edge seal was also good.
- Metallization: Two levels of metal defined by a dry-etch of normal quality. Metal 2 line profiles were somewhat unusual. The top portion of the line was wider than the main body of the metal. Metal consisted of silicon-doped aluminum. No cap or barrier metals were employed. Standard vias and contacts were used (no plugs). Contacts and vias were completely surrounded by metal.

¹ These items present possible quality or reliability concerns. They should be discussed with the manufacturer to determine their possible impact on the intended application.

ANALYSIS RESULTS II (continued)

- Metal defects: None. No voiding of the metal layers was present. Small notches were noted in the metal layers; however, no problems are foreseen. Small silicon nodules were noted following the removal of the metal, but no problems were present.
- Metal step coverage: Metal 2 aluminum thinned up to 70 percent at vias. Minimum metal 1 thinning was noted due to the slope etch of the contacts. MIL-STD-883D allows up to 70 percent metal thinning for contacts of this size.
- Contacts defects: None. Vias were steep and thick and no reflow was performed. The contact cuts were well sloped. No over-etching of the contacts were noted. No contact pitting or silicon mound growth was noted.
- Interlevel dielectric: Interlevel dielectric consisted of two layers of silicon-dioxide. The first layer appeared to have been subjected to an etchback. No problems were present.
- Pre-metal glass: A layer of reflow glass over densified oxides was used. Reflow was done prior to contact cuts.
- Polysilicon: Single layer of dry-etched polysilicon (no silicide) was used to form all MOS gates on the die. Sidewall spacers were not employed. No poly resistors were present. No problems were present.
- Local oxide (LOCOS) isolation. No step was noted in the oxide at the edge of the well.
- CMOS devices: Standard N+ and P+ implanted diffusions formed the sources/drains for these transistors. No LDD process was employed.

ANALYSIS RESULTS II (continued)

- Bipolar devices: Standard N⁺ diffusions (S/D) were used for emitters and collectors of NPN's and base contacts of PNP devices. Standard P⁺ diffusions (S/D) were also used on the PNP devices at the collector and emitter contacts for better ohmic contact. The base diffusions on the NPN device were a deep P⁺ diffusion (emitter and collector on PNP's). All bipolar devices were located in the N-epi and N⁺ buried layers.

PROCEDURE

The devices were subjected to the following analysis procedures:

External inspection

X-ray

Decapsulation

Internal optical inspection

SEM inspection of assembly features and passivation

Wirepull test

Passivation integrity test

Passivation removal and inspect metal 2

Delayer to metal 1 and inspect

Delayer to poly and inspect poly structures and die surface

Die sectioning (90° for SEM)*

Measure horizontal dimensions

Measure vertical dimensions

Material analysis

**Delineation of cross-sections is by silicon etch unless otherwise indicated.*

OVERALL QUALITY EVALUATION: Overall Rating: Normal

DETAIL OF EVALUATION

Package integrity	N
Package markings	G
Die placement	G
Die attach quality	G
Wire spacing	G
Wirebond placement	G (large bond pads)
Wirebond quality	G
Dicing quality	N
Wirebond method	Thermosonic ball bonds using 1.0 mil gold wire.
Dicing method:	Sawn (full depth)
Die attach:	Silver-filled epoxy
Die surface integrity:	
Tool marks (absence):	N
Particles (absence):	N
Contamination (absence):	N
Process defects (absence):	N
General workmanship	N
Passivation integrity	G
Metal definition	NP
Metal integrity	NP
Contact coverage	G
Contact registration	N
Contact defects	N

G = Good, P = Poor, N = Normal, NP = Normal/Poor

PACKAGE MARKINGS

Top

(logo) L4990
N911A9531
MALAYSIA

Bottom

none

WIREBOND STRENGTH

Wire material: 1.0 mil diameter gold
Die pad material: Aluminum

Sample 1

of wires tested: 10
Bond lifts: 0
Force to break - high: 15g
 - low: 12g
 - avg.: 13.9g
 - std. dev.: 1.0

DIE MATERIAL ANALYSIS

Passivation: Nitride over two layers of silicon-dioxide.
Die metallization: Silicon-doped aluminum.
Interlevel dielectric: Two layers of silicon dioxide.
Pre-metal glass: Layer of CVD glass over various densified oxides.

HORIZONTAL DIMENSIONS

Die size:	2.6 x 2.9 mm (102.5 x 114 mils)
Die area:	7.5 mm ² (11,685 mils ²)
Min pad size:	0.16 mm x 0.16 mm (6.3 x 6.3 mils)
Min pad window:	0.15 mm x 0.15 mm (5.8 x 5.8 mils)
Min metal 2 width:	5.8 microns
Min metal 2 space:	6.4 microns
Min metal 2 pitch:	12.2 microns
Min via:	4.0 microns
Min metal 1 width:	3.0 microns
Min metal 1 space:	3.0 microns
Min metal 1 pitch:	6.0 microns
Min contact:	1.8 microns
Min poly width:	2.6 microns
Min poly space:	3.2 microns
Min gate length*	
- (N-channel)	2.6 microns
- (P-channel)	4.0 microns
<u>PNP device</u>	
Min P+ emitter:	7.5 microns
<u>NPN device</u>	
Min N+ emitter:	6.5 microns
Min N+ emitter to edge of P+ base:	2.5 microns
P+ base to edge of isolation:	5.8 microns
Min P+ isolation width:	11 microns

* *Physical gate length*

VERTICAL DIMENSIONS

Die thickness: 0.35 mm (14 mils)

Layers

Passivation 3: 0.9 micron

Passivation 2: 0.75 micron

Passivation 1: 0.2 micron

Aluminum 2: 3.0 microns

Interlevel dielectric-glass 2: 0.6 micron

-glass 1: 0.45 - 1.1 micron

Aluminum 1: 0.75 micron

Pre-metal glass: 0.6 micron

Poly: 0.3 micron

Local oxide: 1.0 micron

N+ S/D diffusion

- (NPN, N+ emitter and collector): 0.35 micron

P+ S/D diffusion

- (for ohmic contact at P+ contacts): 0.5 micron

Deep P+: 1.6 micron

P well: 5.0 microns

N- epi: 6.0 microns

N+ buried layer: 17 microns (from surface)

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top

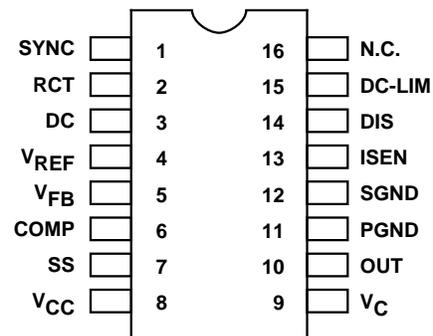


Figure 1. Package photograph and pinout of the SGS-Thomson L4990. Mag. 5x.

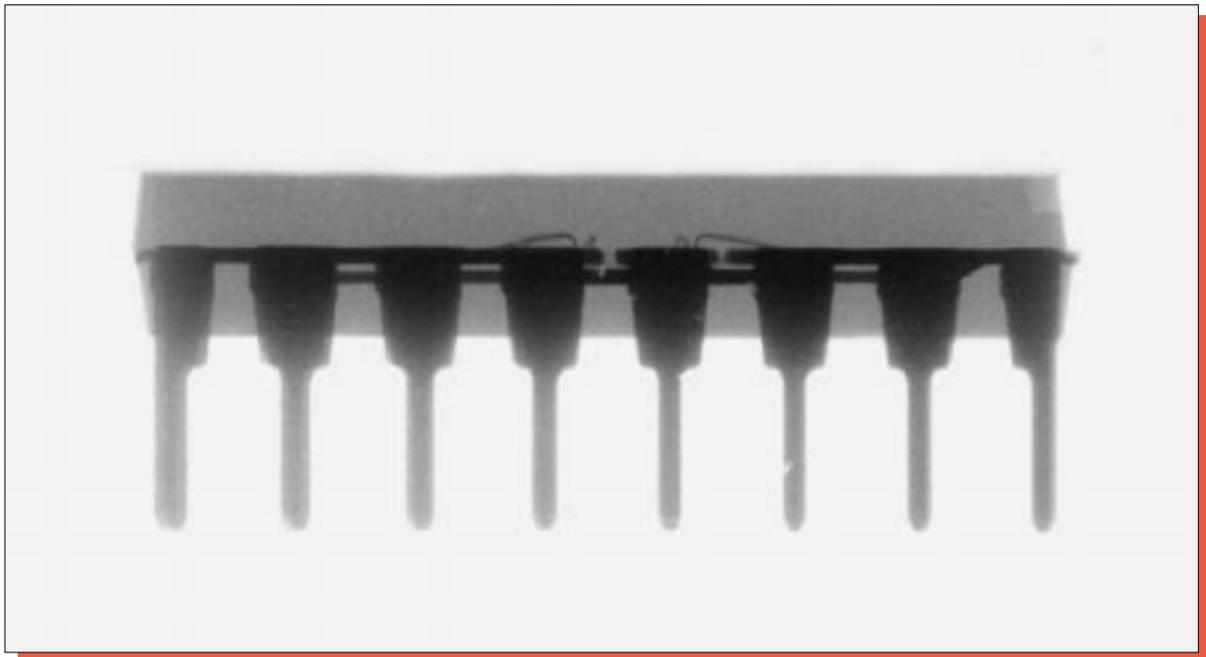
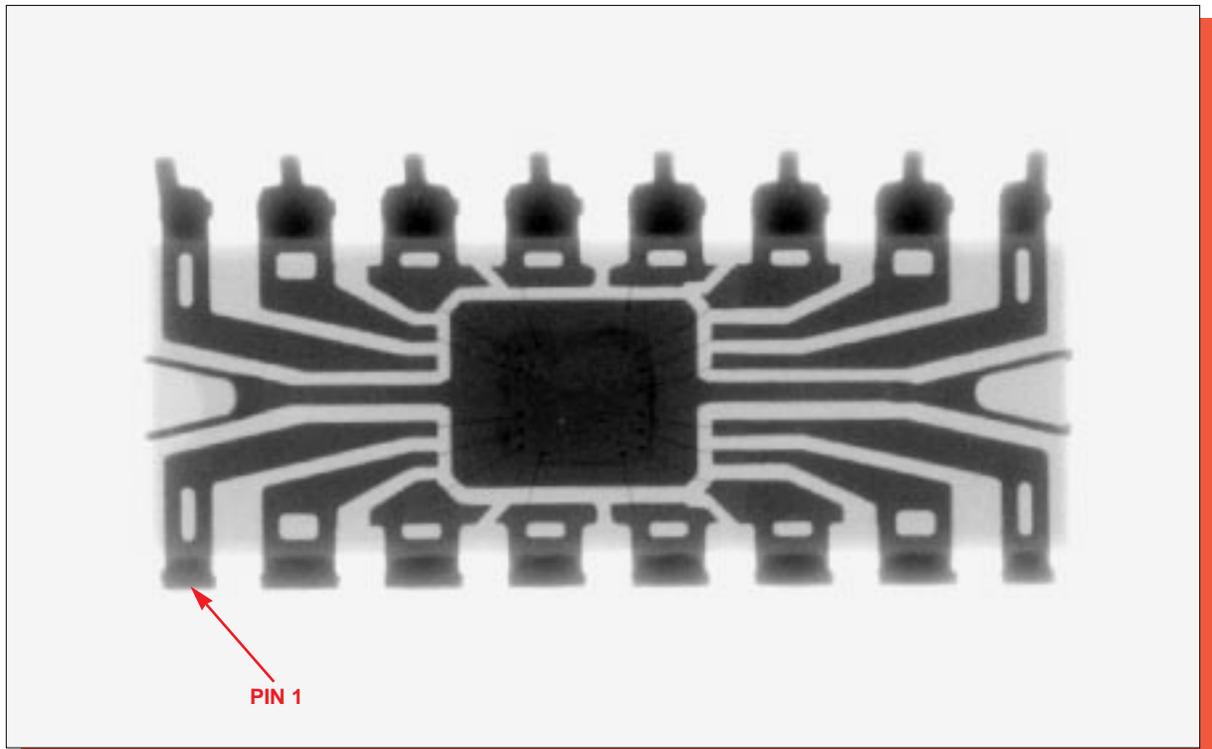
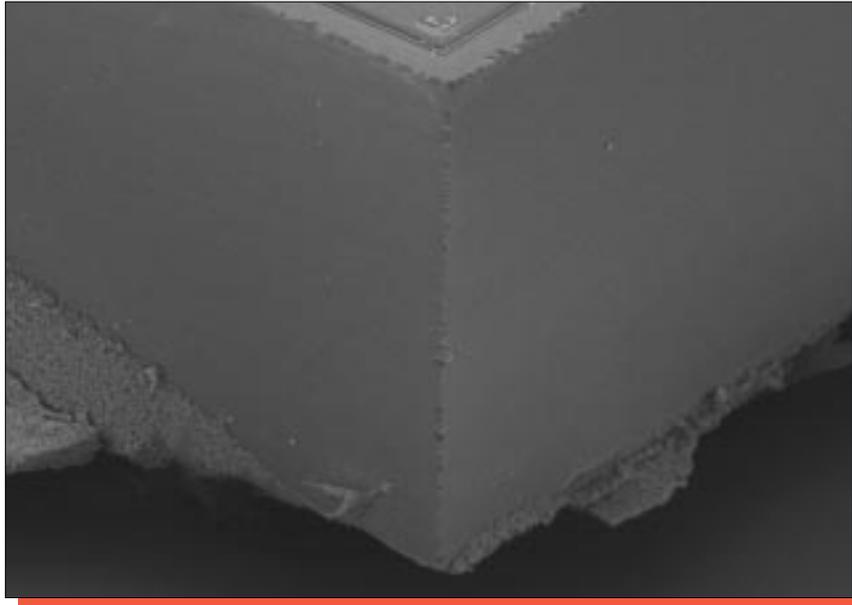
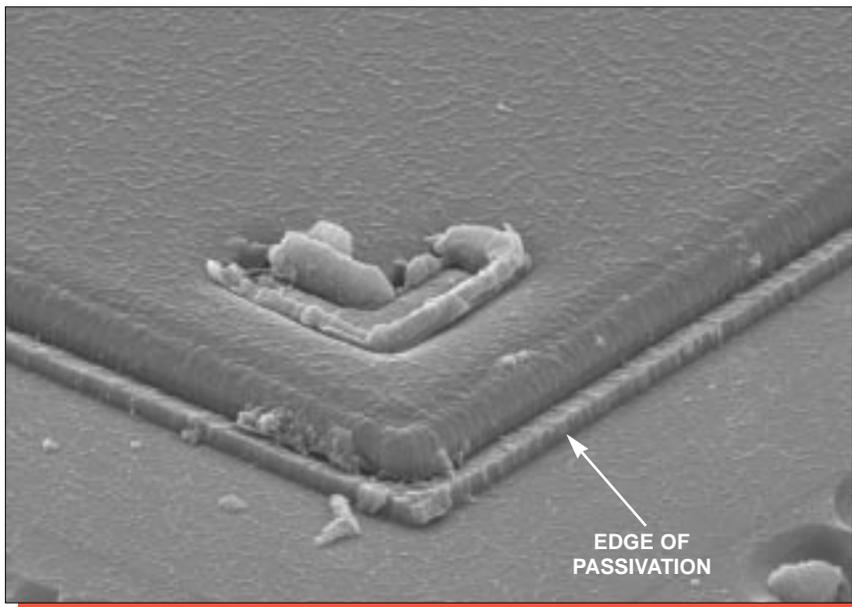


Figure 2. X-ray views of the package. Mag. 6.5x.



