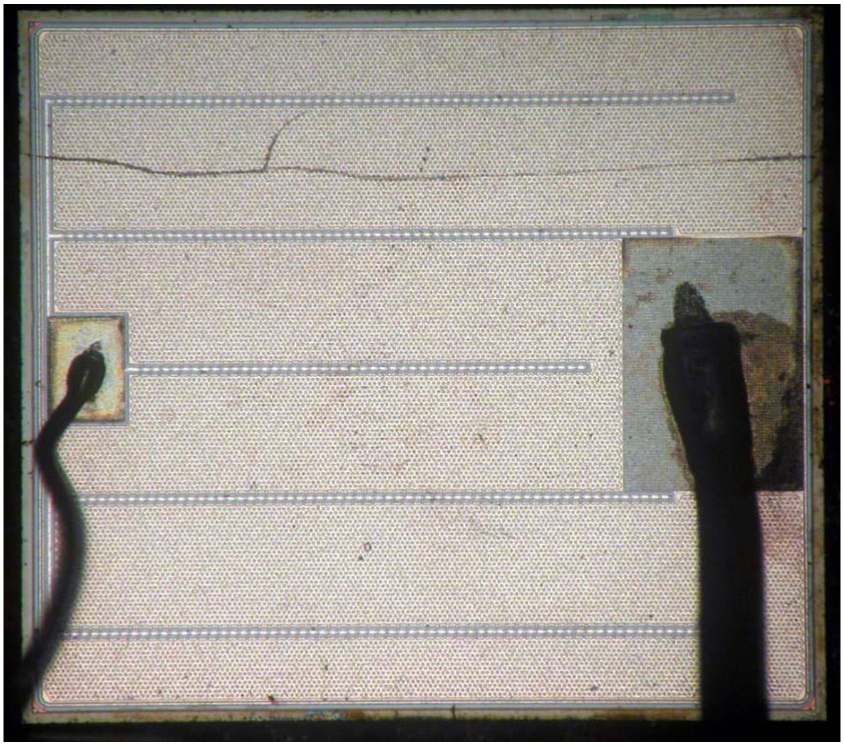
Failure Analysis Report
of
Road Runner Power MOSFET

Prepared for:
Acme Supplies, Inc.



Prepared by: Program Manager
Reviewed by: Engineer

Report Date
IAL Project 15555

History:

One Road Runner Power MOSFET was received from Acme Supply, Inc. for failure analysis. The submitted device was manufactured by Wiley Coyote International.

Summary:

Electrical testing showed that all leads had early breakdowns. Decapsulation revealed a cracked die. Mechanical stress is the most likely cause of this failure. Placing the die very close or over the mold lock, and having die attach in the mold lock would reduce the plastic mold compound adhesion to the paddle. The delamination from this would cause stress on the die. Vibration, flexing, rapid thermal changes, or excess screw torque would add to the predisposition of expanding the crack.

Procedure:

Process Step	Sample	Figures	Observations/Comments
External Visual inspection	Failed device	1-3	No defects were seen.
X-Ray	Failed device	4-6	Die appears to be on or very close to the mold lock channel. Die attach has flowed into the mold lock channel.
SAM	Failed device & Correlation device	7	Package delamination along the upper die edges was noted. SAM analysis also shows a lighter colored area on the upper part of the die. This was later found to be the area of the die that was cracked.
Electrical analysis	Failed device & Correlation device	8-10	All leads exhibited early electrical turn on (leakage).
Die visual inspection	Failed device	11-15	A crack was noted across the die. Liquid crystal analysis gave a transition site at one spot along the crack. Deprocessing showed gate damage.

Discussion:

No anomalies were observed from the visual inspection. X-ray analysis showed the die to be on or very close to the mold lock channel. Also, die attach appears to have flowed into the mold lock channel. Scanning Acoustic Microscopy (SAM) showed package delamination near the upper die edges. SAM analysis also showed a lighter colored area on the upper part of the die. This was later found to be the area of the die that was cracked.

Electrical testing showed that all leads had early breakdowns. The gate to source characteristics showed the largest current leakage (70uA at 3v). After decapsulation, a cracked die was observed. Liquid Crystal analysis identified a transition site along the die crack near the source pad. Other than the die crack, no additional surface damage was observed at the liquid crystal site. Deprocessing the device showed a damaged gate area at the liquid crystal site.

