

New Imaging Indicator for ESD Safety Testing

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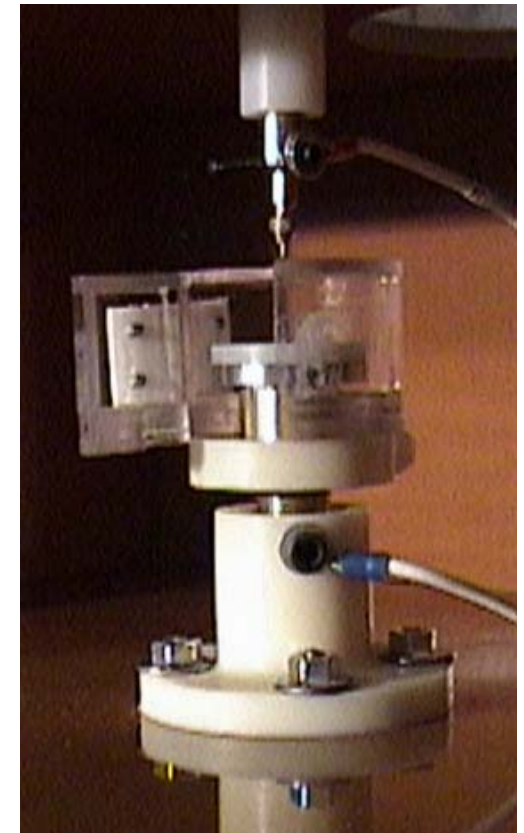
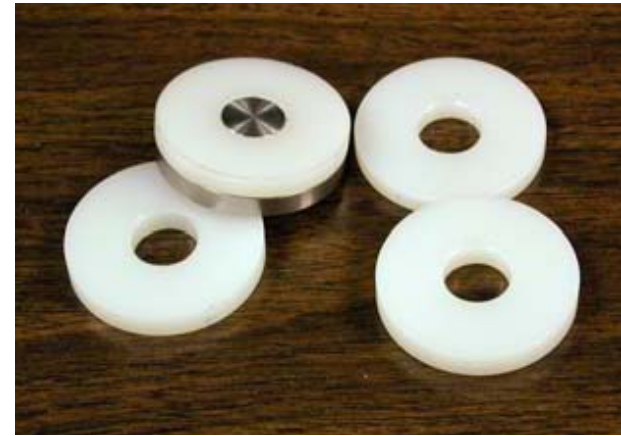
Livermore, CA

ABL Electrostatic Discharge (ESD) Sensitivity Tester



Sample holders

- Each test sample is placed in a test holder consisting of a stainless steel sample holder base fitted with an insulating washer.
- The loaded sample holder is placed on the support base.
- Good electrical contact between the sample holder and the grounding post is essential.

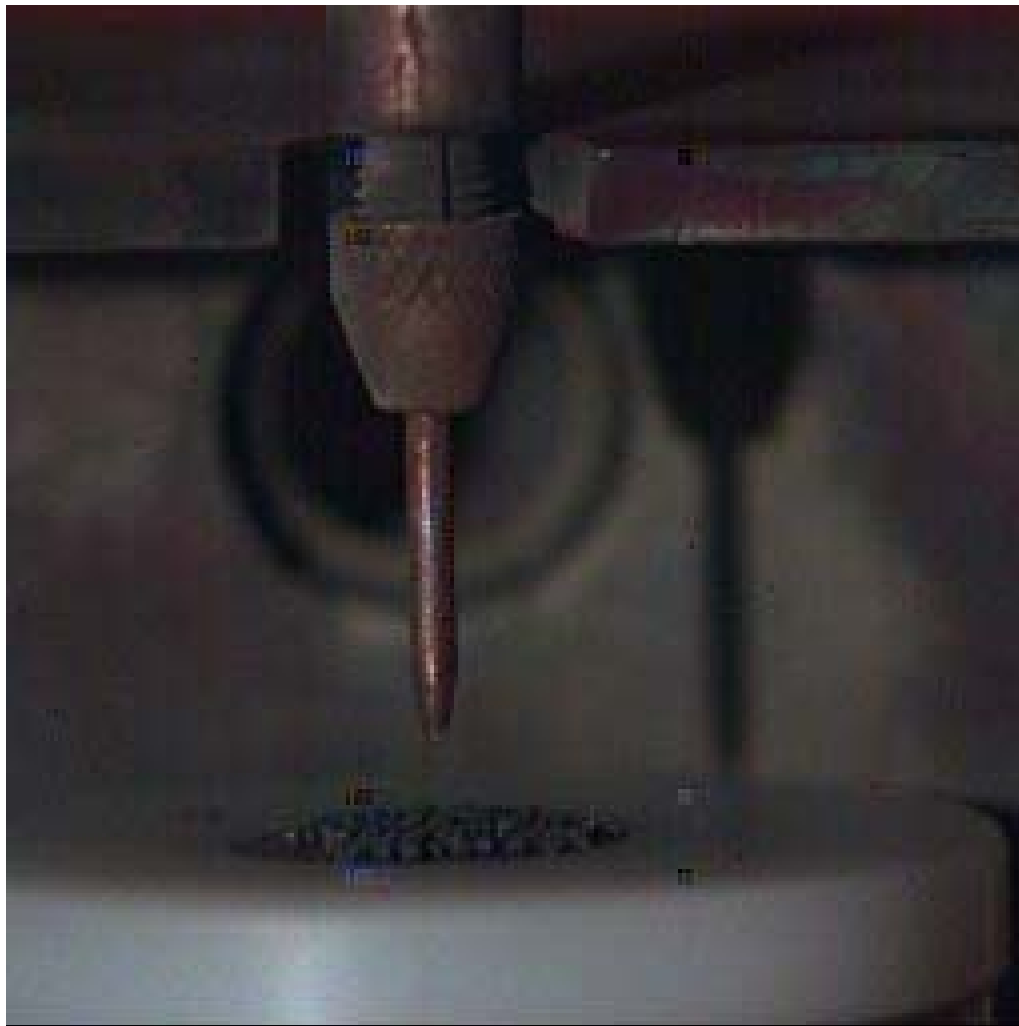


Go/No Go Indicators for ESD Testing

- Odor
- Color
- Sound
 - Pop/snap
 - Bang
 - Loud report
- Flash/Flame
- Flame trace
- Spark
- Propagating Fire
 - Sample consumed
- “Flyers”
- Hardware damage
- Smoke
- Gas analysis
 - CO/CO₂
 - NO_x
- Tape (scotch)
 - Burned/singed
 - Soot deposition
 - Torn
- High speed video
- **SLR camera**



High Speed Video costs ~\$50K



Camera and Lens Used for Image Capture (~\$2000)