Mag. 200x



Mag. 1600x

Figure 3. SEM views of dicing and edge seal. 60°.

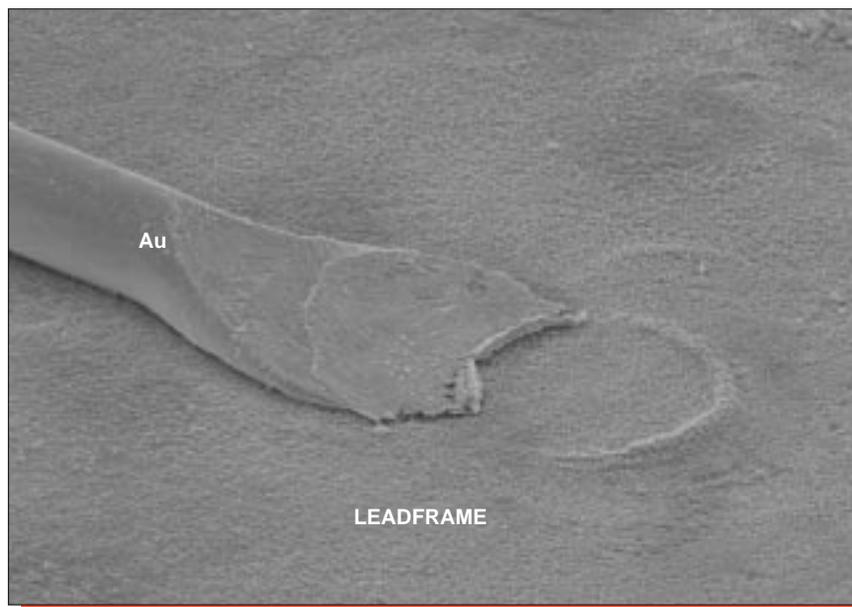
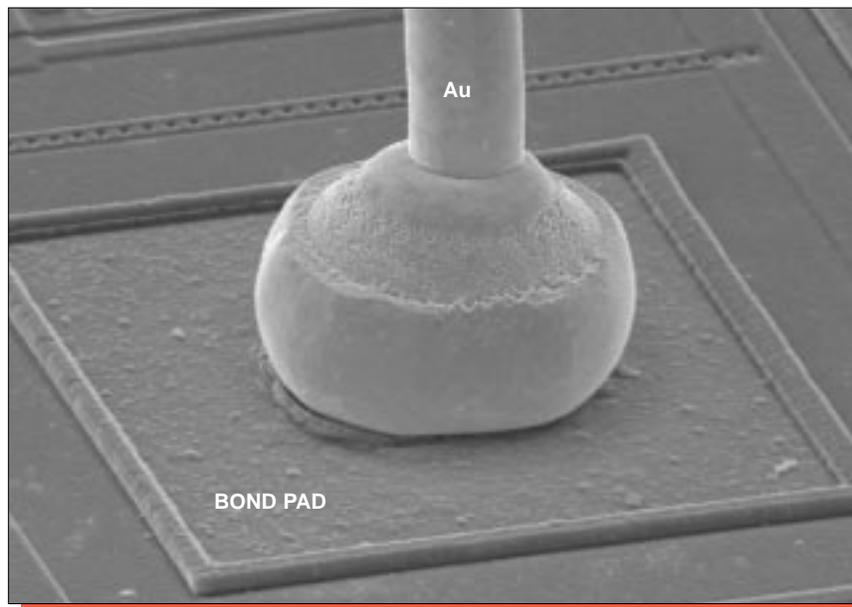


Figure 4. SEM views of typical wirebonding. Mag. 625x, 60°.

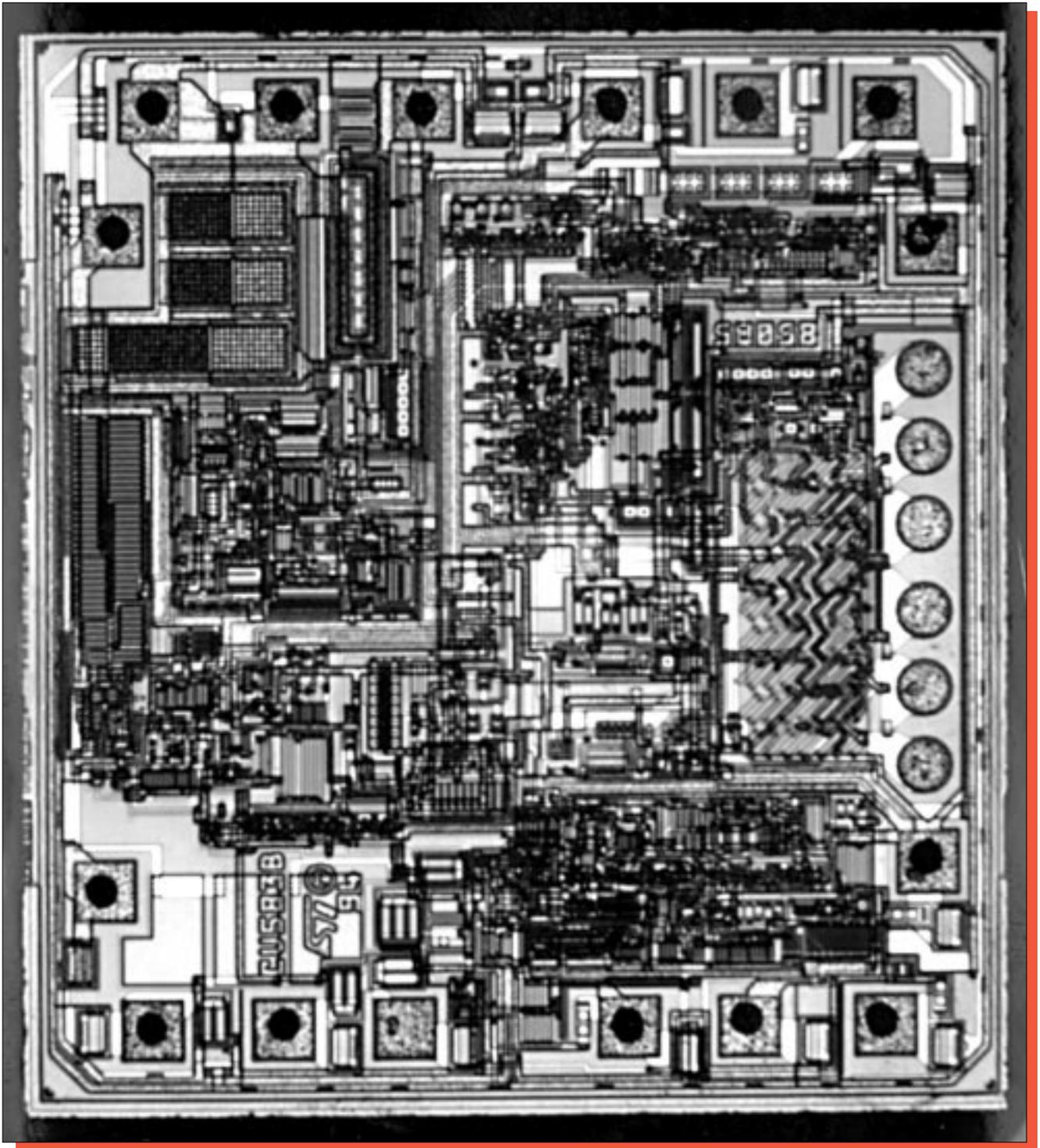
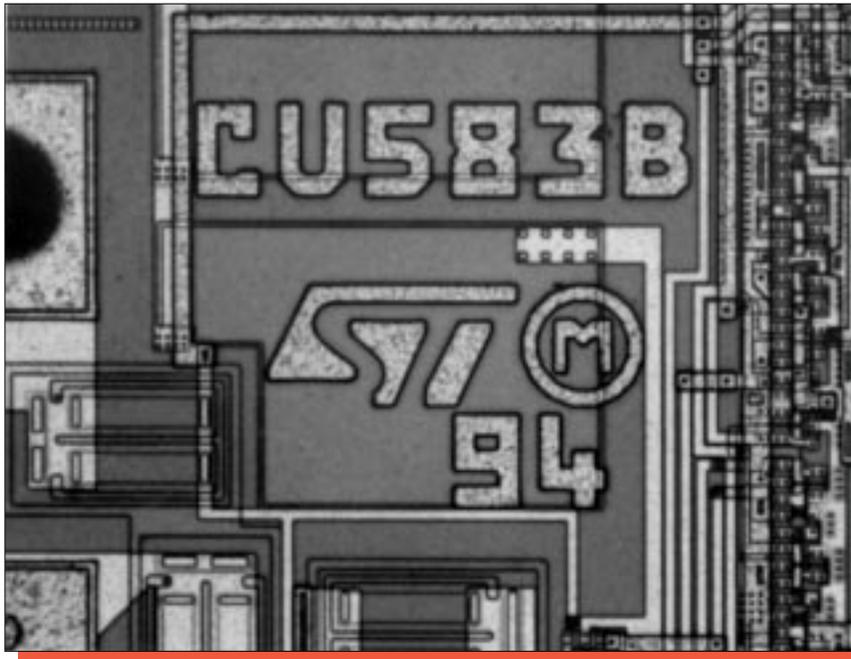
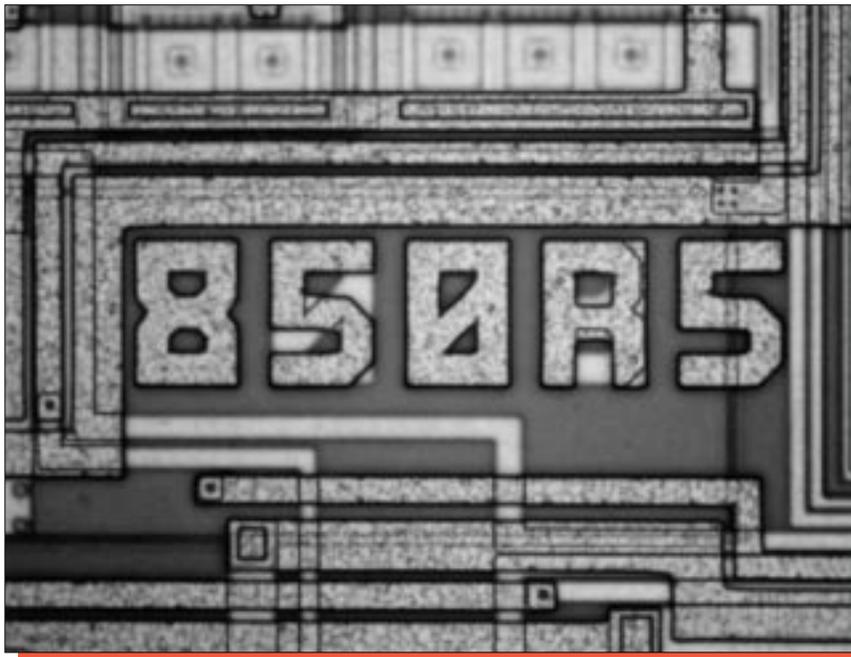


Figure 5. Whole die photograph of the SGS-Thomson L4990. Mag. 64x.



Mag. 200x



Mag. 320x

Figure 6. Optical photographs of markings on the die surface.