Conclusions:

Mechanical stress is the most likely cause of this failure. Placing the die very close or over the mold lock, and having die attach in the mold lock would reduce the plastic mold compound adhesion to the paddle. The delamination from this would cause stress on the die. This delamination and stress build-up could occur over time ultimately resulting in a crack. Based on the visual inspection and the SAM results, the crack most likely started on the left edge of the die. Once the crack occurred, a leakage site formed along the crack edge causing the damaged polysilicon gate. This electrical defect was the symptom detected as failure.

Vibration, flexing, rapid thermal changes, or excess mounting screw torque would add to the predisposition of expanding the crack. Once the die was cracked, metal shorting (along the crack) most likely caused the gate damage seen at the liquid crystal transition site.

Package Analysis:

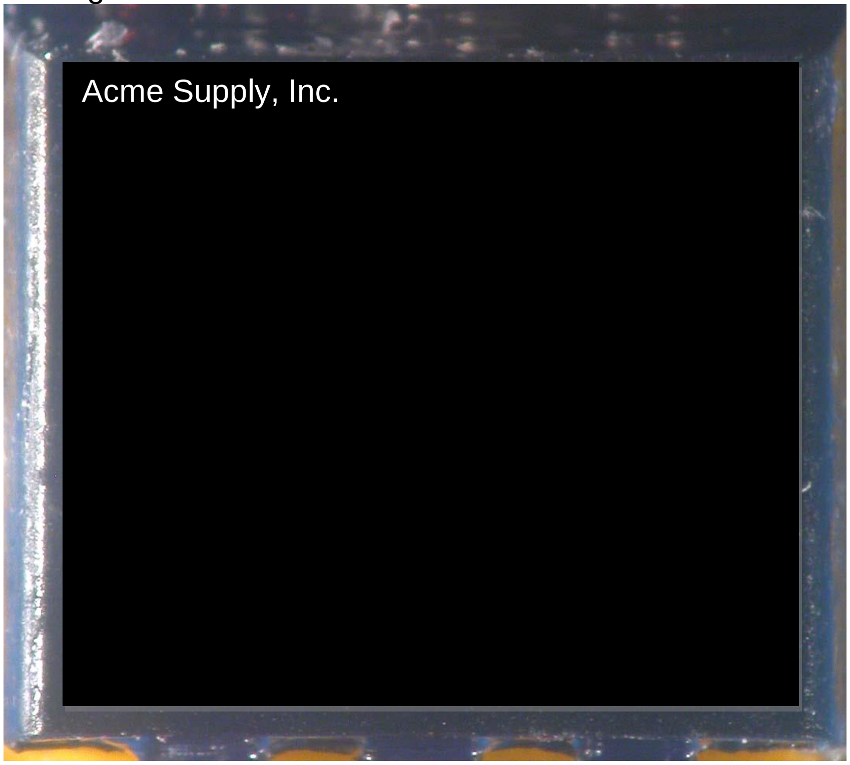
The external visual inspection of the failed device revealed no defects (references figures 1 through 3).

Figure 1: Failed device package top.

Figure 2: Failed device package bottom.

Package Analysis continued:

Figure 3: Photograph of failed device package top markings.