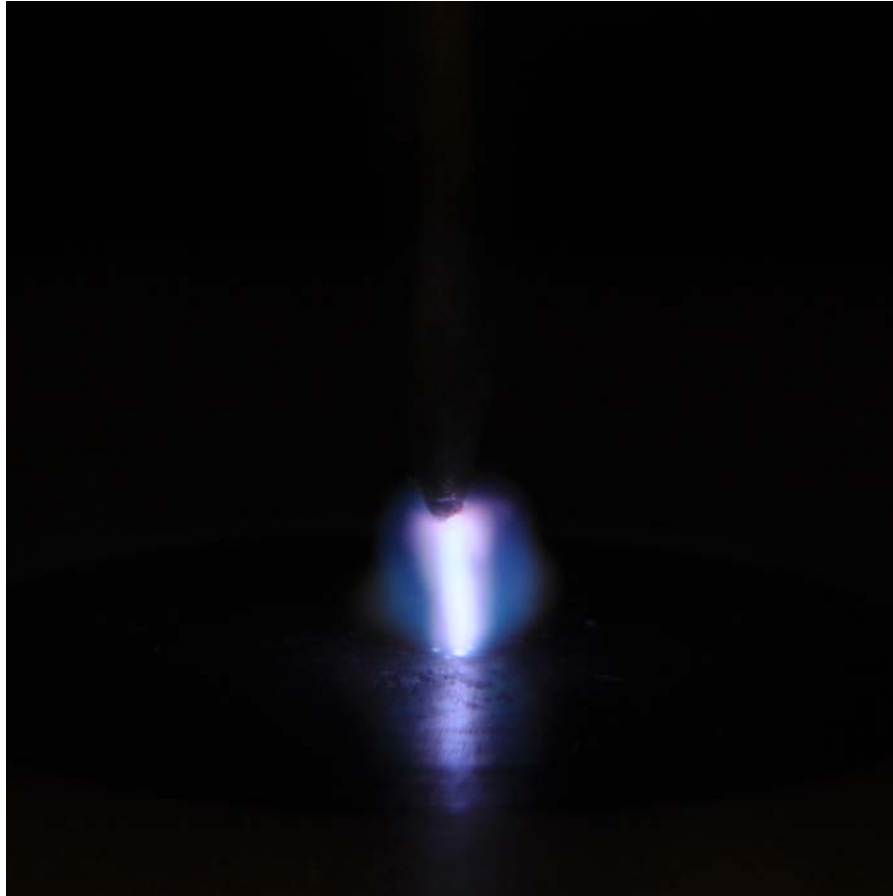


Camera Specs:

- Nikon D90 camera body (12.3 MP CMOS)
- Nikkor 200mm Micro Lens
- Aperture – f20
- ISO – 200
- 1 second exposure time
- ~ 24 inch distance from camera to subject
- Tripod mounted
- AV displayed to 20" TV for immediate GO/NO GO determination



Are Blanks Really Blank?

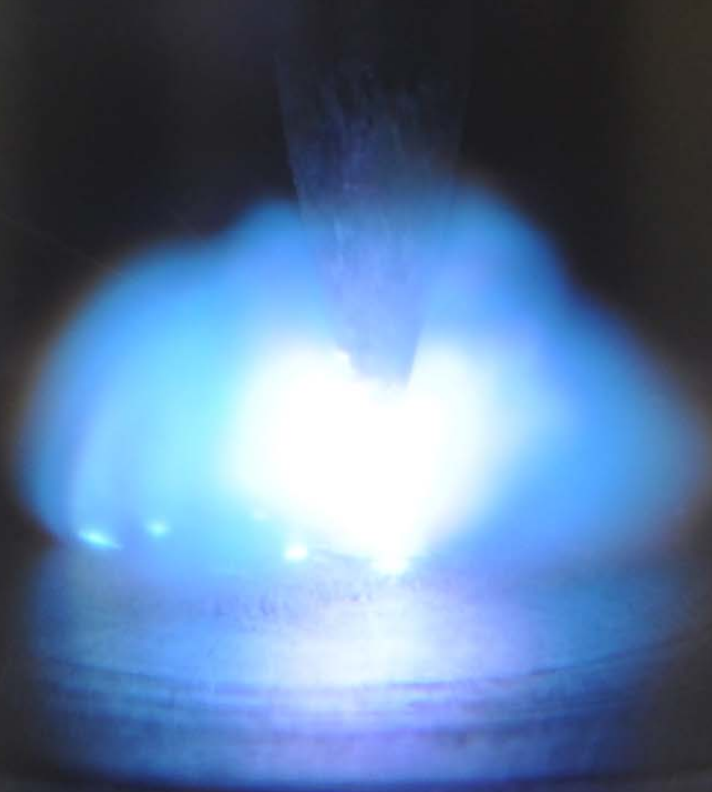


“flyers” (ejecta from base plate) can be seen even with no sample present—more at higher power