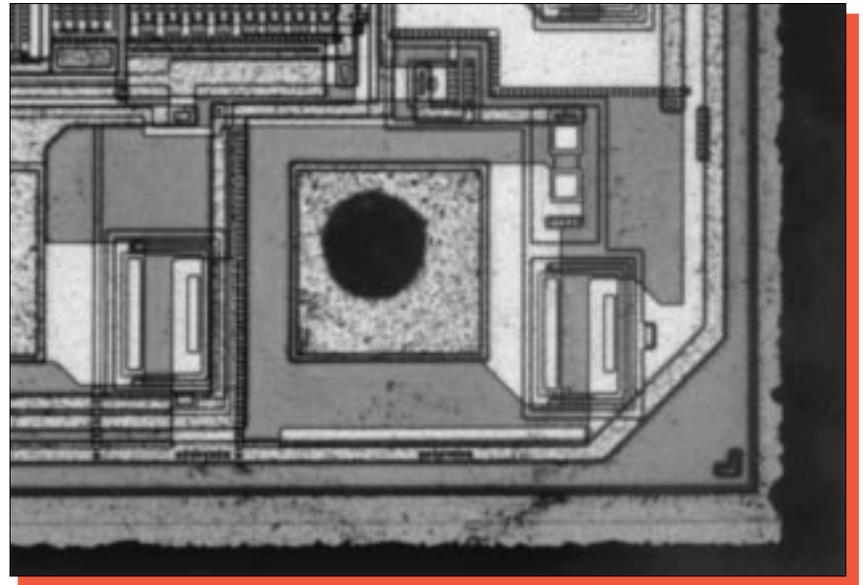
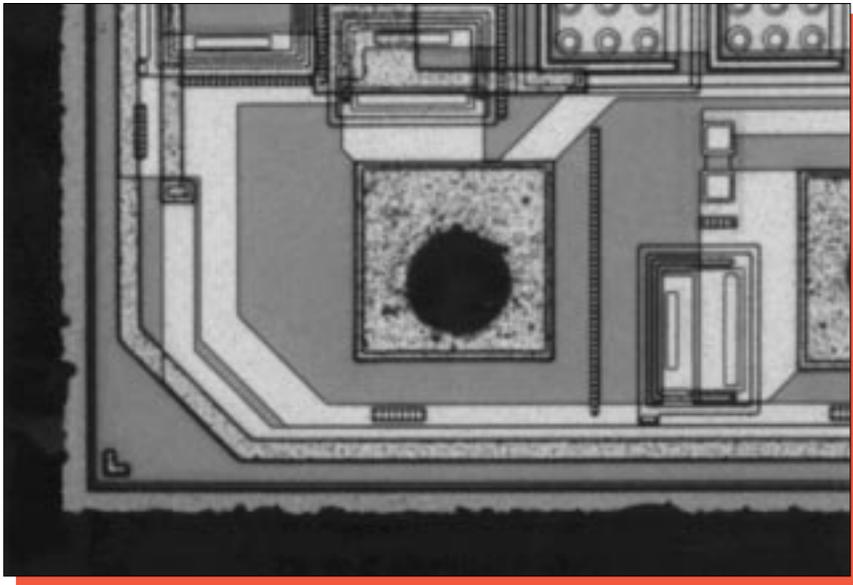
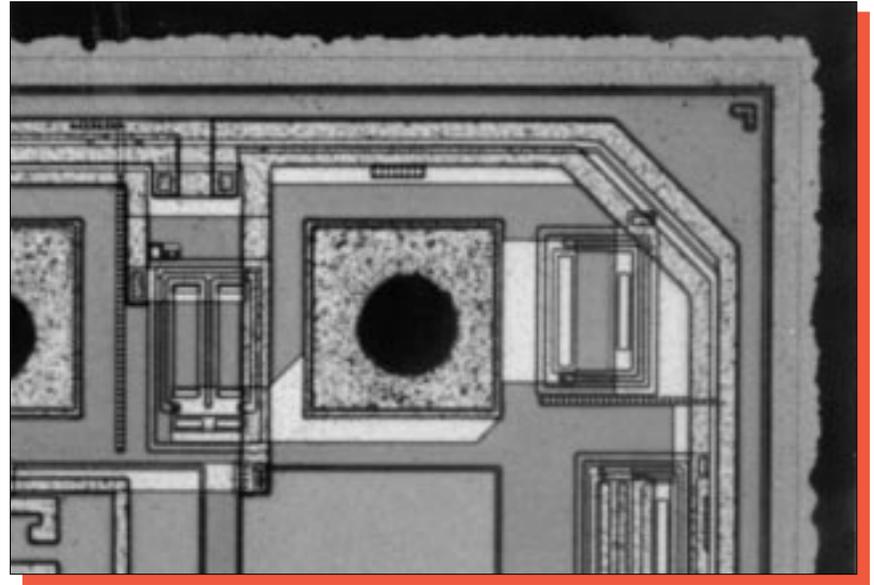
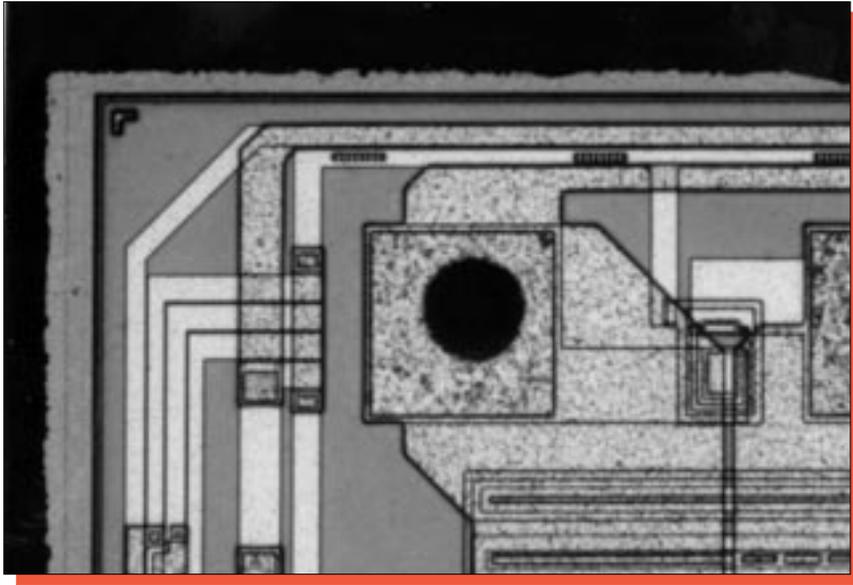
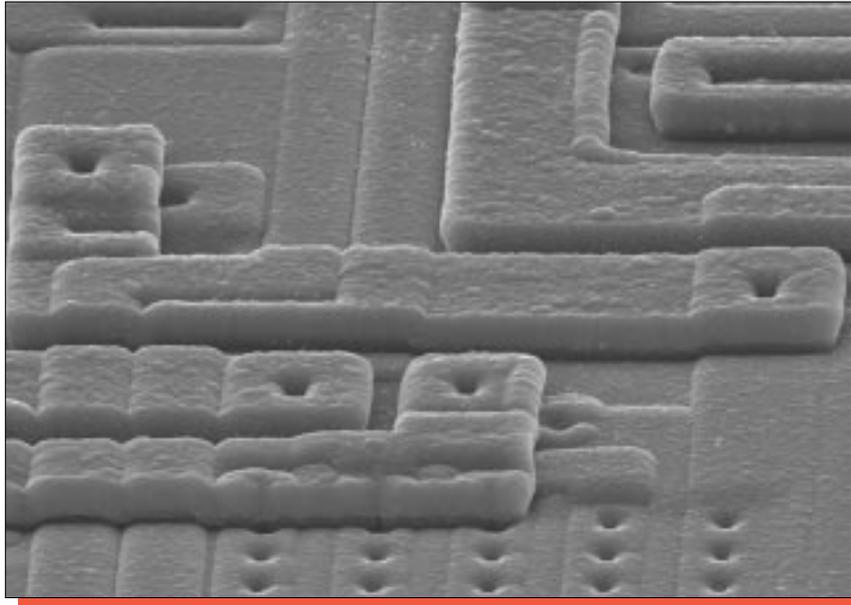
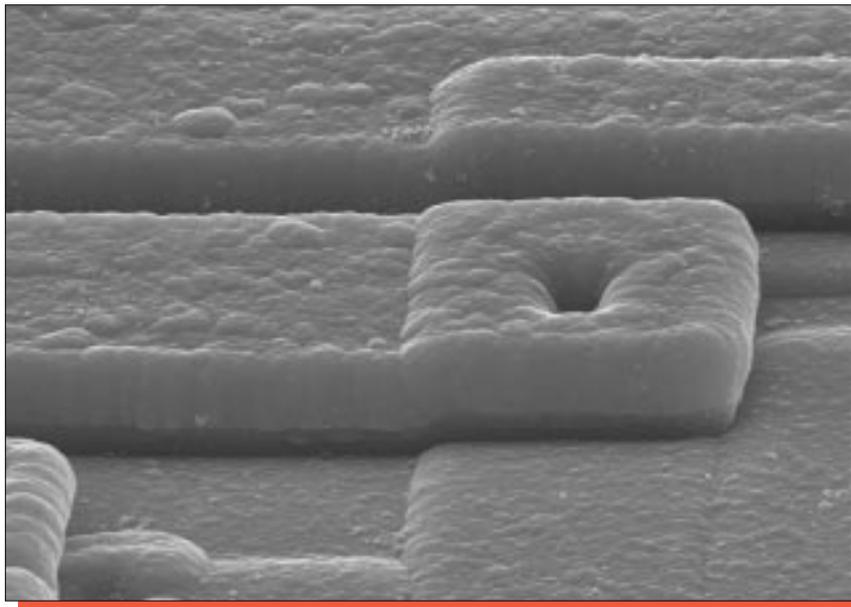


Figure 7. Optical views of the die corners. Mag. 160x.

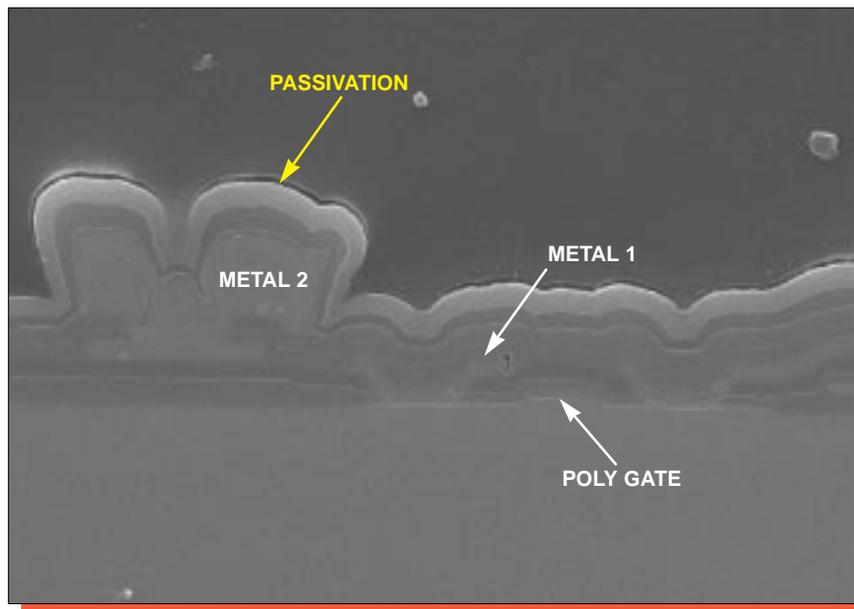


Mag. 1400x

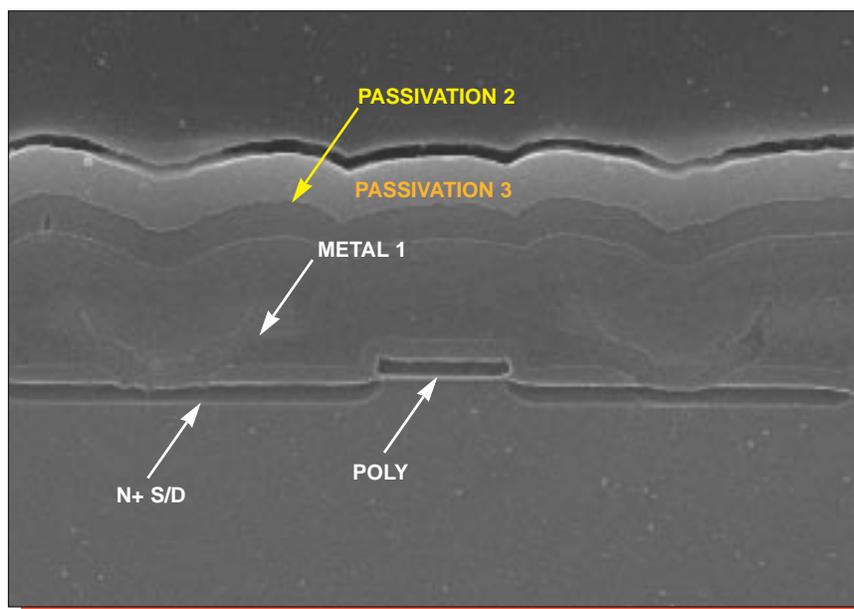


Mag. 3200x

Figure 8. Perspective SEM views of overlay passivation coverage. 60°.

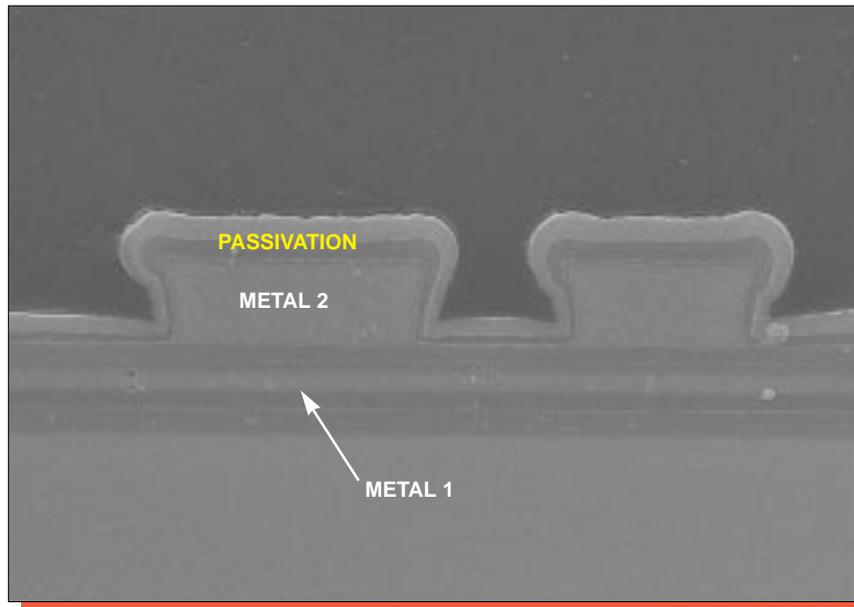


glass etch, Mag. 3200x

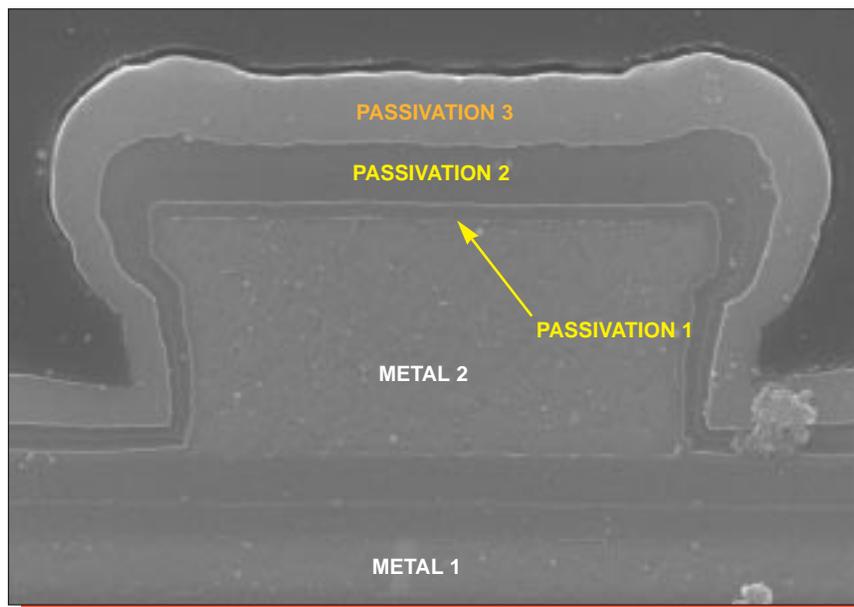


Mag. 6500x

Figure 9. SEM section views of general structure.