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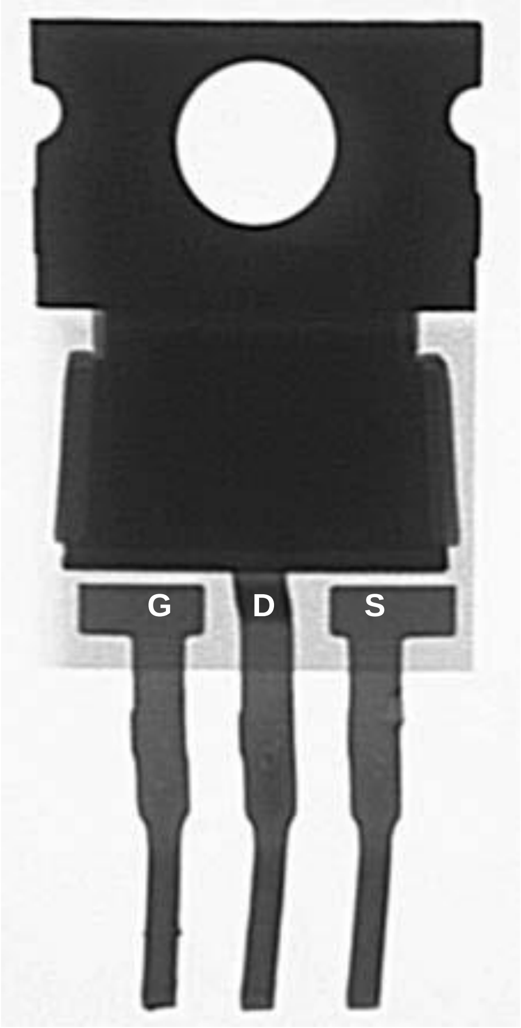
X-ray Analysis:

An inspection of the failed device using a real time x-ray system (reference figures 4 through 6). Figures 5 and 6 show the die is on or very close to the mold lock channel. Figure 5 shows die attach has flowed into the mold lock channel (dark line on the along upper die edge).

Figure 4: X-ray image of the failed device.



X-ray Analysis:

Figure 5: X-ray image of the failed device die area.

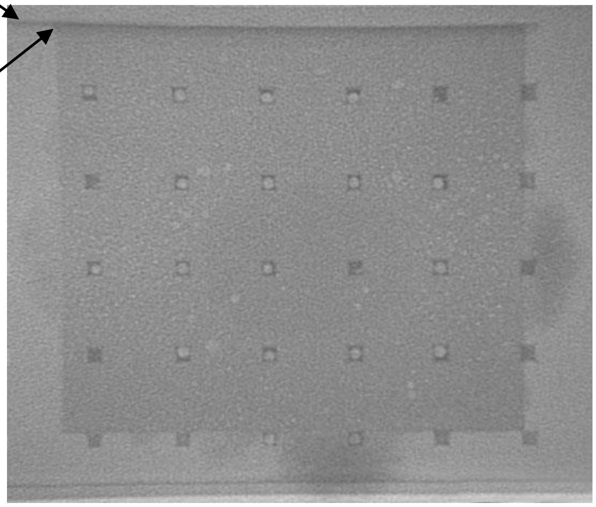
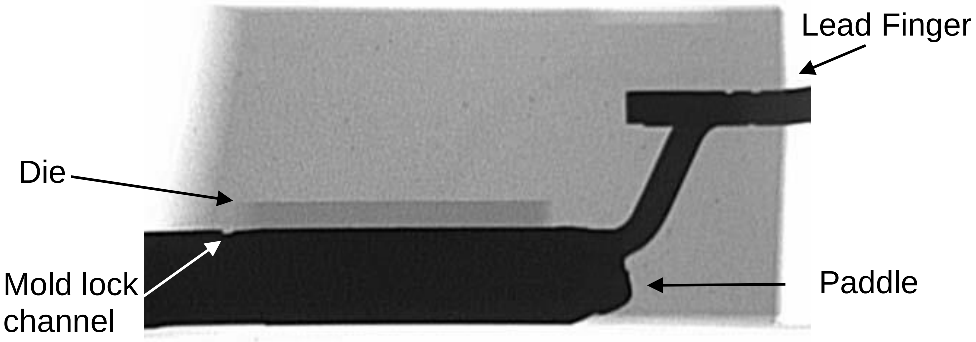