Typical blank image

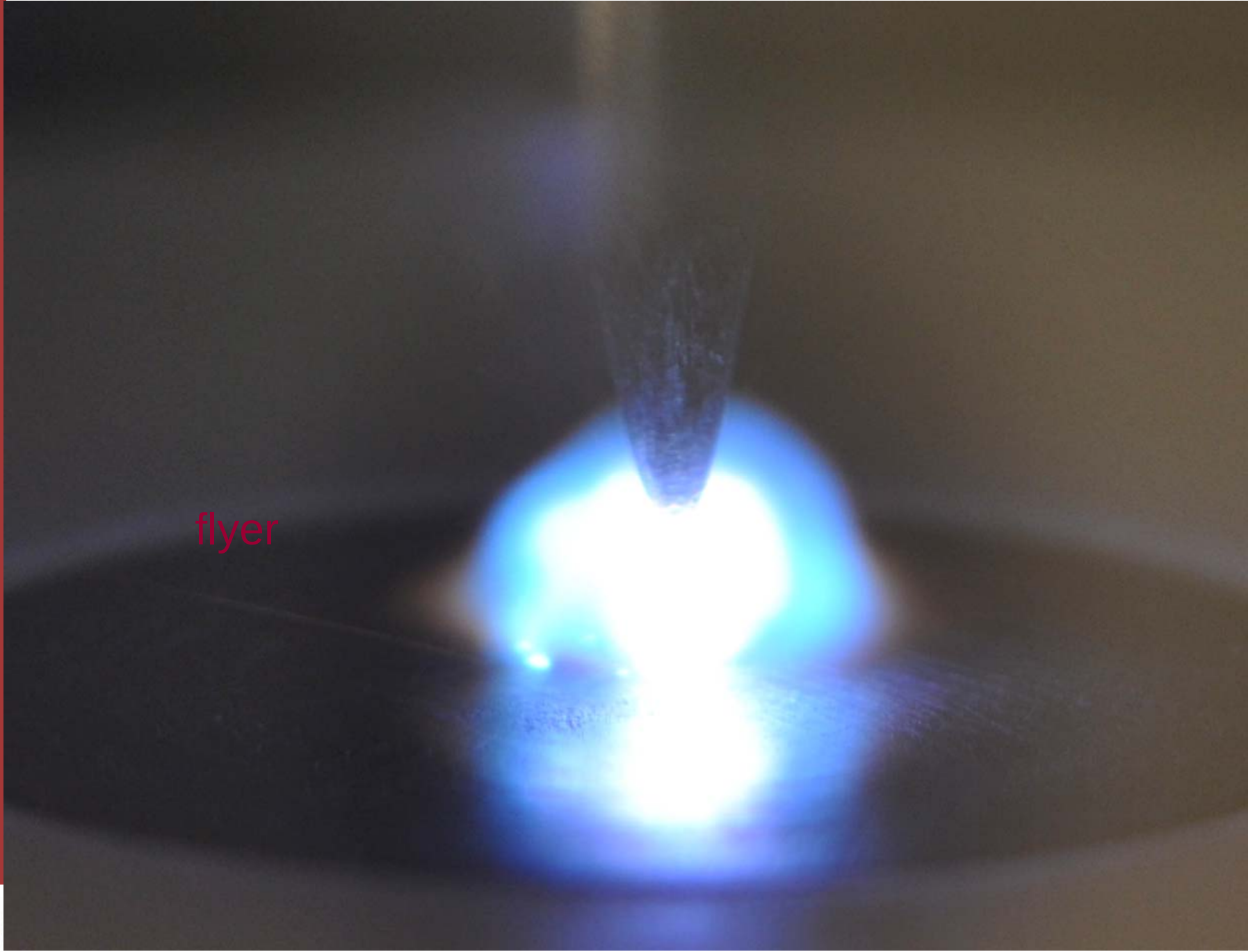


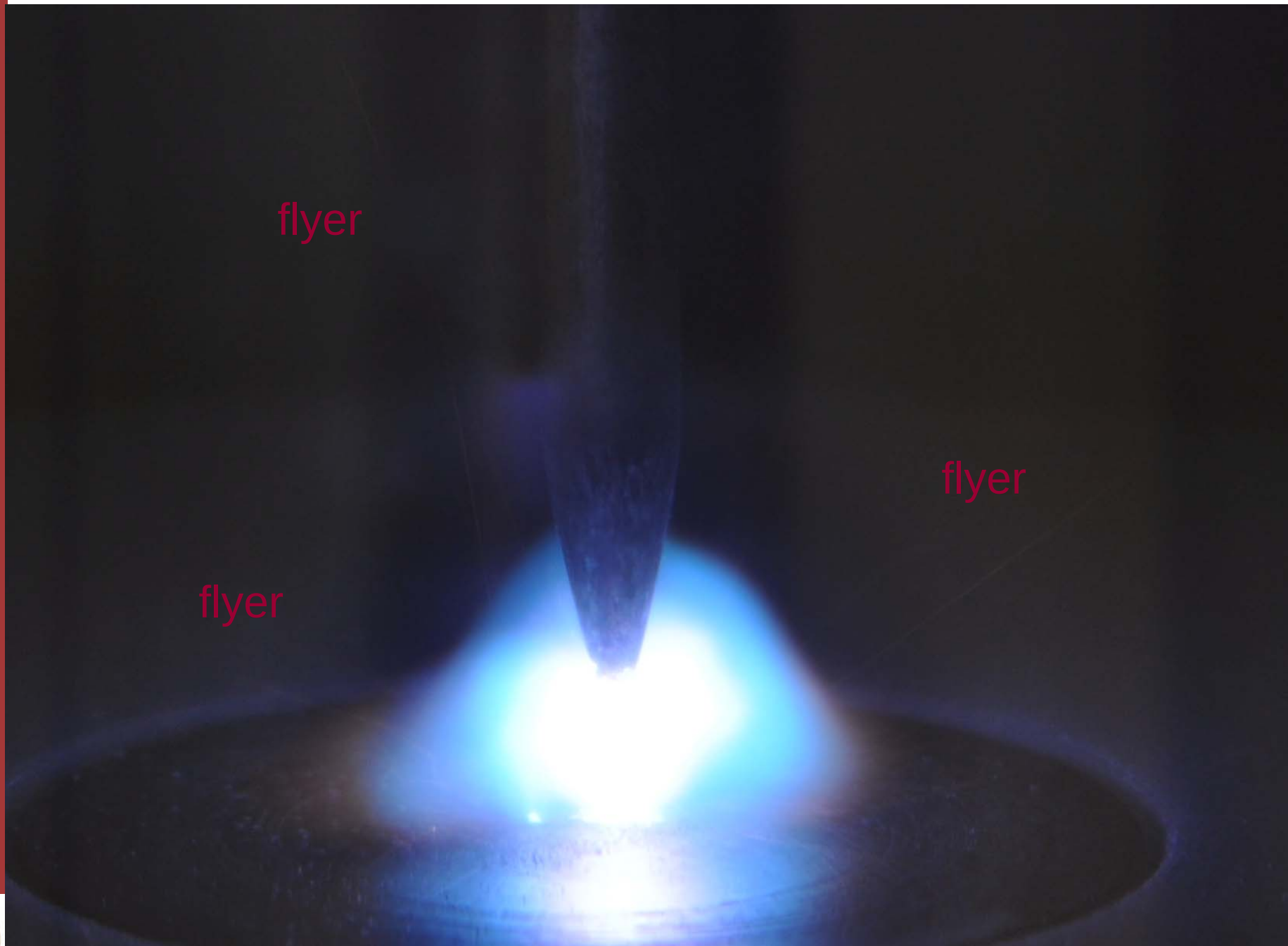
flyer





flyer





flyer

flyer

flyer

Potential Complications with the Camera

- Glare
- “Flyers” or ejecta from the base plate (can also give a false positive with visual indication)
- Little orange color sometimes
 - Seen in blanks too



Homemade Explosives (HME's)

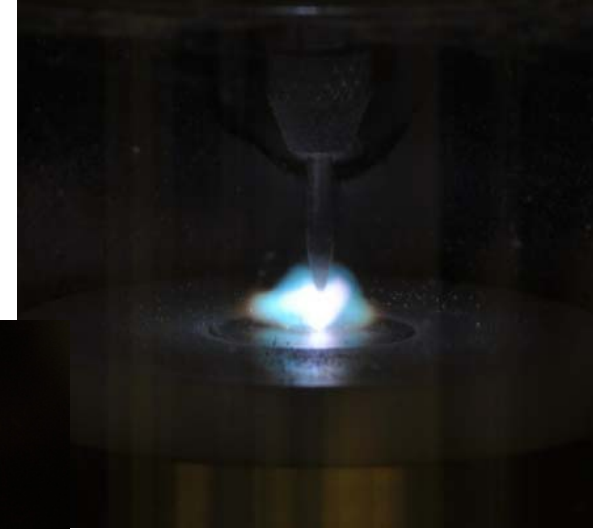
What materials are being tested?

- Pure explosive compounds
 - PETN
 - RDX
- Fuel alone (aluminum powder)
 - Valimet H2
 - German Blackhead
- Fuel with oxidizer
 - KClO_3 /Sugar
 - KClO_3 /Al
 - KClO_3 /Nitrobenzene

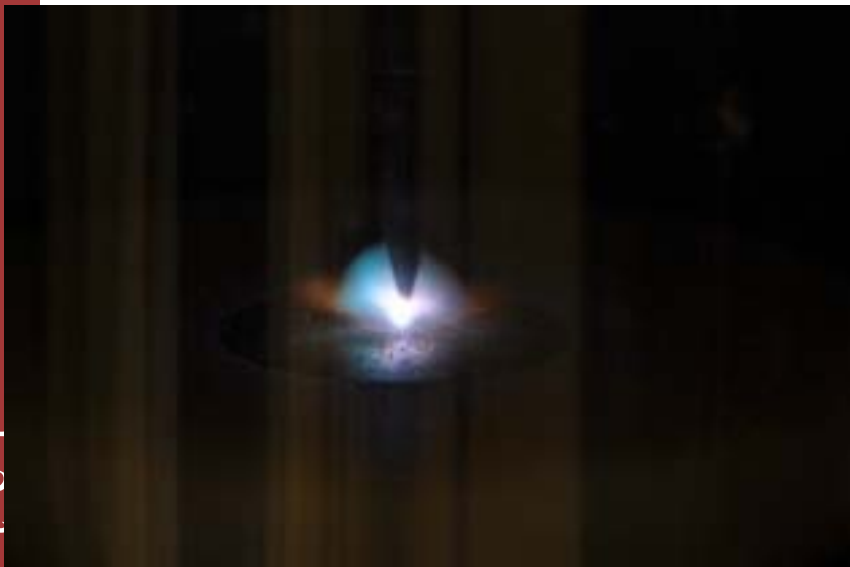
PETN (Powder)