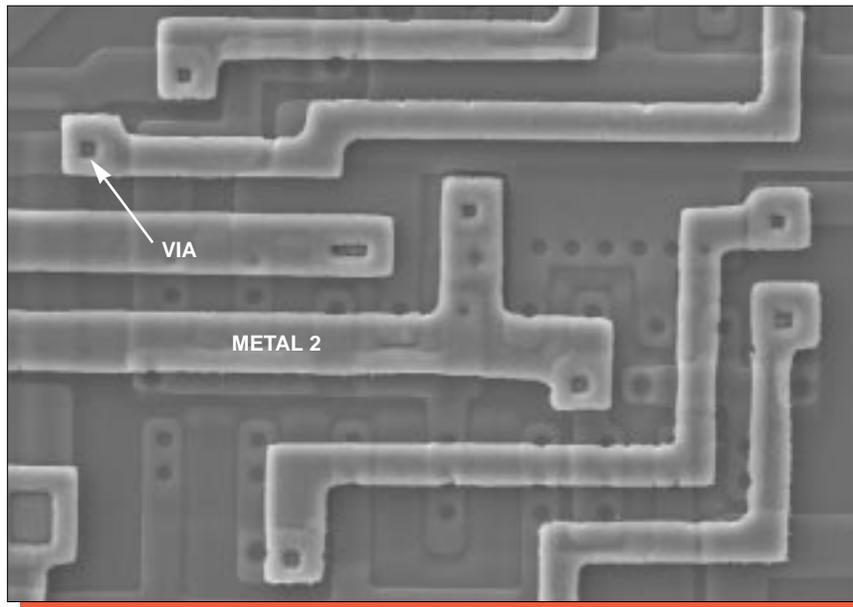


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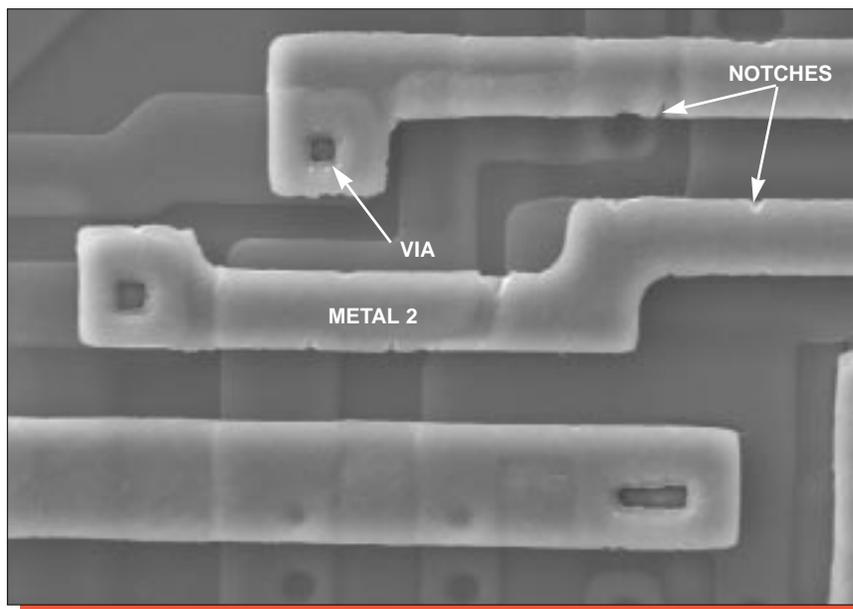


Mag. 10,000x

Figure 10. SEM section views of metal 2 line profiles.

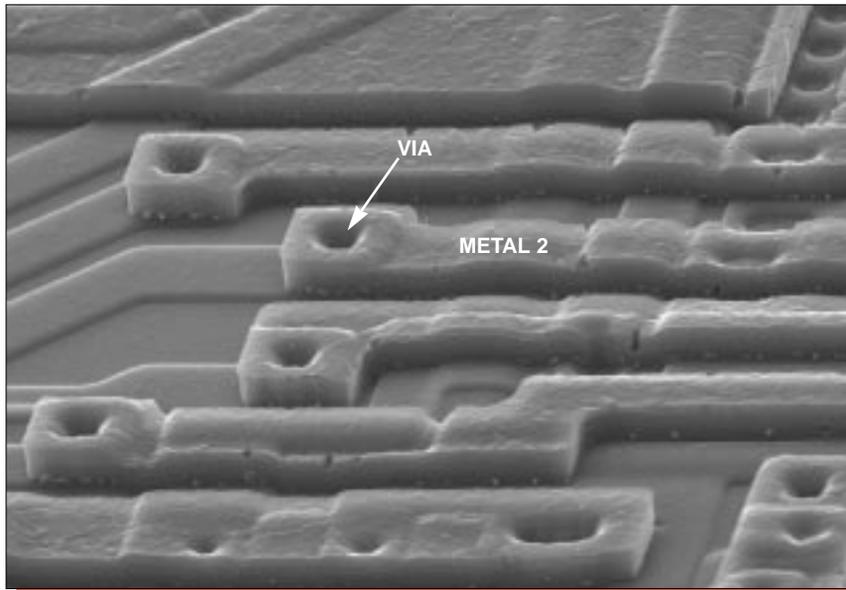


Mag. 810x

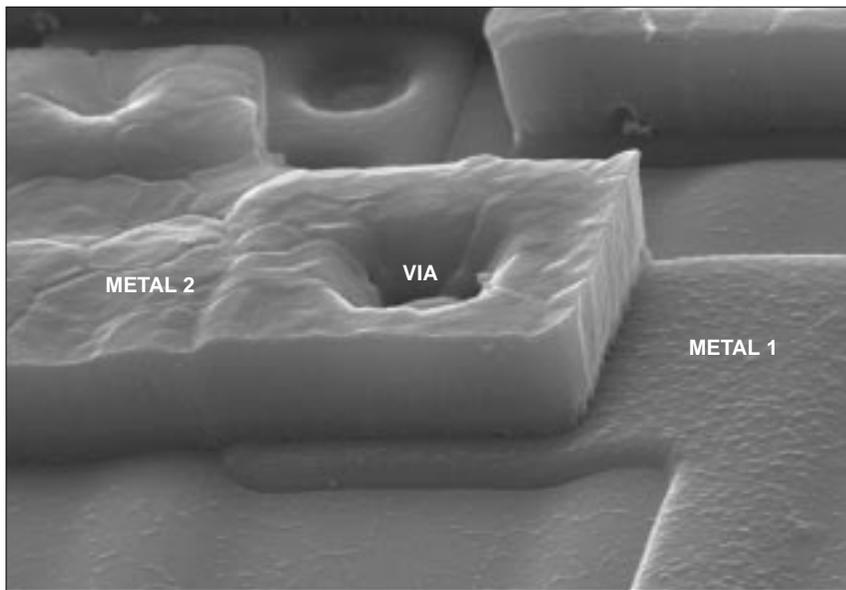


Mag. 1600x

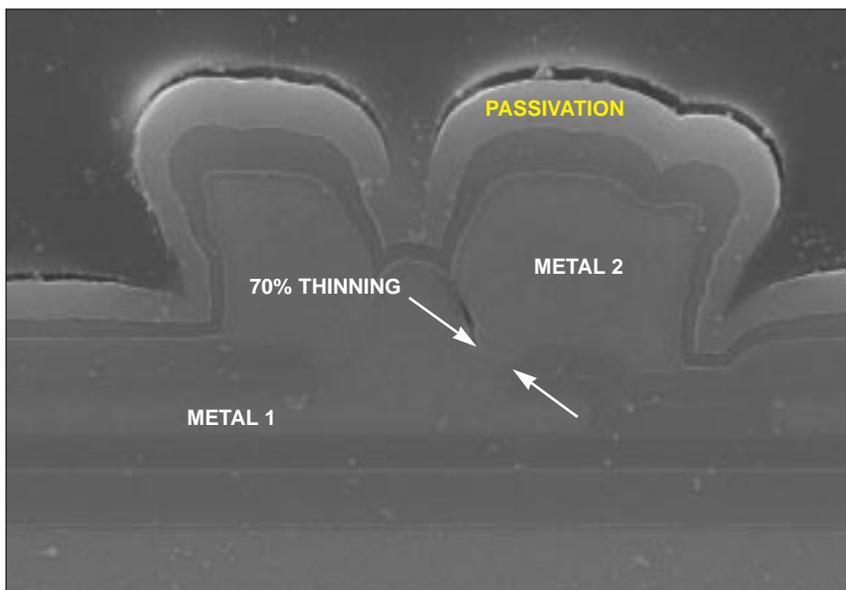
Figure 11. Topological SEM views of metal 2 patterning. 0°.



Mag. 1600x, 60°

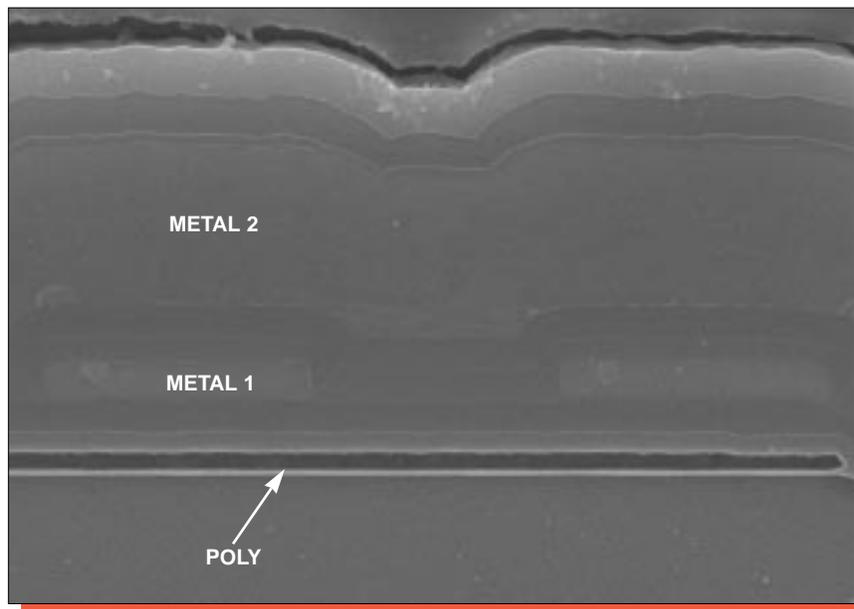


Mag. 5000x, 60°

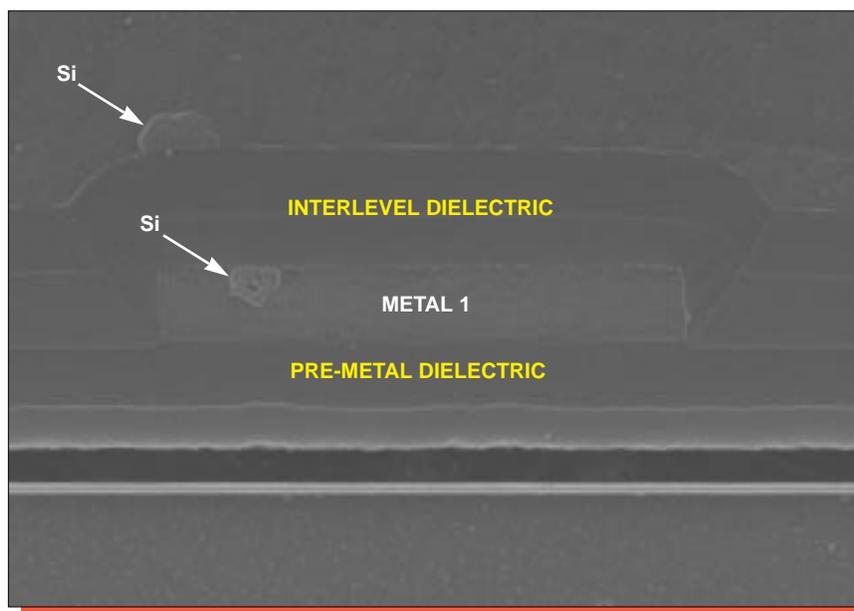


Mag. 6500x

Figure 12. SEM views of metal w2 coverage and M2-to-M1 via.