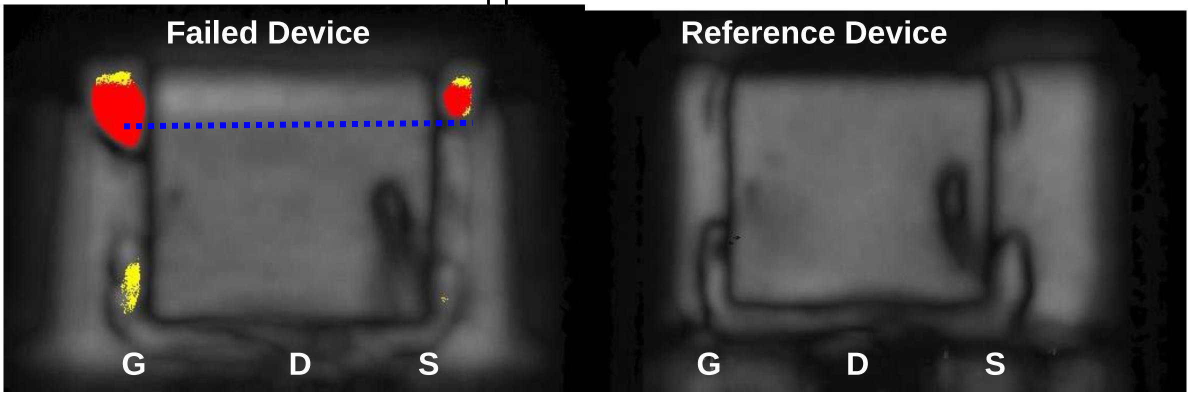
Figure 6: X-ray image of the failed device package side view.



SAM Analysis:

After the conformal coating was removed, Scanning Acoustic Microscopy (SAM) was performed on the failed devices. Package delamination was noted on the failed device only (reference figure 7). SAM analysis also shows a lighter colored area on the upper part of the die. This was later found to be the area of the die that was cracked.

Figure 7: SAM image of the failed device and reference device. Package delamination near the top edges of the die was noted on the failed device, shown in red. The blue dashed line is the approximate crack location identified in visual.



Electrical Analysis:

Curve trace analysis was performed. Electrical anomalies were noted on all leads (reference figures 8 through 10).

Figure 8: IV curve of the gate vs. source.