PETN Powder 0.1 μ F (1.25 J) – Clearly a GO



Blank



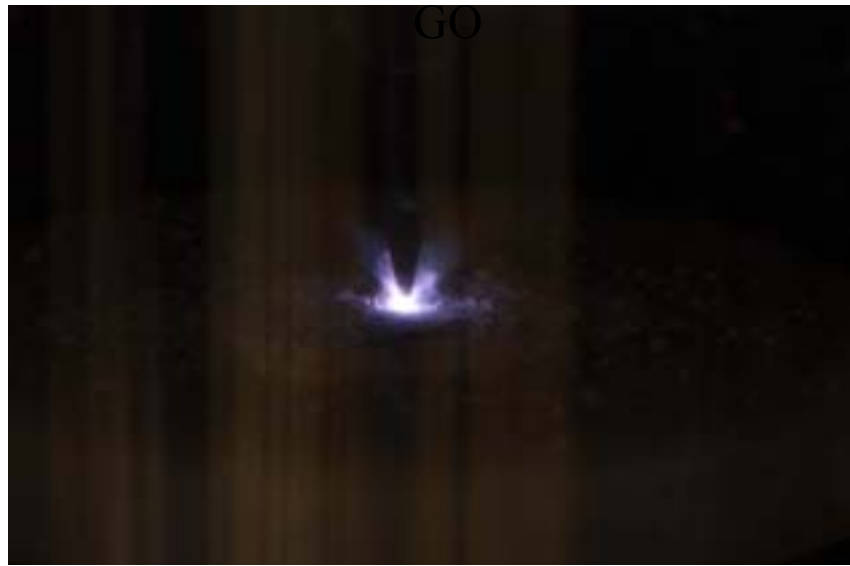
Blank - 0.02 μ F (0.25 J)



PETN - 0.02 μ F (0.25 J) NO



PETN - 0.02 μ F (0.25 J) GO (via gas analyzer)



PETN - 0.012 μ F (0.15 J) NO GO

PETN (Powder) Results

PETN - Powder

Capacitance
(μF)

0.1																			
0.05																			
0.02																			
0.012																			
0.006																			
0.002																			
0.001																			

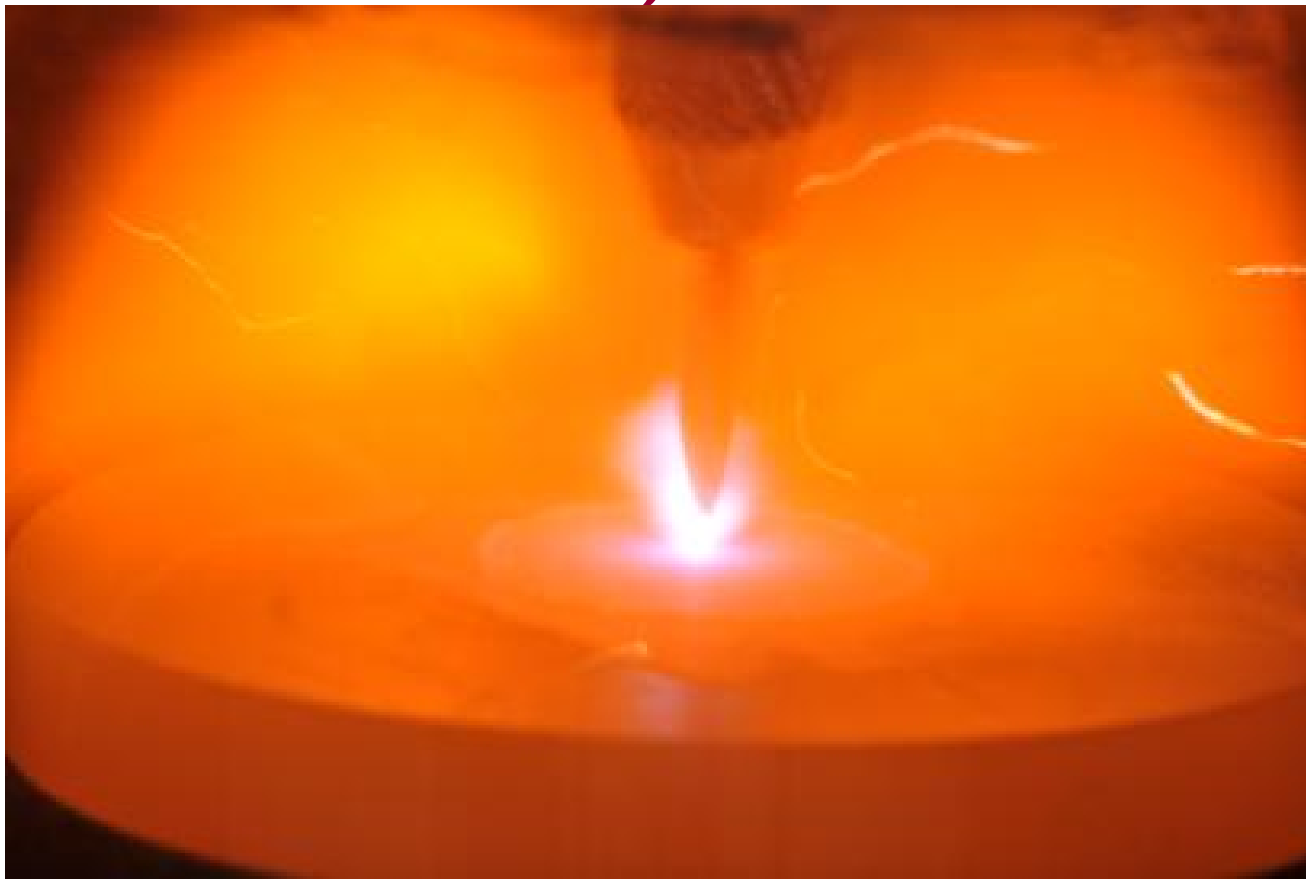
Final TIL – 0.02 μF (0.25 J)

Lit Values: (industry reports) 0.19 J

(LANL) 62 mJ

(DBREIE) 0.325 J

RDX, Class 5 from Kirstin Warner (Indian Head)-IDCA standard



Go at 0.05 uF (0.625J)