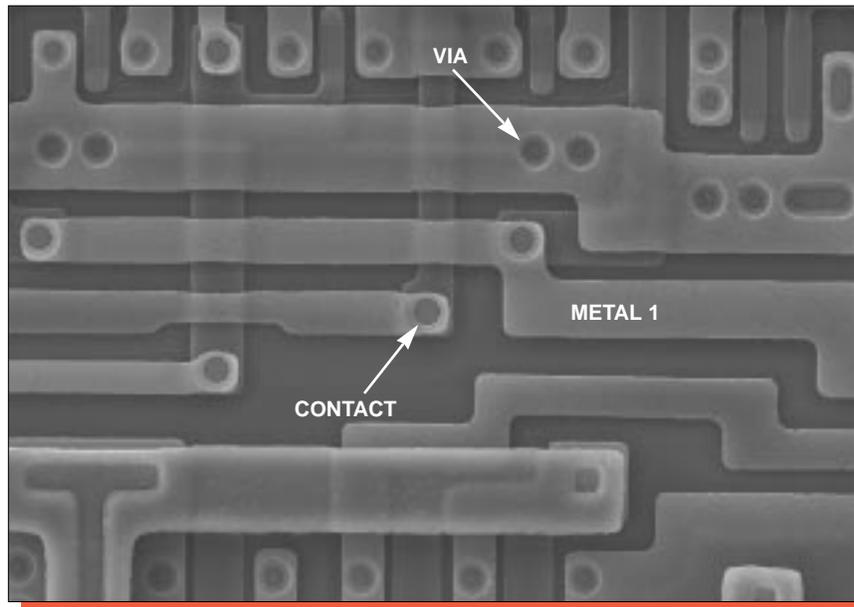


Mag. 6500x

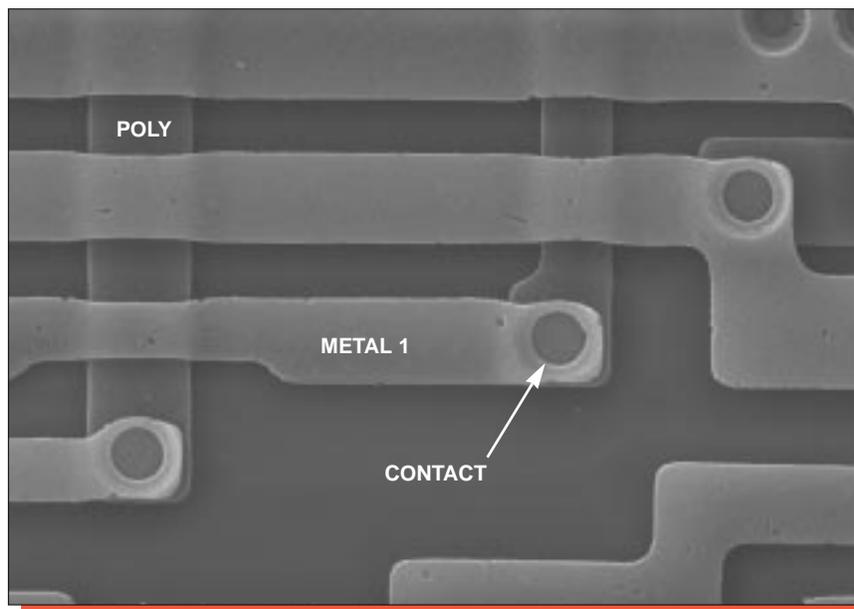


Mag. 13,000x

Figure 13. SEM section views of metal 1 line profiles.

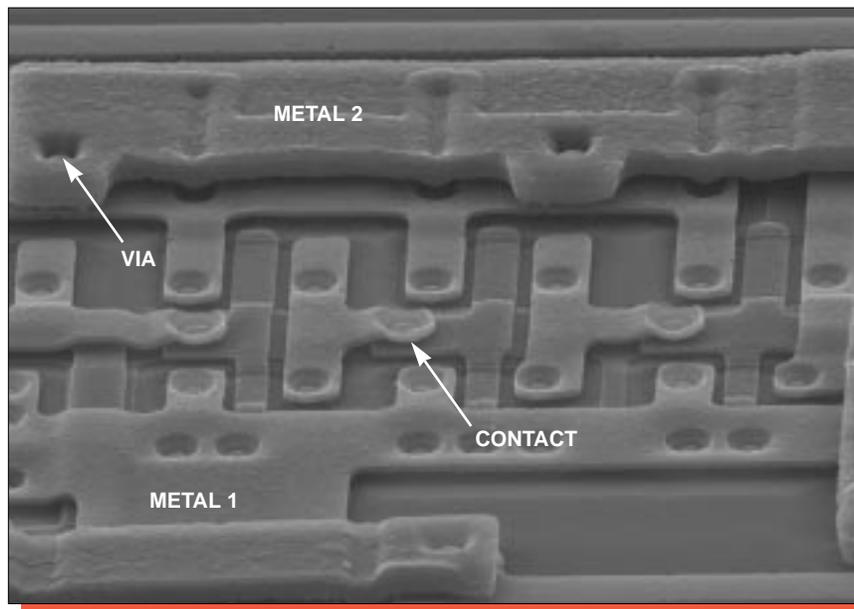


Mag. 1100x

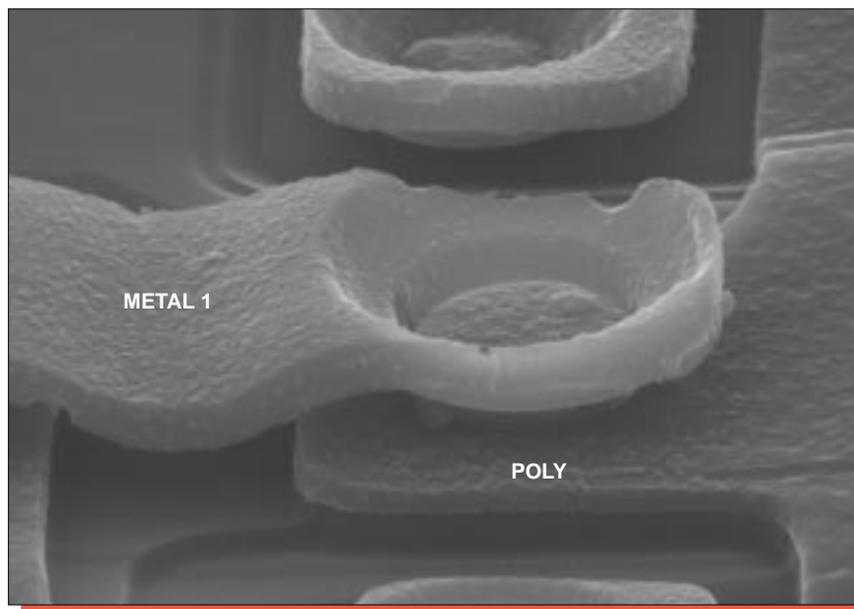


Mag. 2200x

Figure 14. Topological SEM views of metal 1 patterning. 0°.

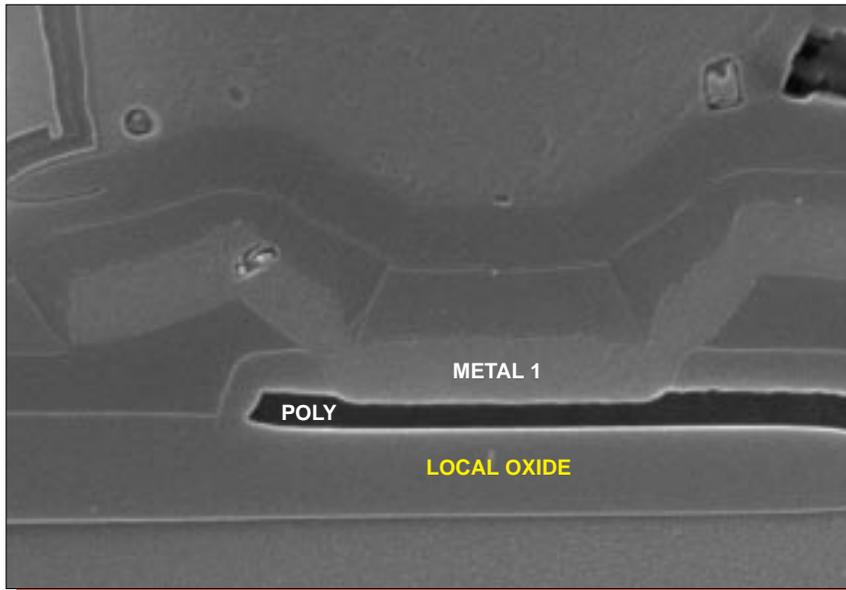


Mag. 1400x

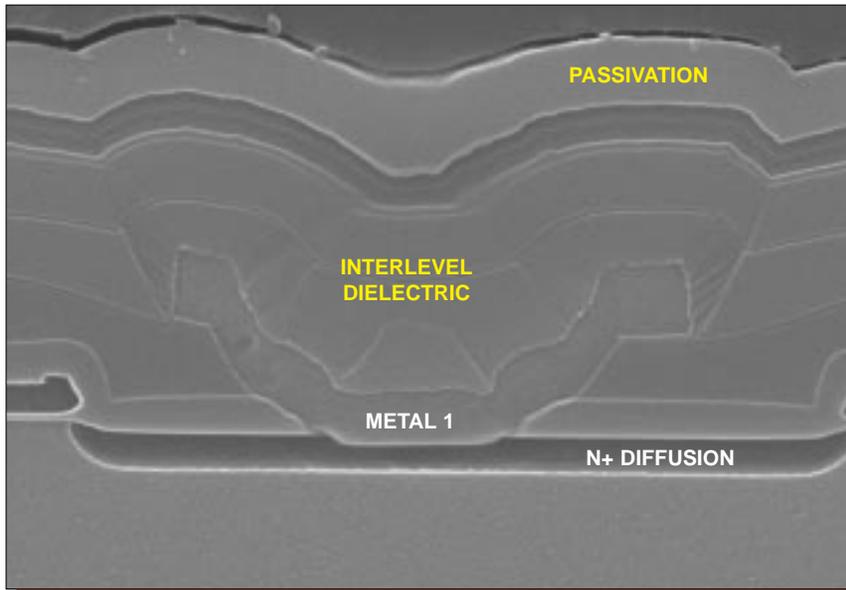


Mag. 10,000x

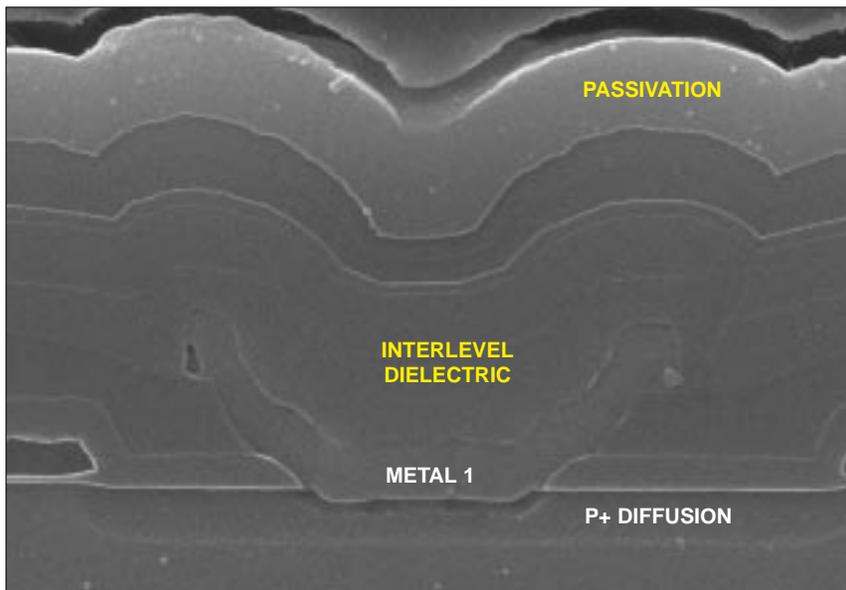
Figure 15. SEM views of metal 1 coverage. 60°.



metal 1-to-poly

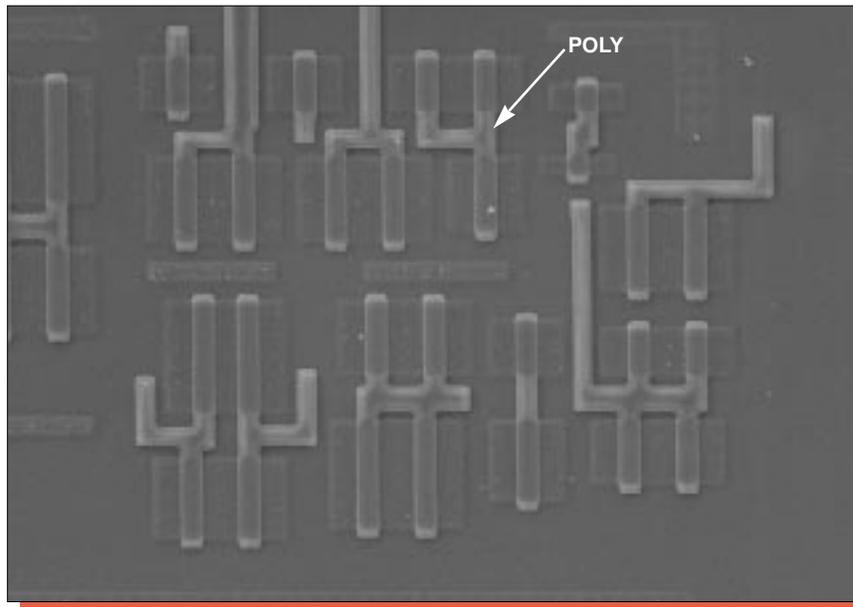


metal 1-to-N+

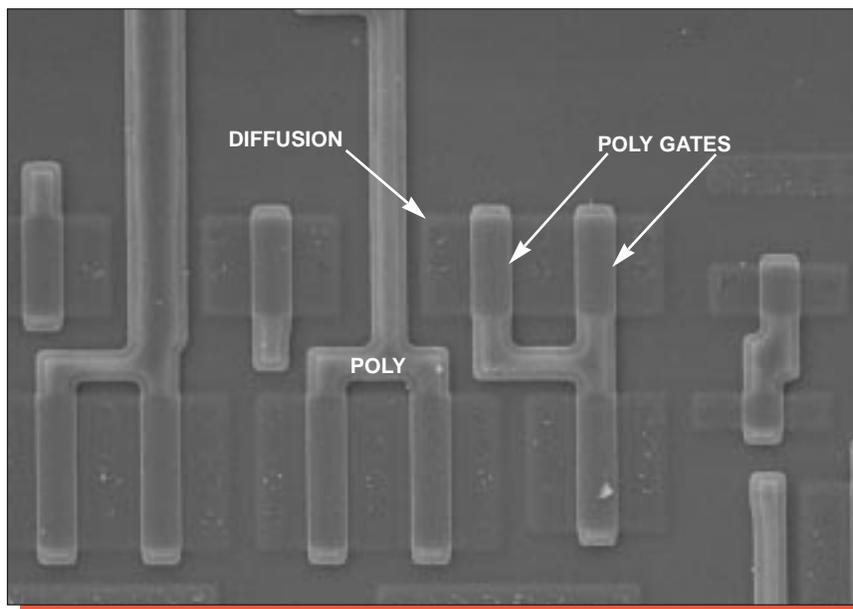


metal 1-to-P+

Figure 16. SEM section views of metal 1 contacts. Mag. 13,000x.