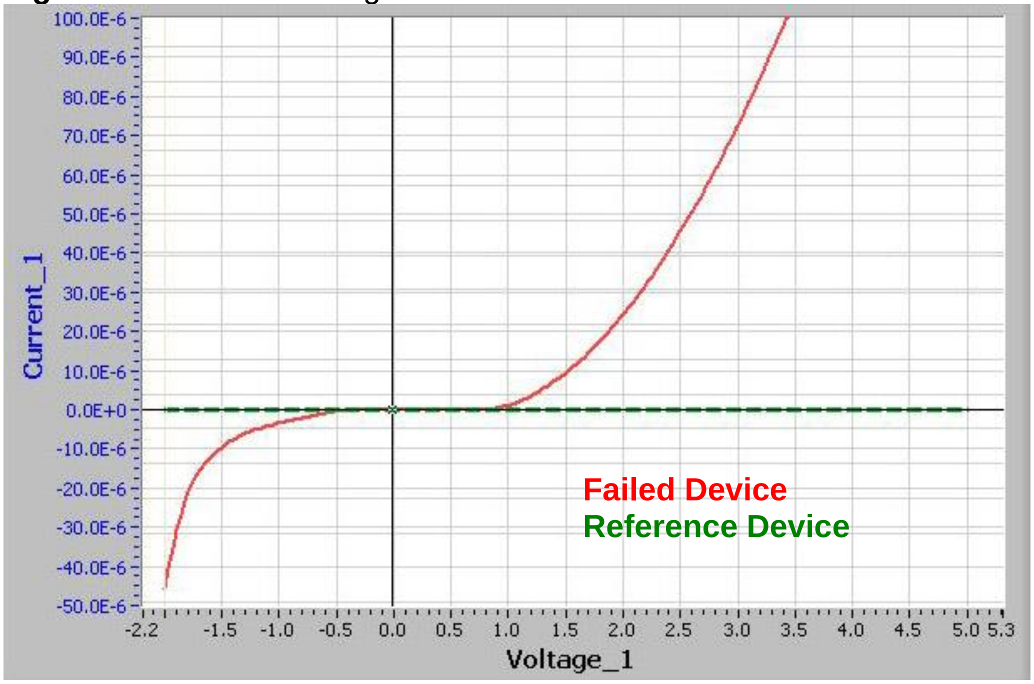
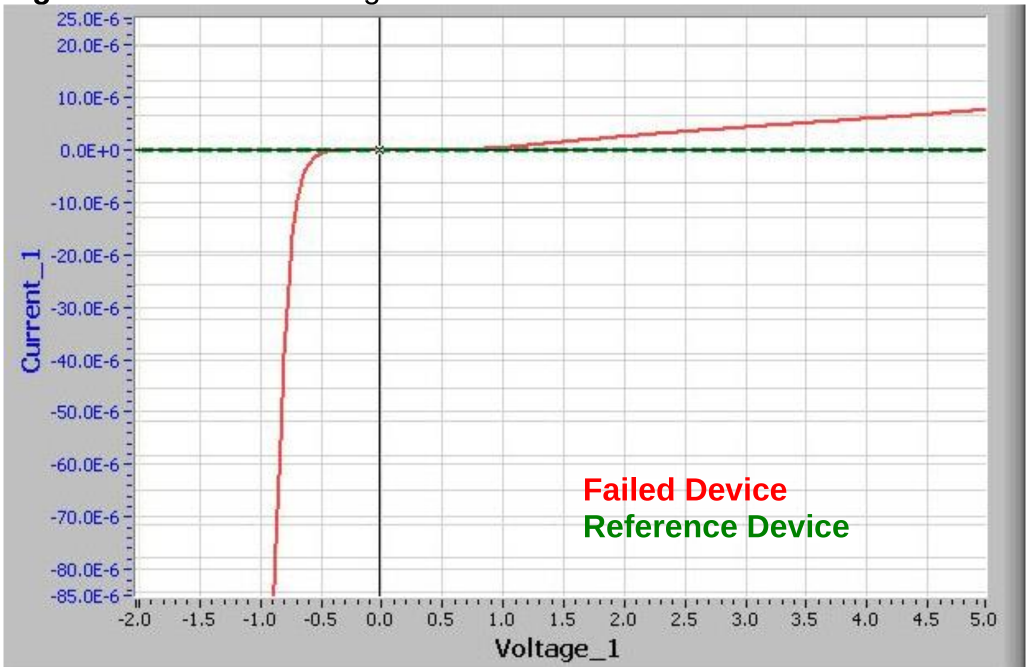
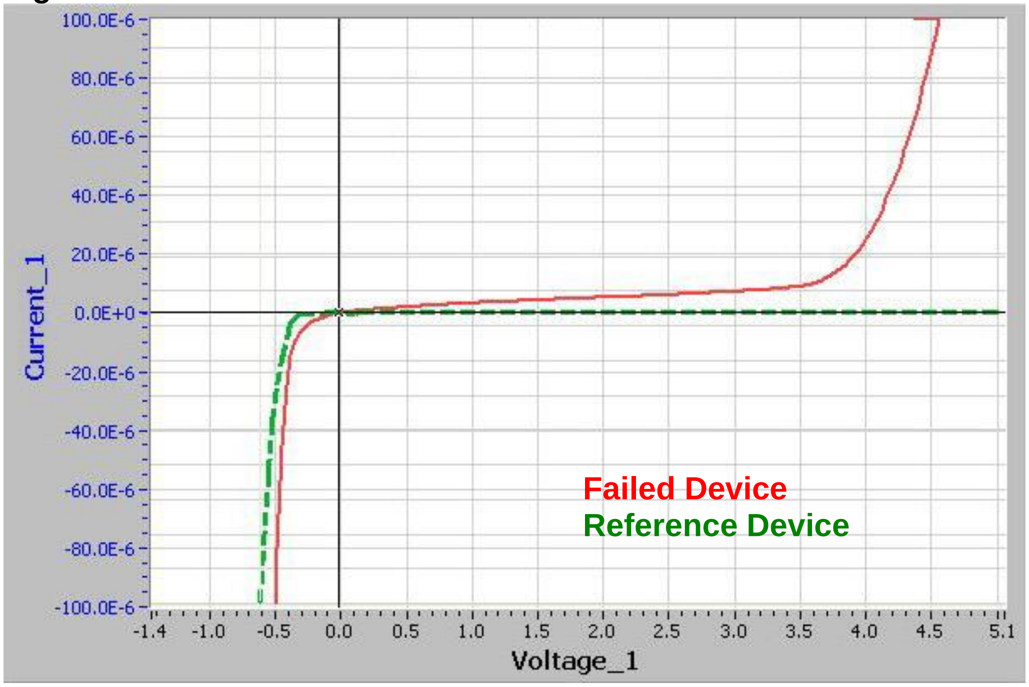


Figure 9: IV curve of the gate vs. drain.