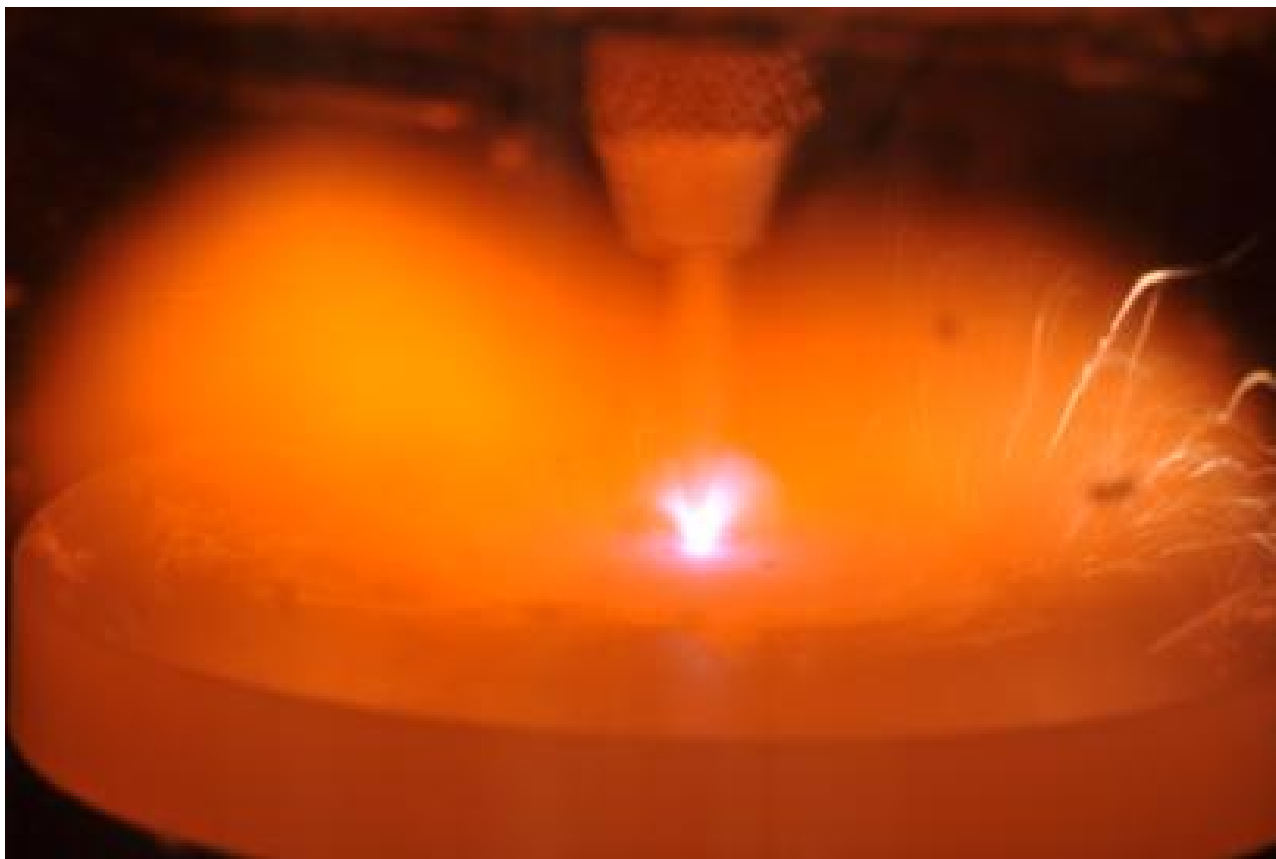


Blank

Gas Analysis

	Before	After	Delta
CO ₂	357	911	554
CO	73.1	80.4	7.3

RDX standard



Blank



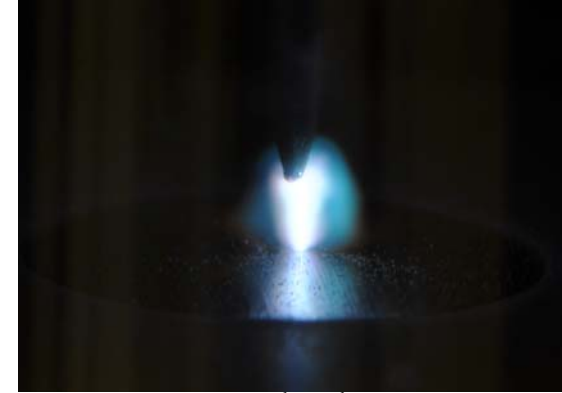
No Go

Go at 0.02 uF (0.25J)

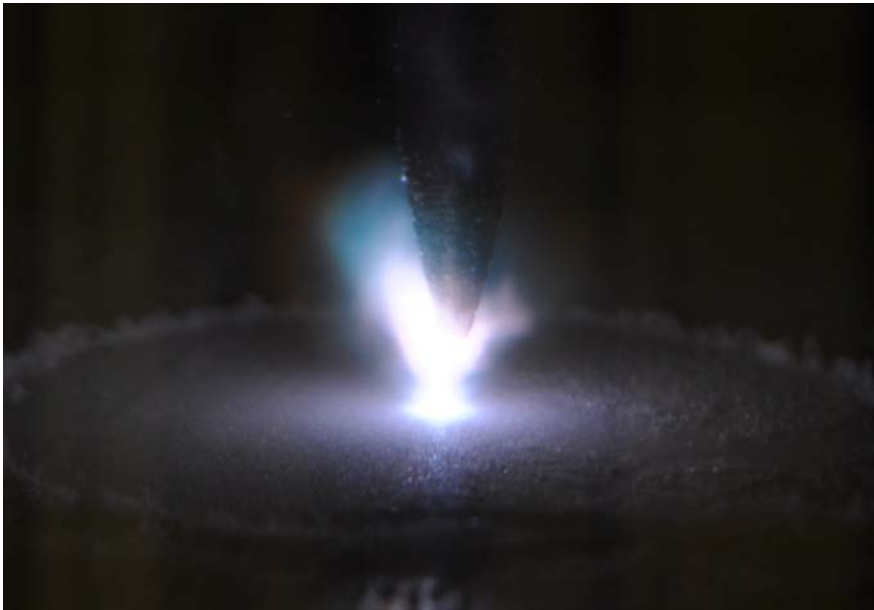
Gas Analysis

	Before	After	Delta	Before	After	Delta
CO ₂	357	362	5	352	610	258
CO	73.4	72.7	-0.7	72.7	77.2	4.5

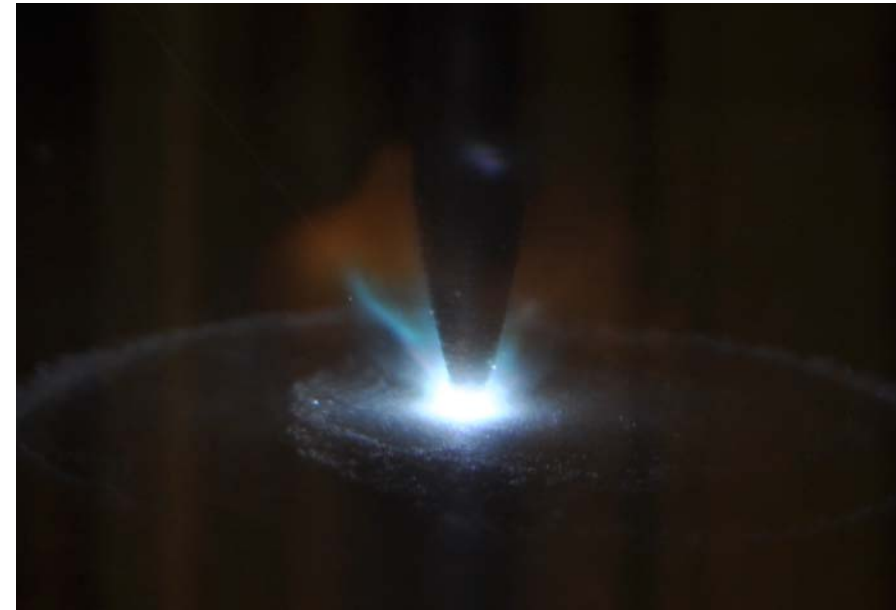
RDX standard



Blank



Typical No Go image



Orange color seen on 5/20 tests

No Go at 0.01 μ F (0.125J)