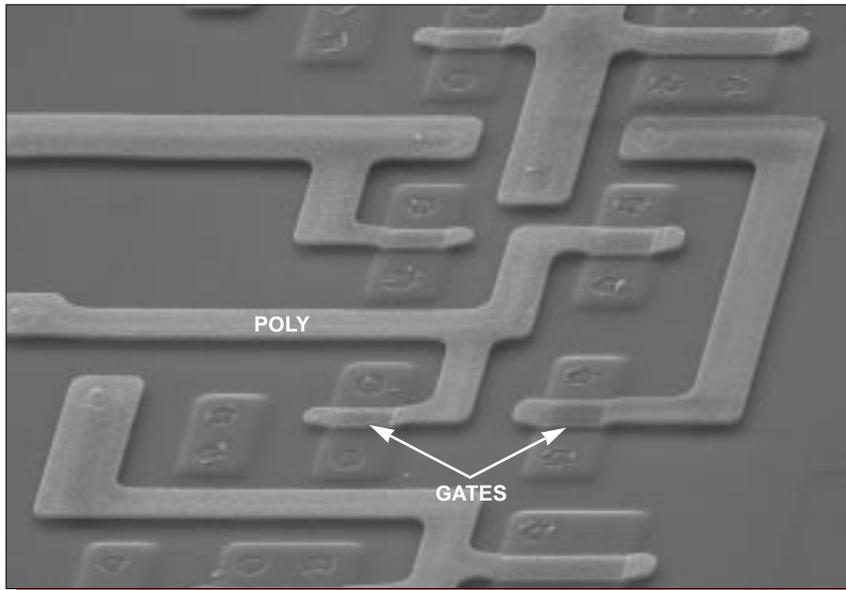


Mag. 440x

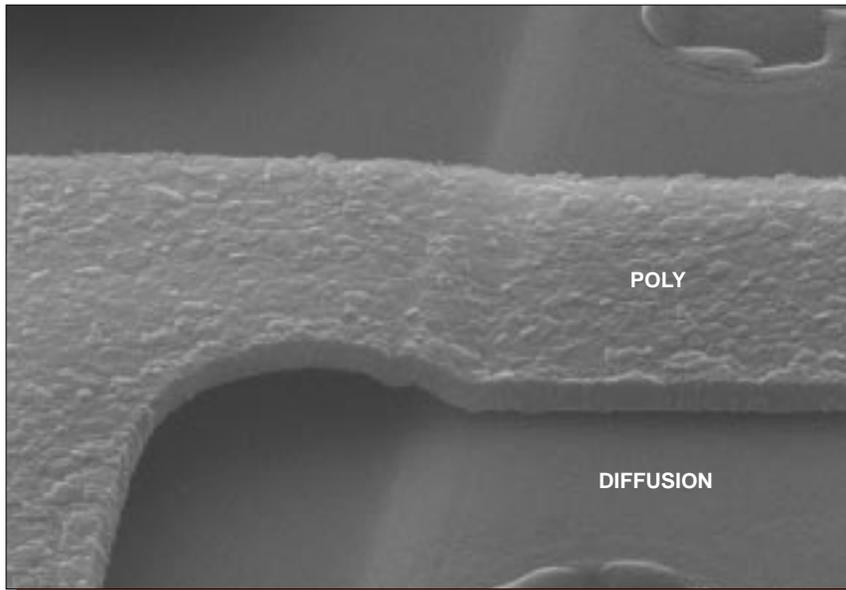


Mag. 775x

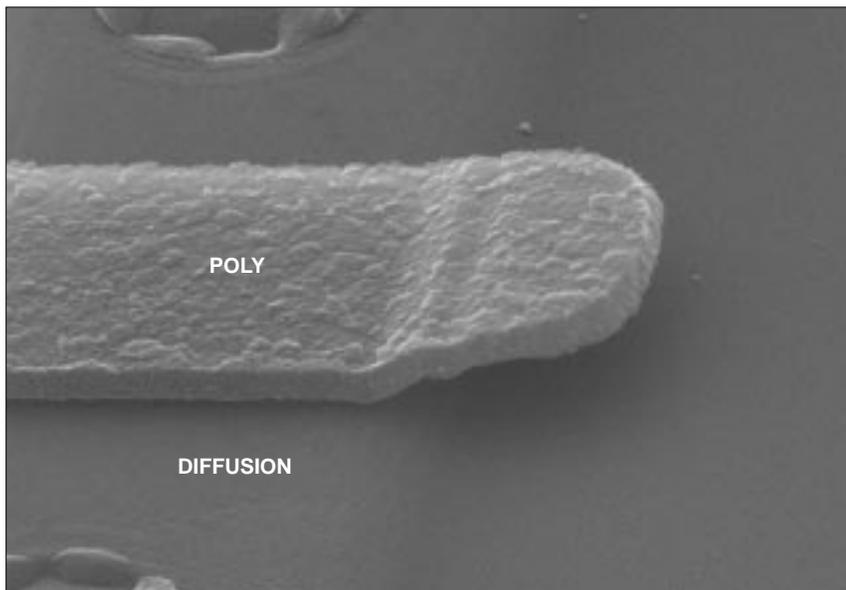
Figure 17. Topological SEM views of poly patterning. 0°.



Mag. 1600x

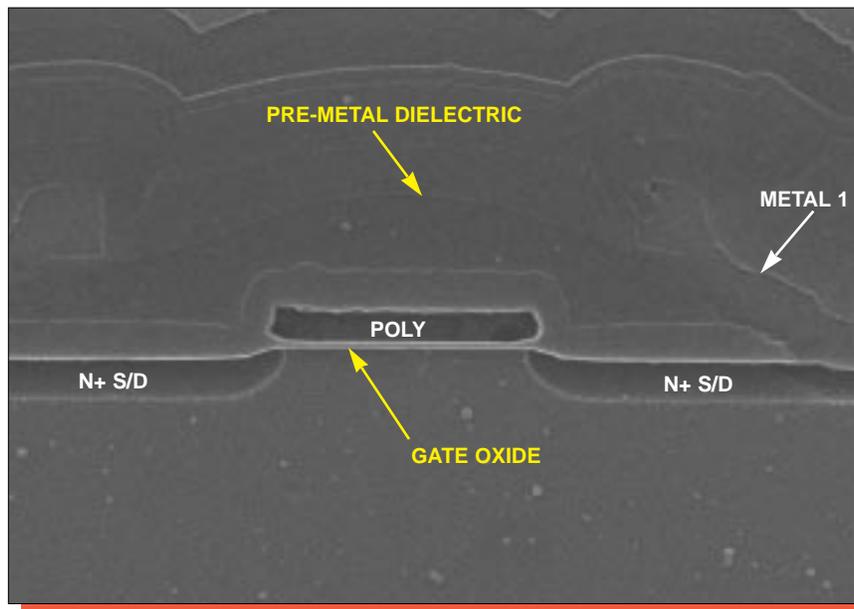


Mag. 13,000x

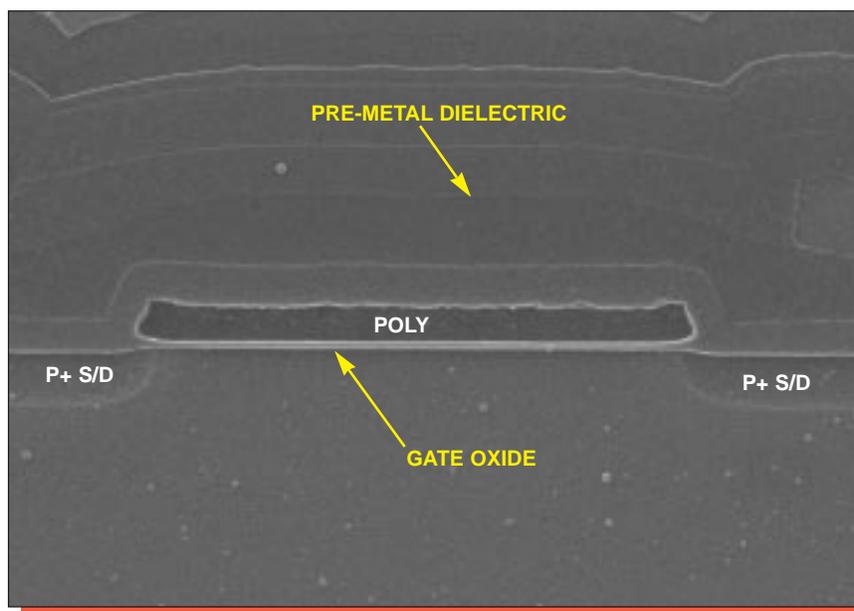


Mag. 13,000x

Figure 18. Perspective SEM views of poly coverage. 60°.



N-channel



P-channel

Figure 19. SEM section views of typical transistors. Mag. 13,000x.

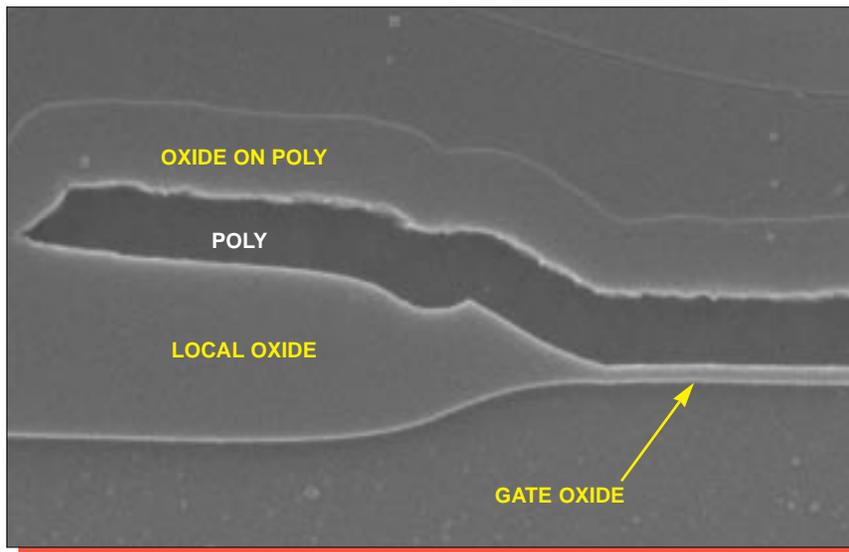


Figure 20. SEM section view of a local oxide birdsbeak. Mag. 26,000x.