Electrical Analysis continued:

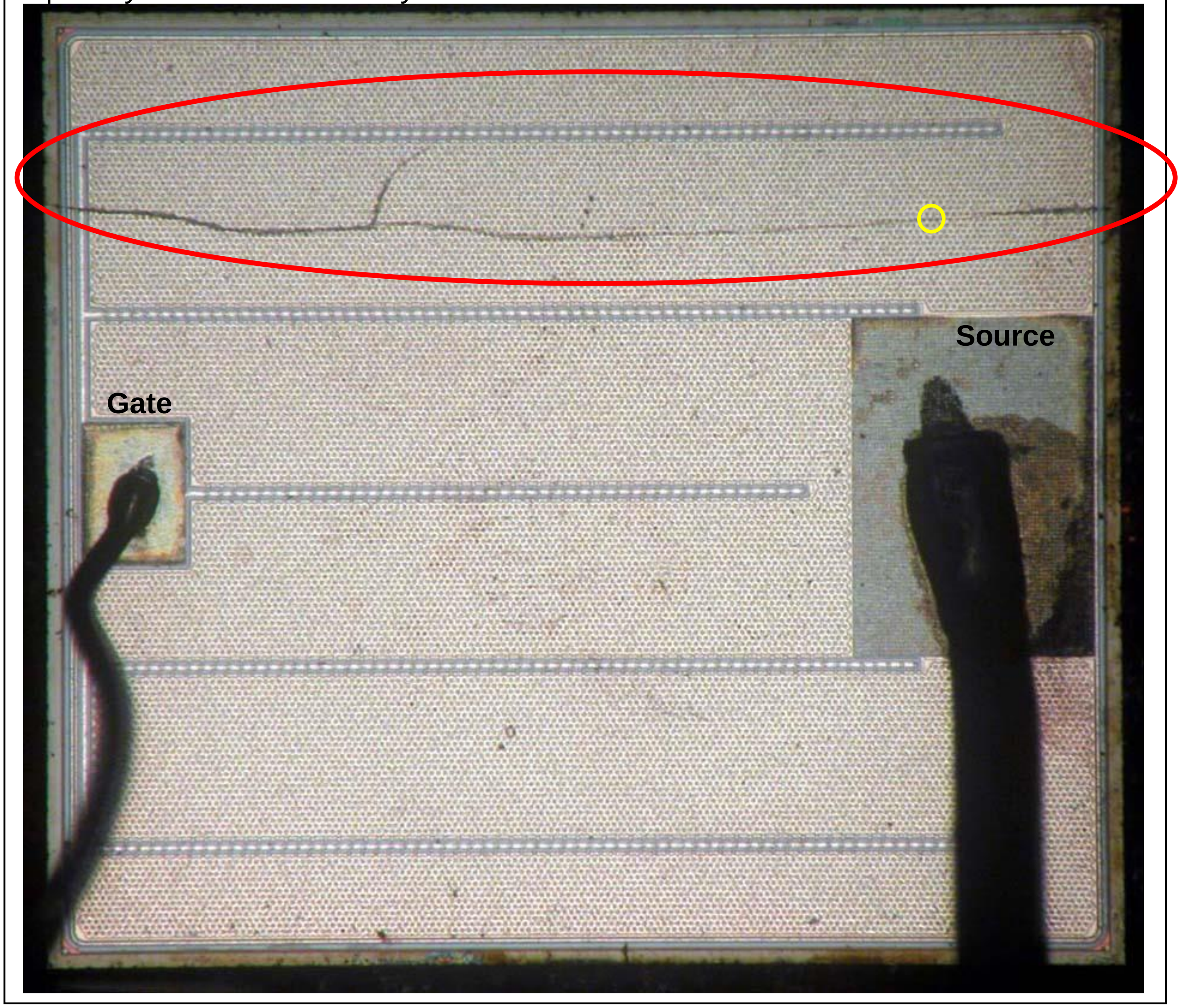
Figure 10: IV curve of the source vs. drain.