Run no.	1		2		3		4		5		6		7		8		9		10	
Gas (CO ₂) (bef/peak)	355	355	353	354	353	351	357	358	356	352	356	356	350	353	353	352	355	356	352	352
Gas (CO) (bef/peak)	72.5	72.6	72	72.2	72.1	72.1	71.9	71.9	71.8	71.7	71.6	71.7	71.5	71.7	71.6	71.7	71.7	71.7	71.6	72.1

Summary of RDX ESD Testing

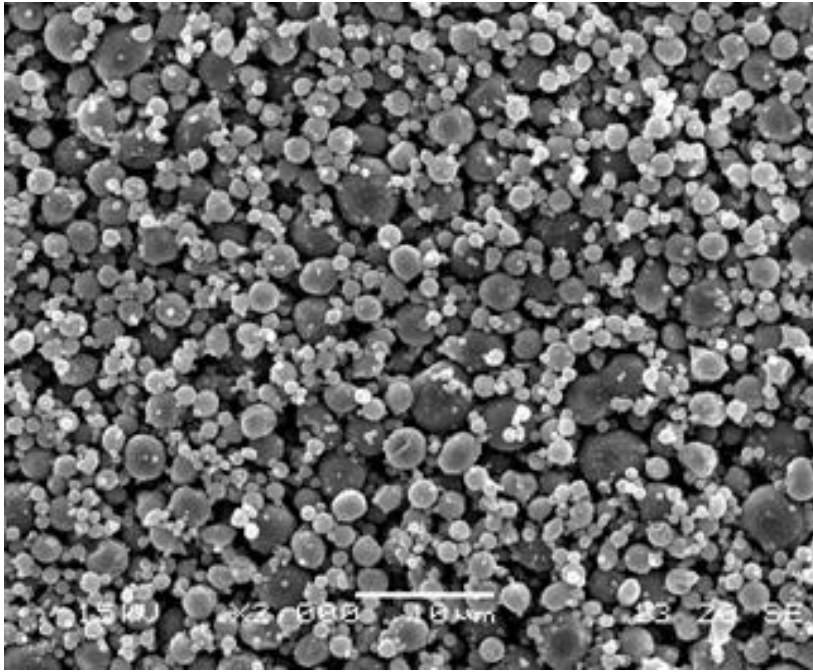
RDX, Class 5 Standard

Capacitance
(μF)

0.05																				
0.02																				
0.01																				

- Final TIL - 0.01 μF (0.125 J)
- Lit Values:
 - IDCA-LANL 0.025 J
 - IDCA-IHD 0.095 J
 - IDCA-AFRL 0.06 J
- This data gives us some confidence in our ESD testing capability and specifically using the camera to indicate a Go/No Go

SEM Comparison of Aluminum Powders

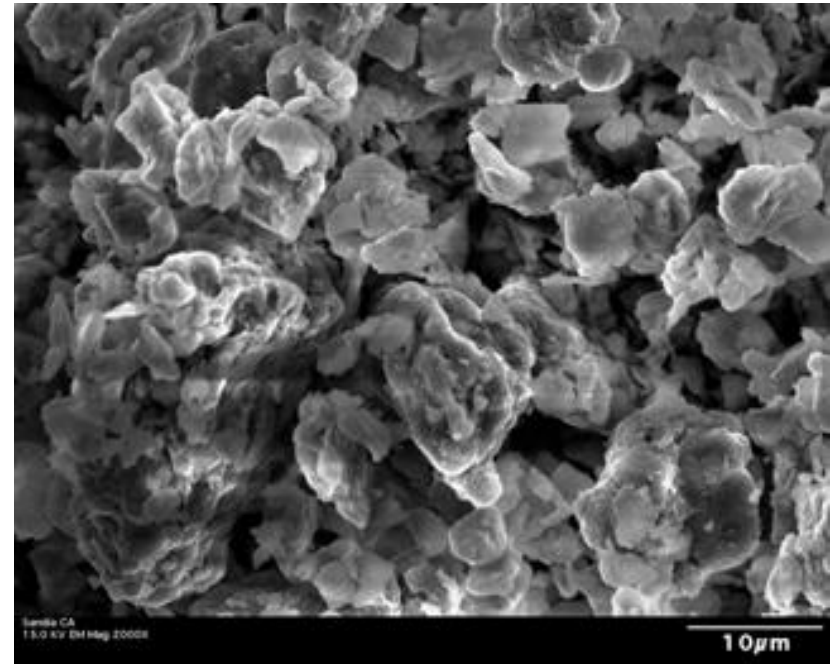


Valimet, grade H2 Spherical

90% - < 6.8 μm

50% - < 3.7 μm

10% - < 1.7 μm



German Blackhead flake

Aluminum ESD Testing

0.006 μF (0.075 J)