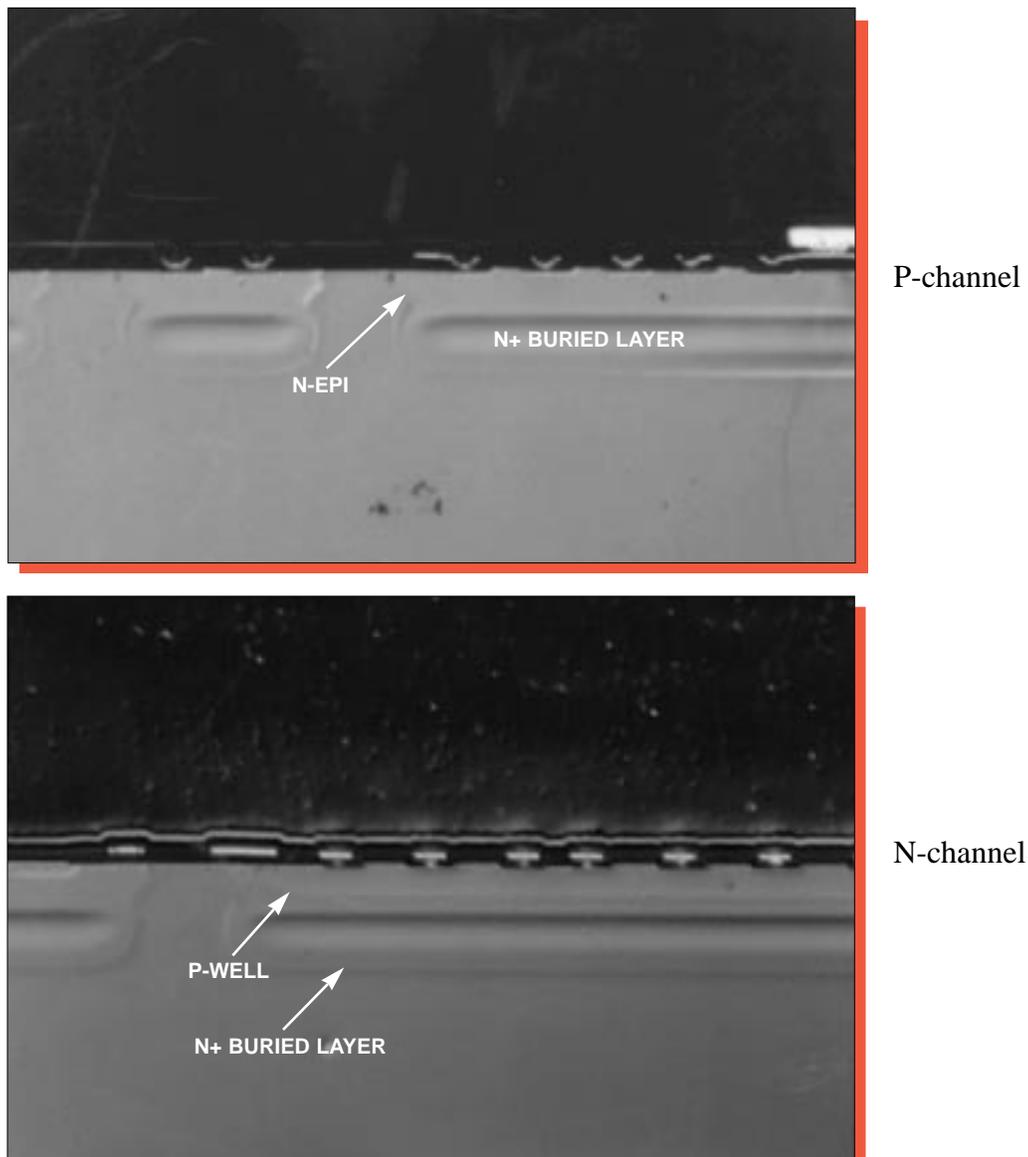
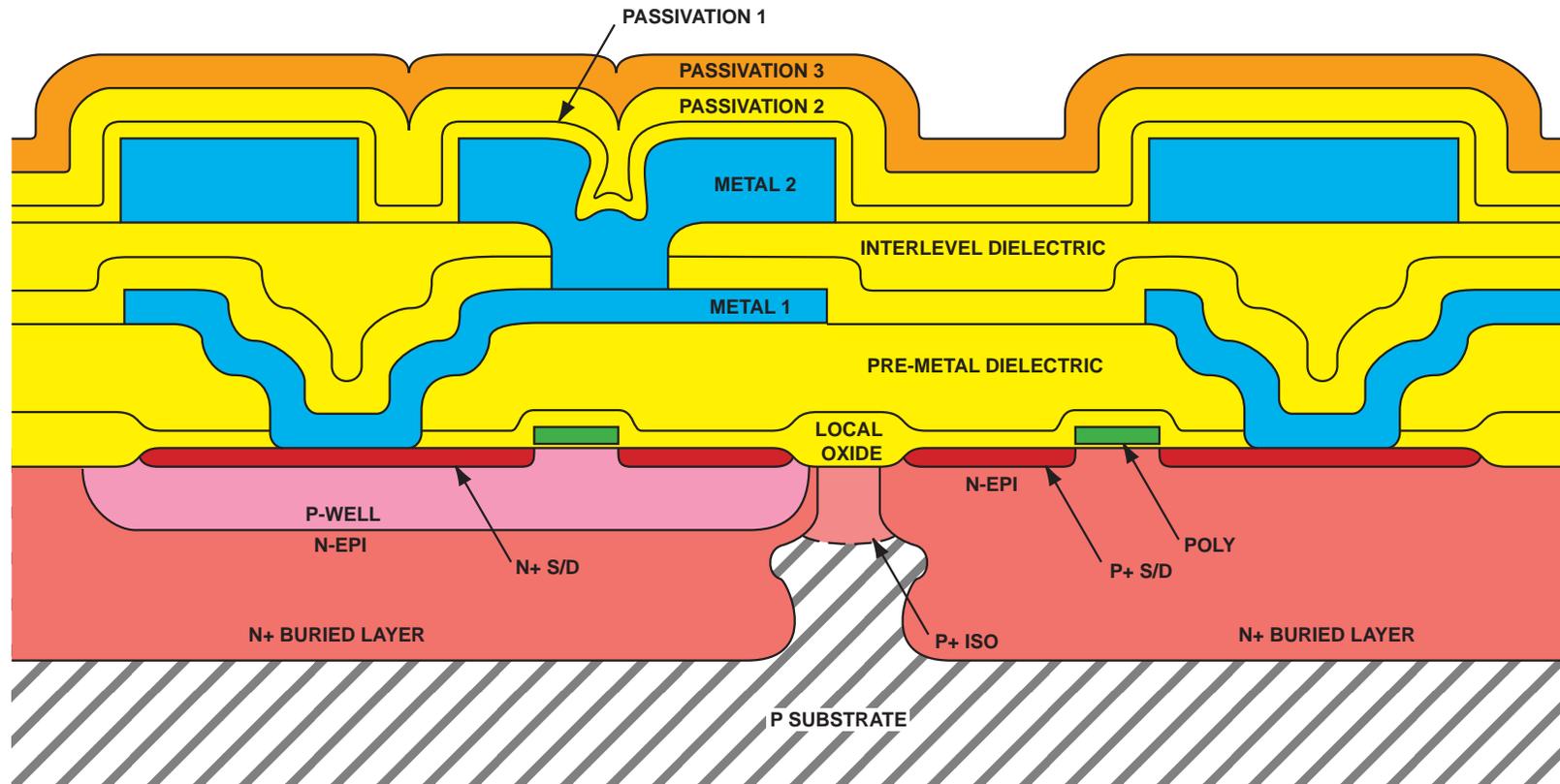
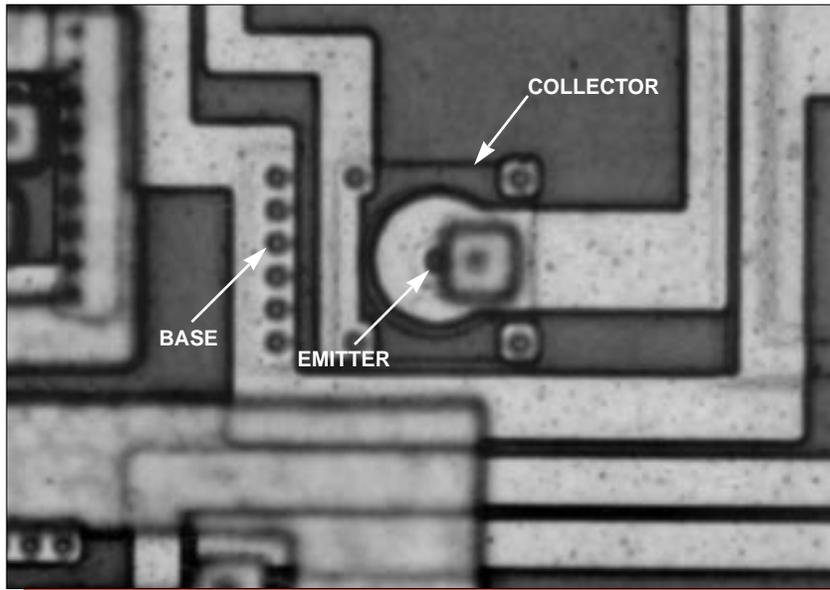


Figure 21. Optical section views of the well structure. Mag. 800x.

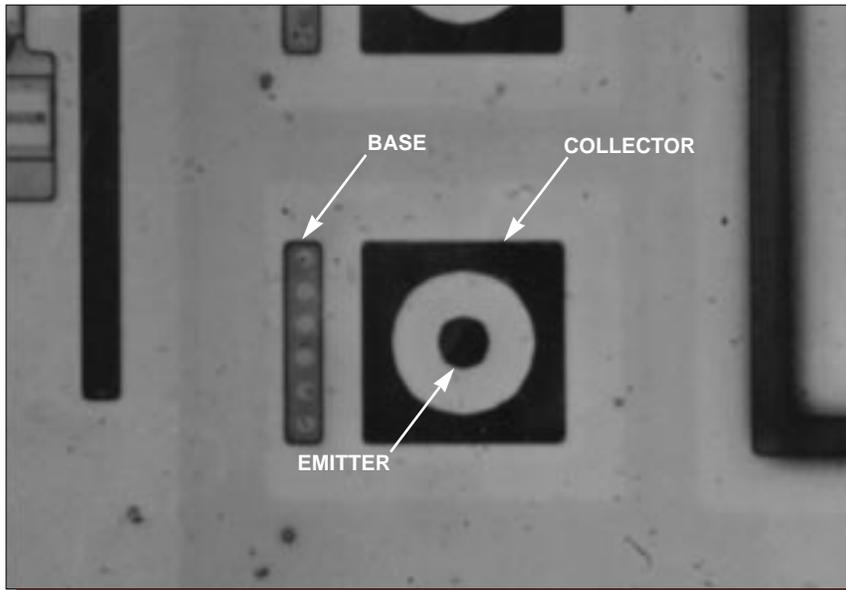


Orange = Nitride, Blue = Metal, Yellow = Oxide, Green = Poly,
 Red = Diffusion, and Gray = Substrate

Figure 21a. Color cross section drawing illustrating device structure.



intact



delayed

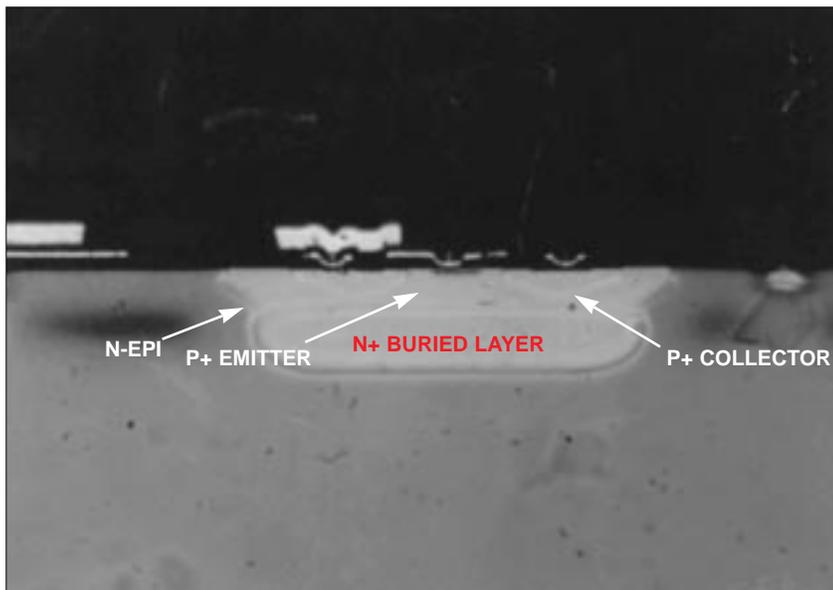
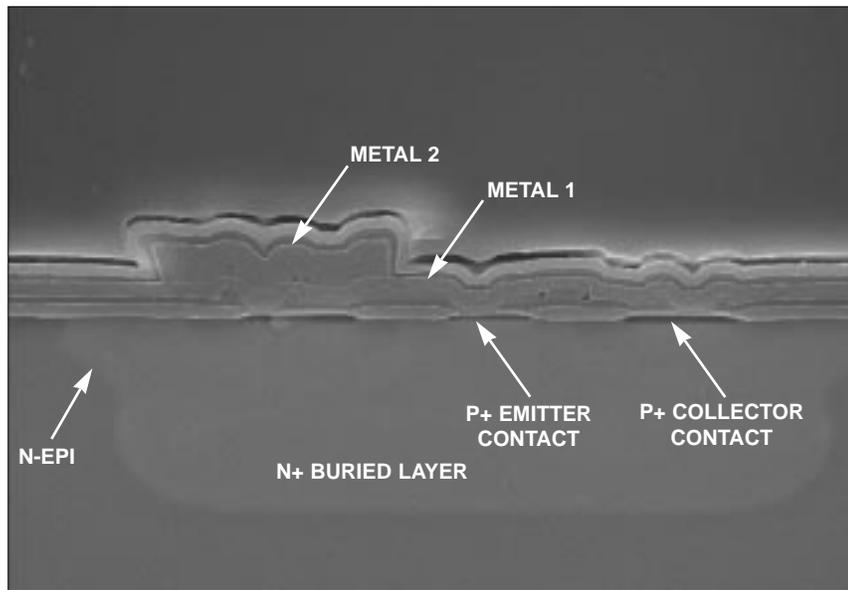
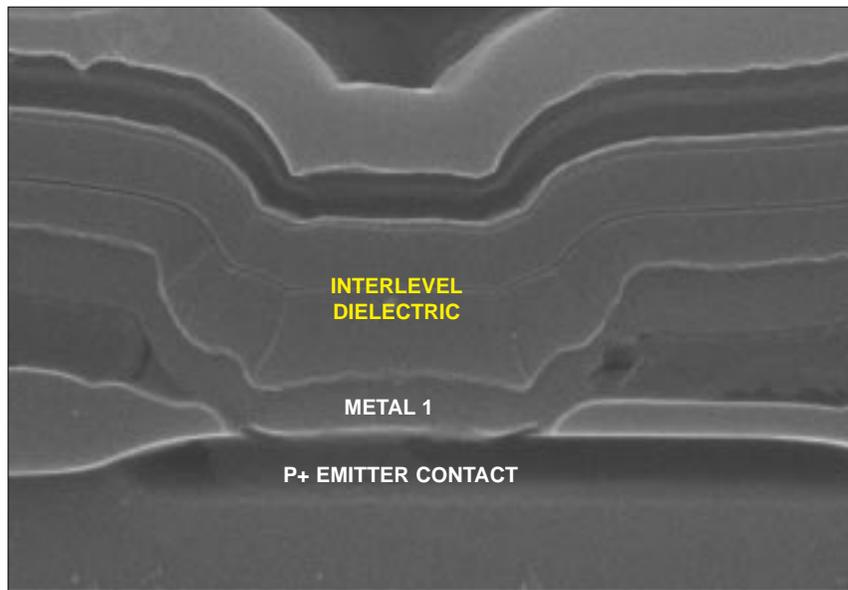


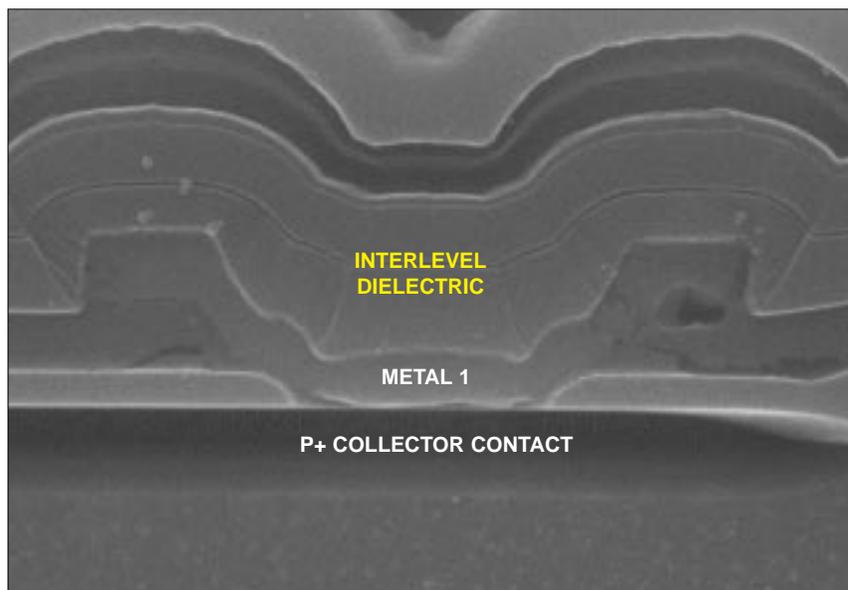
Figure 22. Optical views of the PNP device. Mag. 800x.