Die Visual Inspection:

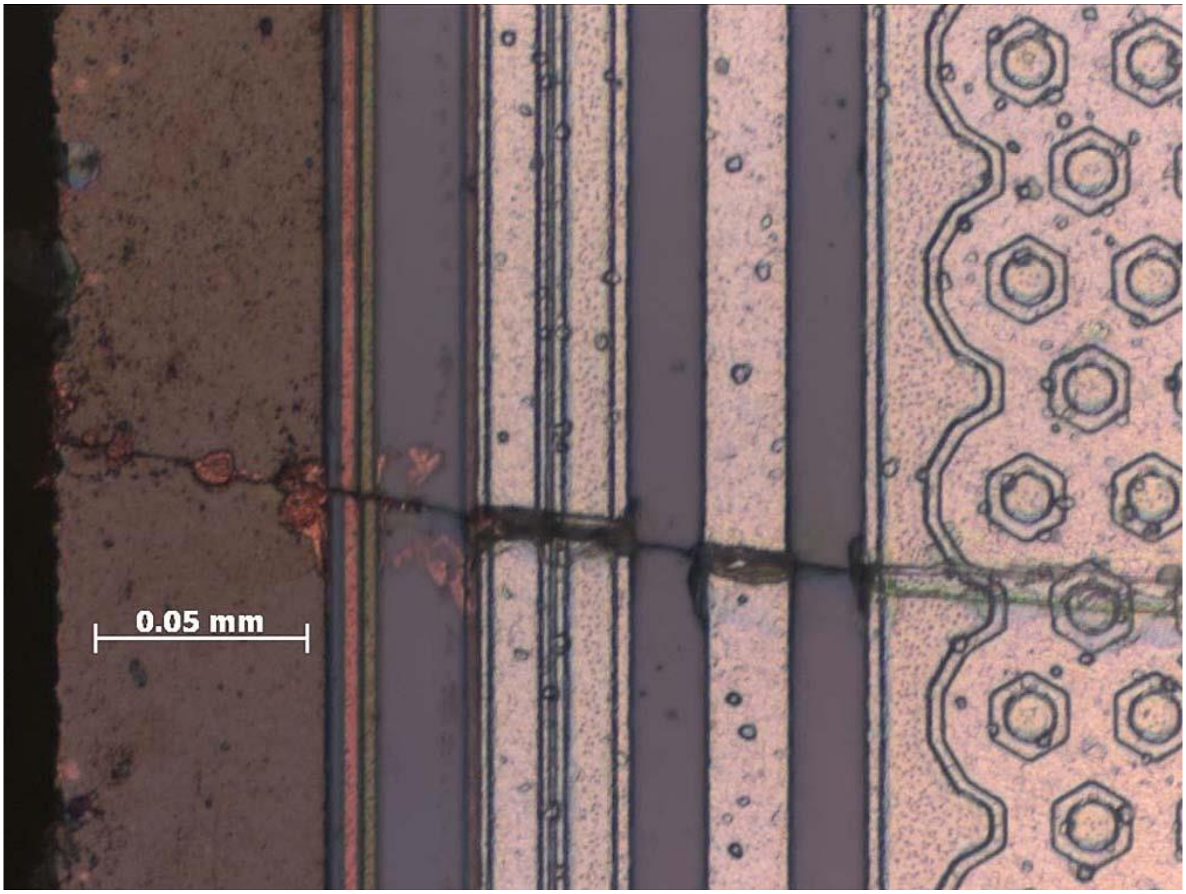
The plastic encapsulant was chemically removed in order to inspect the die. A crack was seen across the die surface (reference figures 11 and 12). Liquid Crystal analysis was performed by biasing the gate to source. A transition site was observed along the crack near the source pad. With the exception of the crack, no other damage was noted at the liquid crystal site.

Figure 11: Photograph of the failed device die; the noted crack is circled in red. The liquid crystal site is circled in yellow.



Die Visual Inspection:

Figure 12: Photograph of the crack at the left edge of the die.



Deprocessing:

Top metal was removed in order to inspect the area of the liquid crystal transition site. A damaged gate region was observed along the crack (reference figures 13 and 14).

Figure 13: Photograph of the liquid crystal area showing a damaged gate region (circled).