Blank



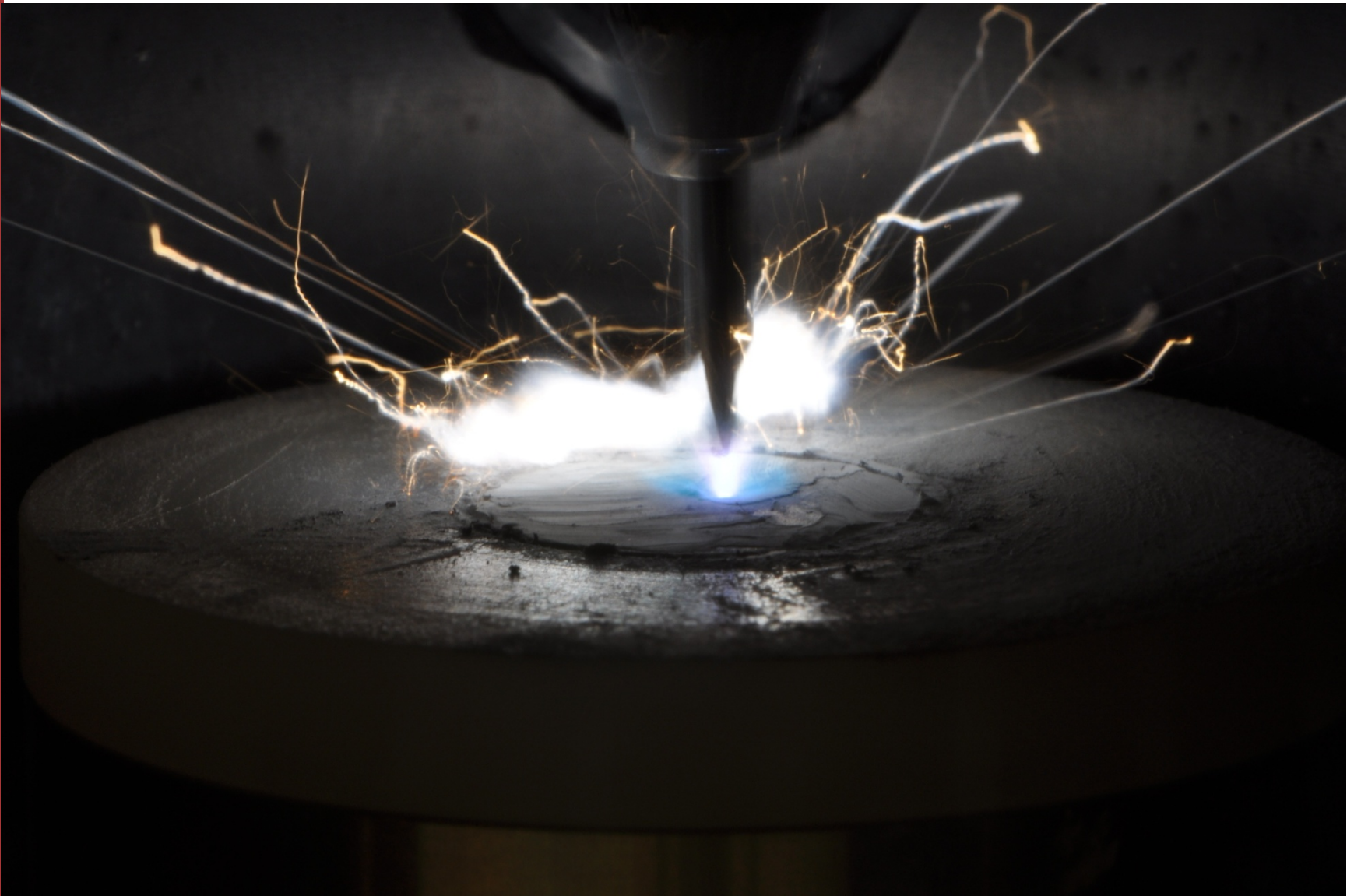
GO

Valimet H2 Spherical



GO

German Blackhead Flake

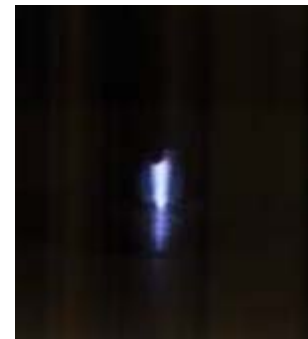


Valimet H2 aluminum 0.02 μ F (0.25 J)
a GO, but closer to TIL

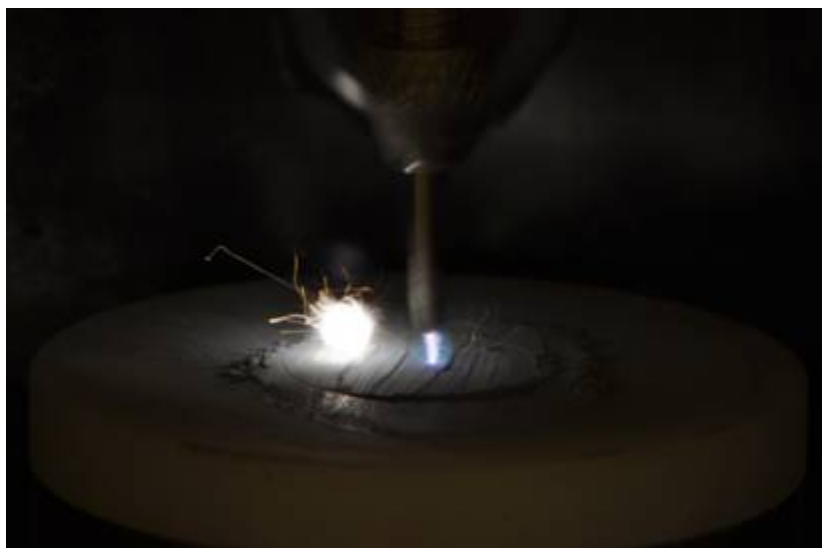


Aluminum ESD Testing

0.002 μ F (0.025 J)

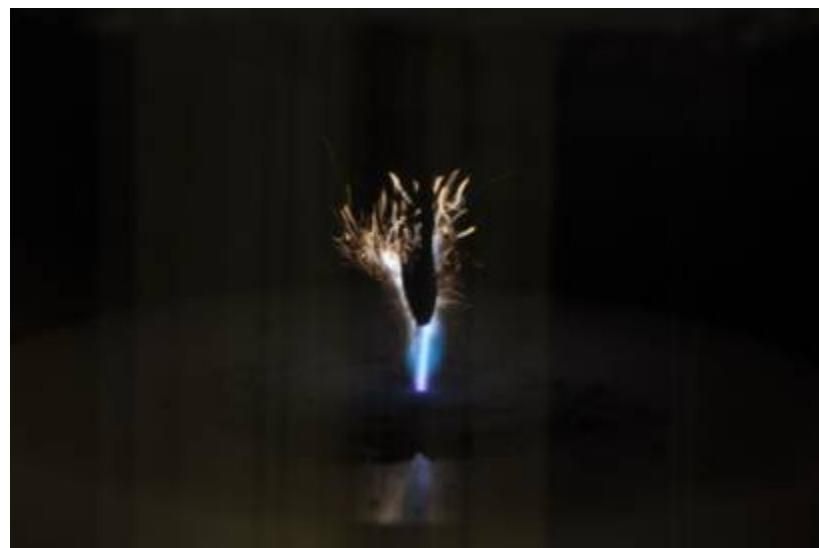


Blank



GO

Valimet H2 Spherical



GO

German Blackhead Flake

Valimet H2 aluminum powder



0.001 μ F (0.0125 J)
GO



0.005 μ F (0.0625 J)
GO



0.002 μ F (0.025 J)
GO

Aluminum ESD Testing

0.0005 μ F (0.00625 J)