Mag. 1600x

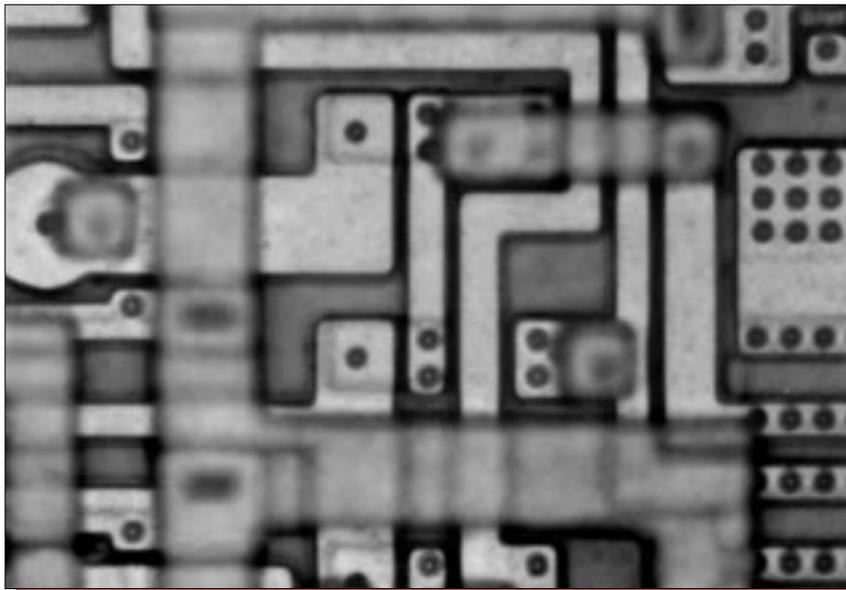


emitter,
Mag. 13,000x

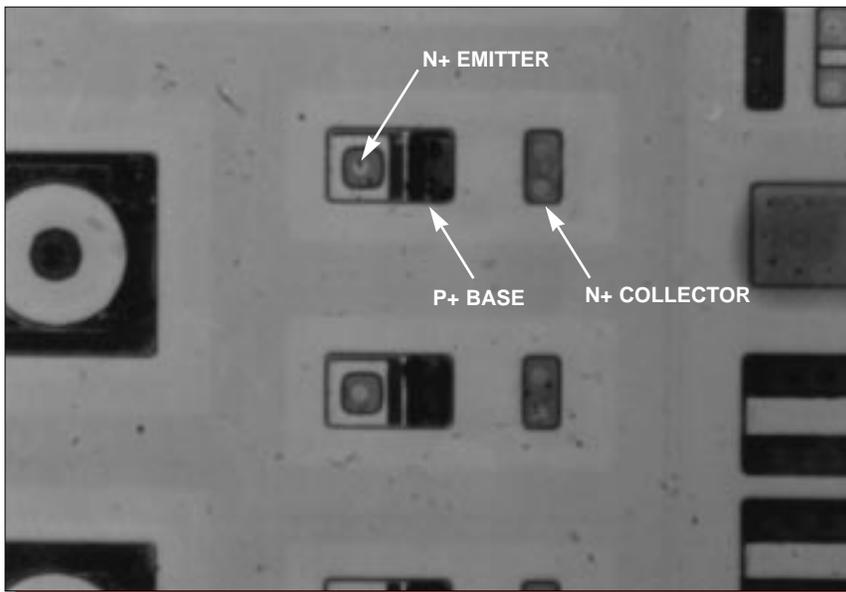


collector,
Mag. 13,000x

Figure 23. SEM section views of the PNP device.



intact



delayed

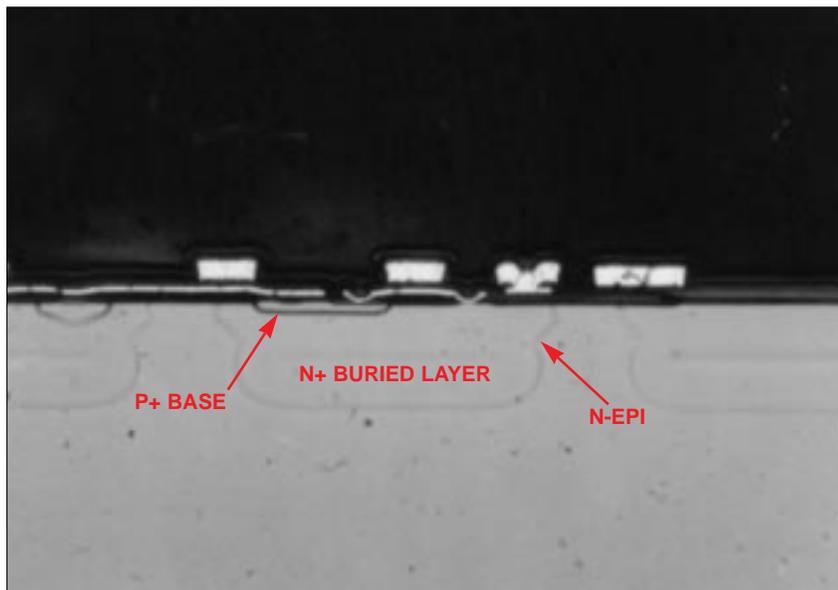
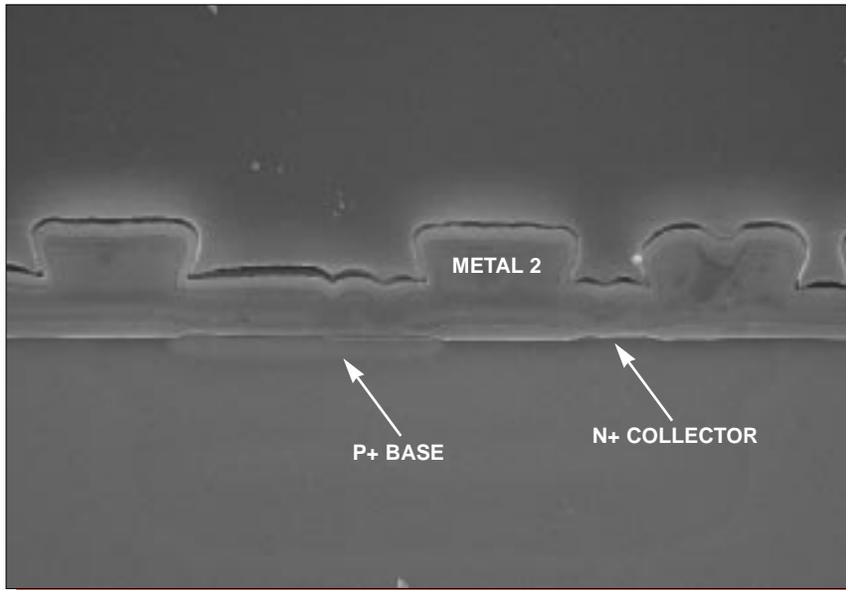
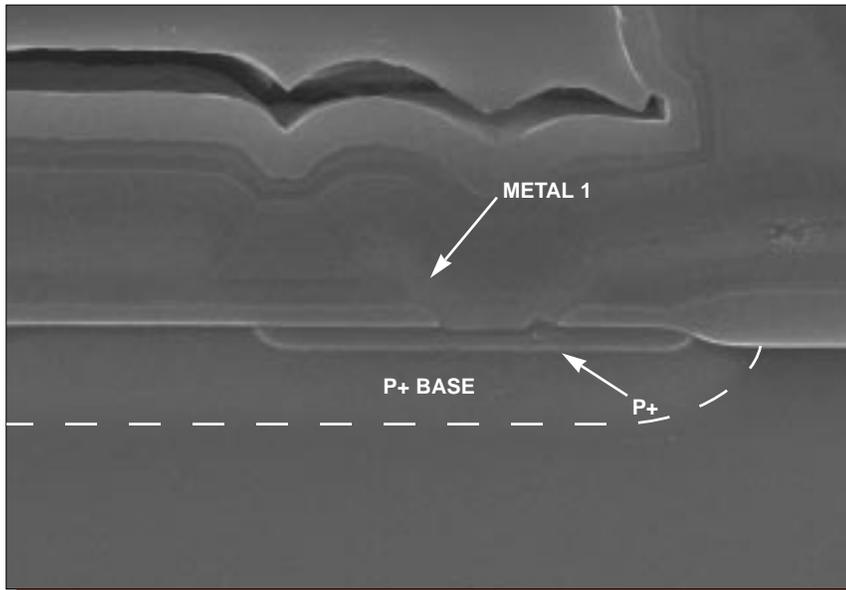


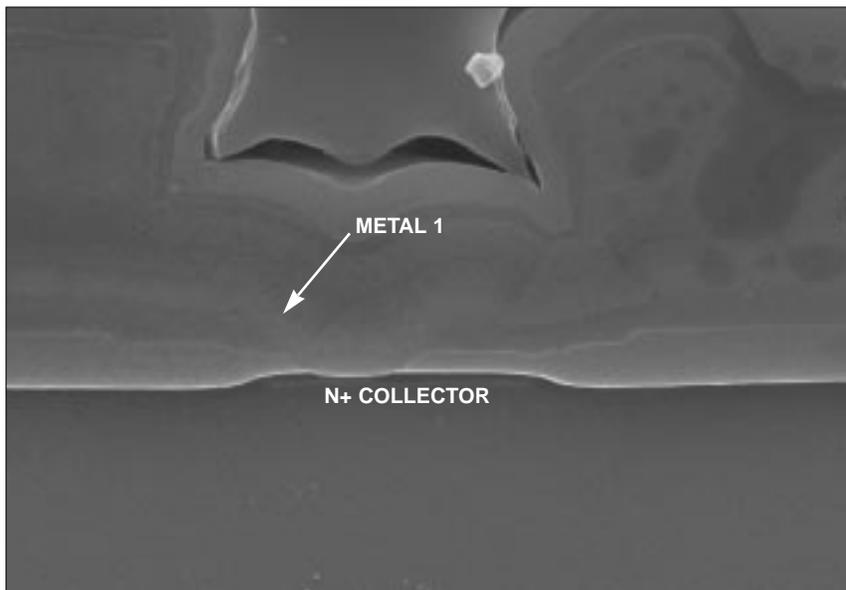
Figure 24. Optical views of the NPN device. Mag. 800x.



Mag. 1600x

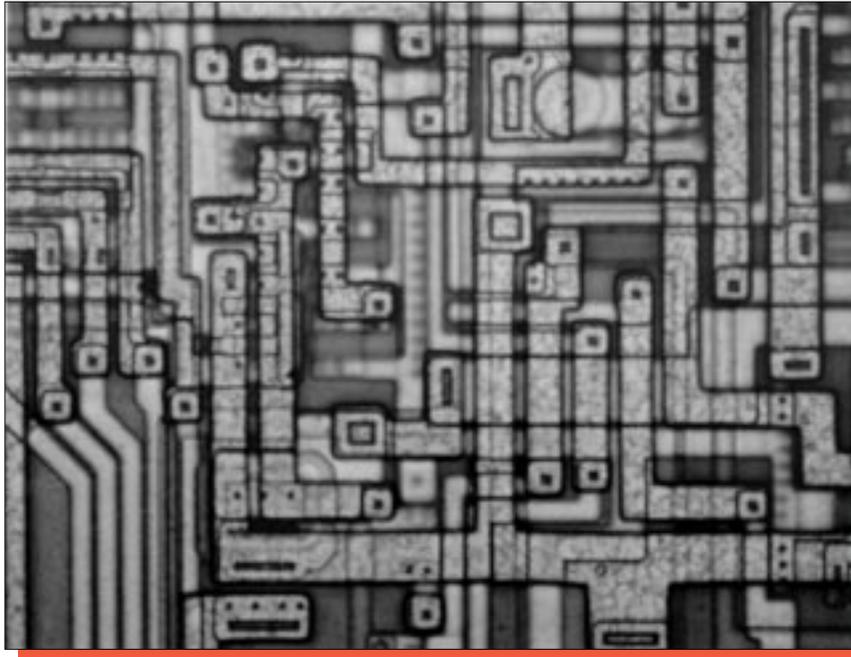


base contact,
Mag. 6500x

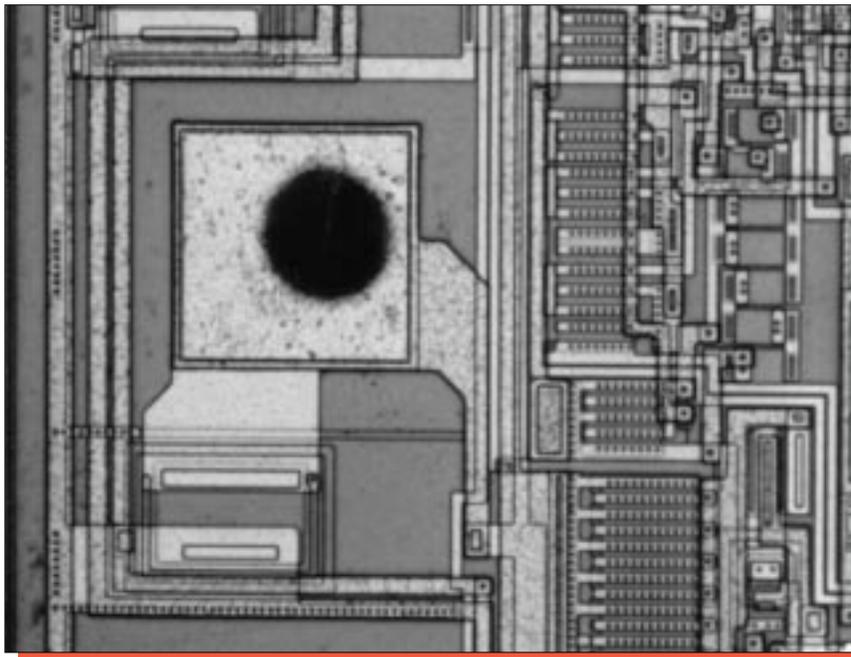


collector contact,
Mag. 6500x

Figure 25. SEM section views of the NPN device.



Mag. 400x



Mag. 200x

Figure 26. Optical views of general circuitry and I/O structure.