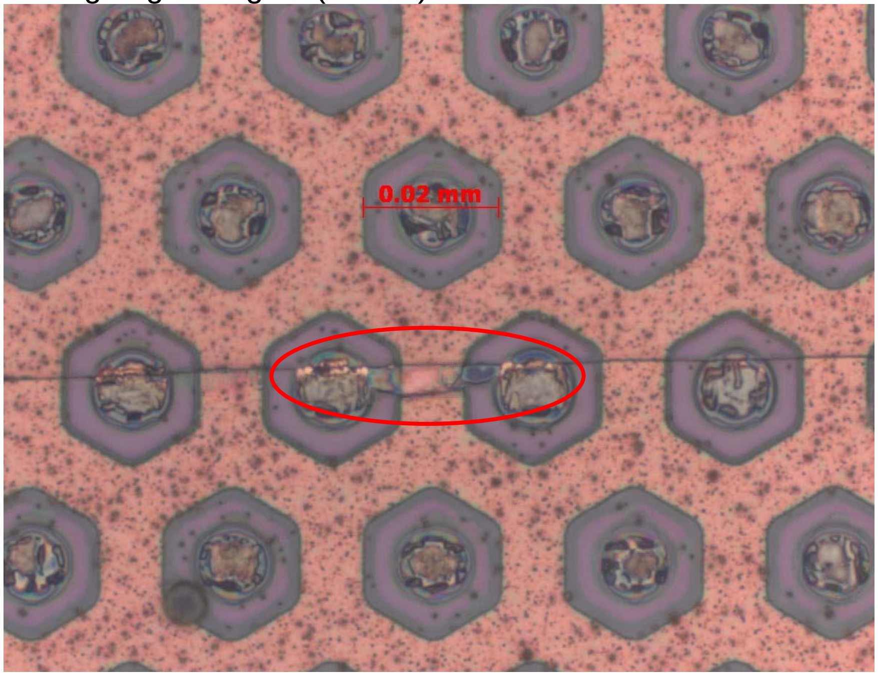
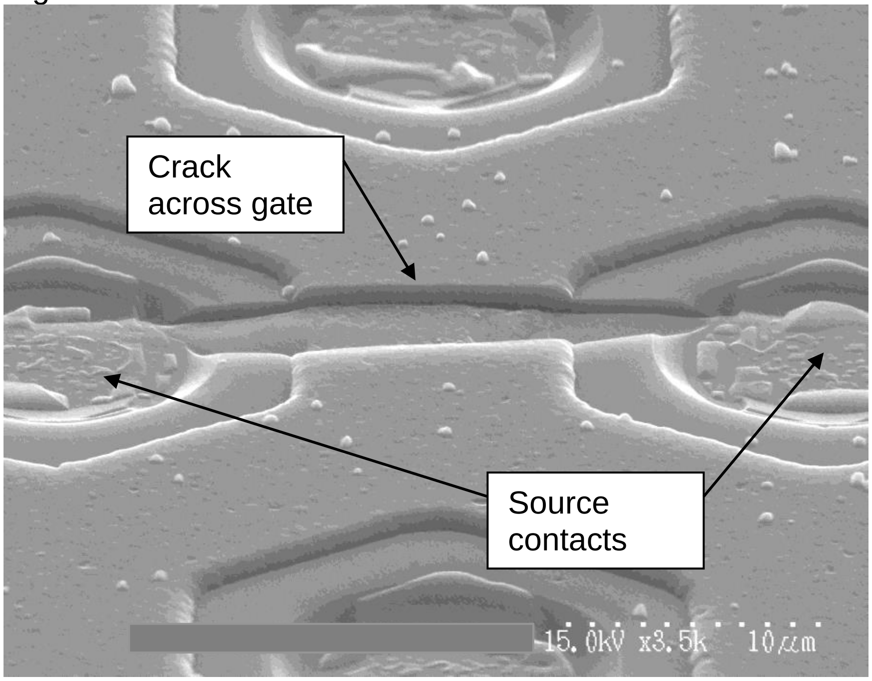


Figure 14: SEM image showing the damaged gate region.



Deprocessing:

Further deprocessing was done to remove the oxide over the gate region. Figure 15 shows the damaged gate region.

Figure 15: SEM image of the damaged polysilicon at the gate region (circled).