Valimet H2 Spherical Al Powder



NO GO

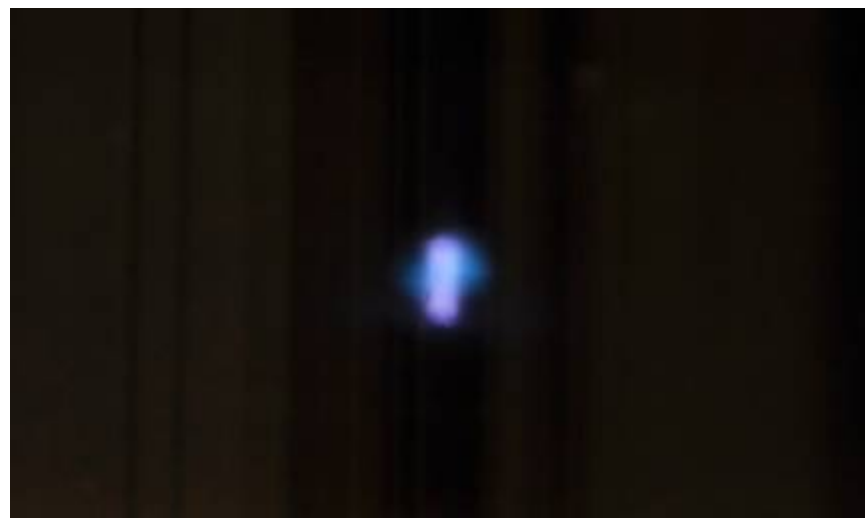
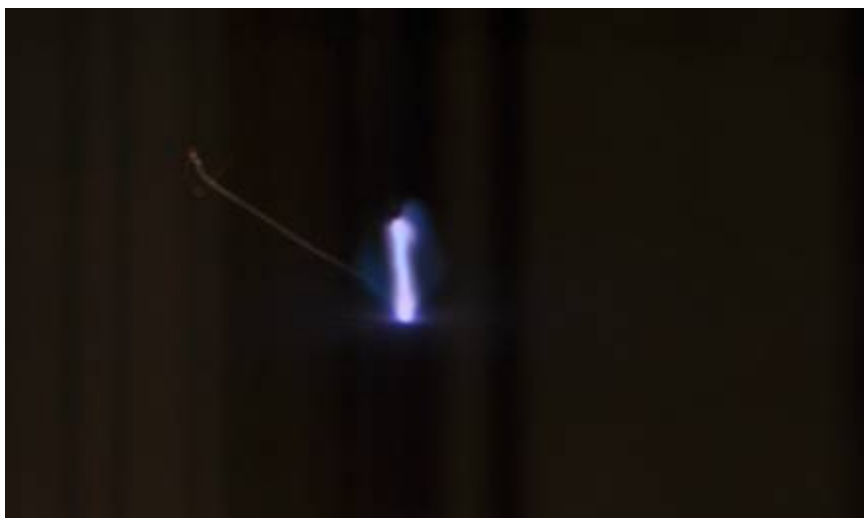
German Blackhead Powder



NO GO



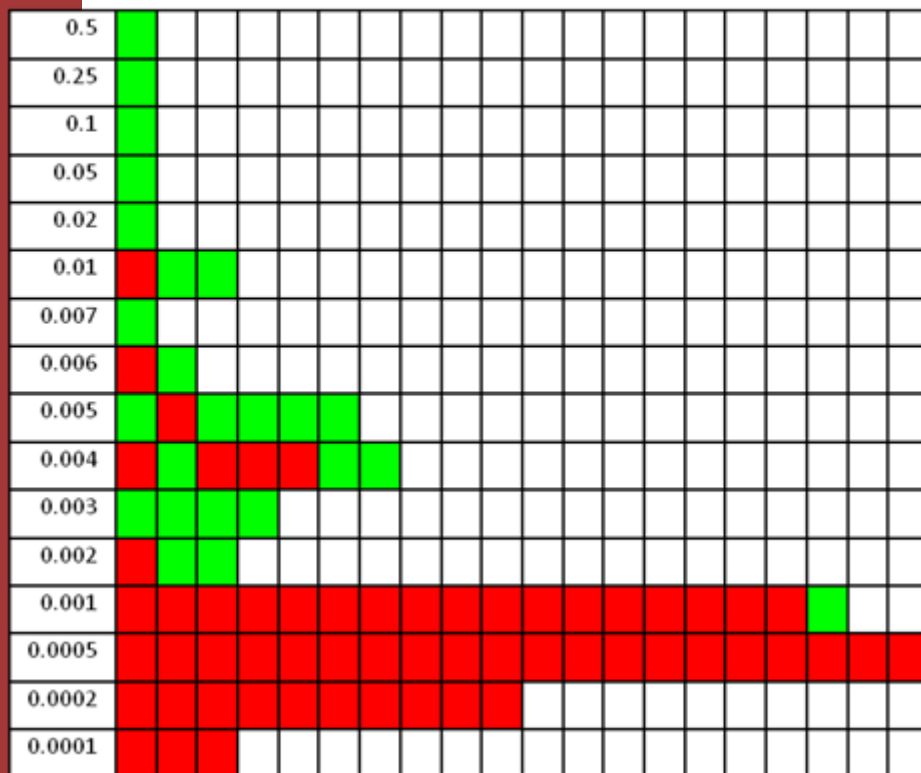
Blank



Summary of Aluminum ESD Testing

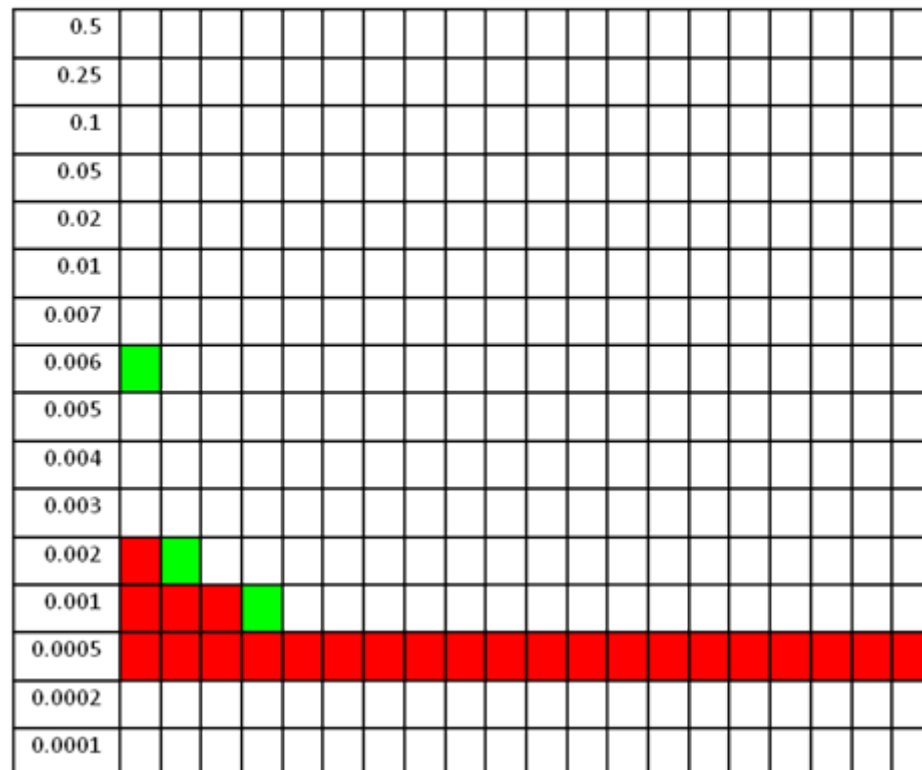
Valimet H2 Spherical Al Powder

Capacitance (μF)



German Blackhead powder

Capacitance (μF)



Final TIL: 0.0005 μF (0.00625 J)
Lit Value: 0.0001-0.010 J

Final TIL: 0.0005 μF (0.00625 J)



Alternate Testing Methods – Scotch Tape Sealed



Blank - 0.5 μ F (6.25 J)



Formula #2 (no tape) - 0.5 μ F (6.25 J) GO



Blank (w/ tape) - 0.25 μ F (3.125 J)



Formula #1 (w/ tape)-0.25 μ F (3.125 J) NO GO?

It doesn't appear that the camera system can be used in conjunction with Scotch tape on the sample.

Summary

- Advantages of image capture
 - Permanent record allows later re-interpretation, if necessary
 - Inexpensive
 - Real time integrated picture on TV
 - Can stare at it as long as desired
 - Can be combined with most other Go/No Go sensors
- Disadvantages of image capture
 - May pick up subtleties other methods miss, making comparisons difficult
 - Does not work well with tape method

