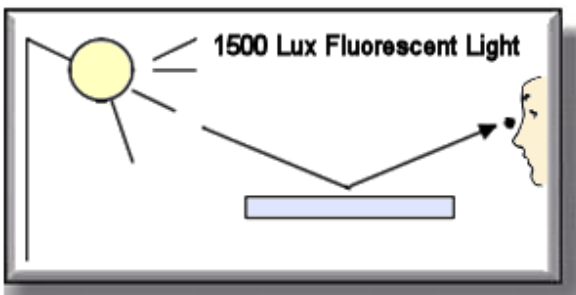


# TFD, Inc., Quality Control

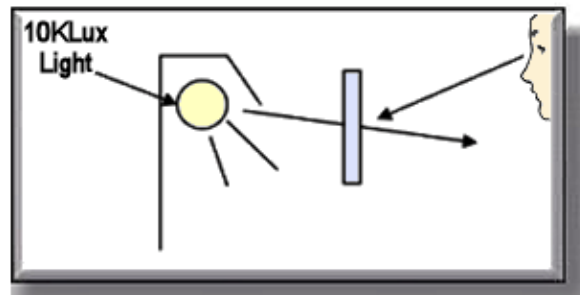
Thin Film Devices (TFD, Inc.) has been proud to incorporate a rigorous quality inspection method and system into every product it manufactures. These methods are incorporated at minimum 25% in process & 100% at outgoing QC.

## 1.0 VISUAL INSPECTION:

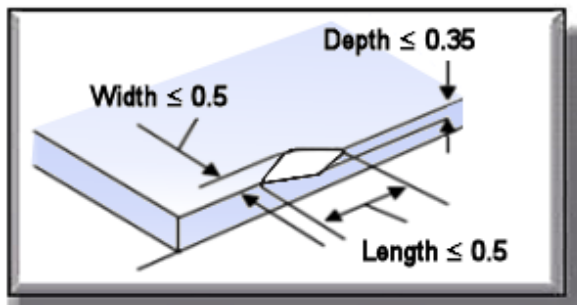
Scratch/ Stain/Chip Inspection: (done by reflection & transmission techniques).



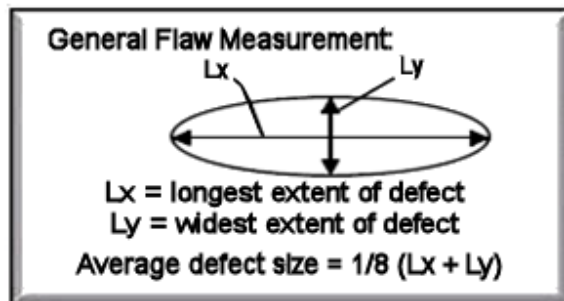
Uniformity and Mark



Scratch, Digs and Chips



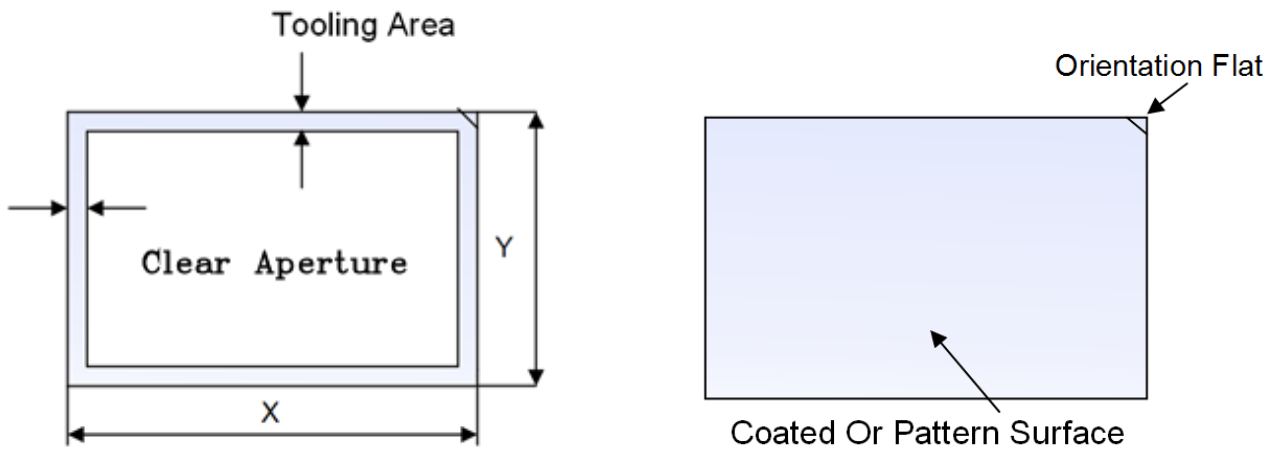
Chip Inspection: (done by calibrated Eye Loupe, dimensions in mm).



**2.0 INSPECTION METHODS AND QUALITY AREA:**

Contents Items	Coated Surface Scratch/Stain	Pattern Surface Scratch/Stain	Bottom Surface Scratch/Stain	Crack/Chip	Pinhole
Light Source	Fluorescent Light 2x30W	Fluorescent Light 2x30W	Fluorescent Light 2x30W	Fluorescent Light 2x30W	Green Halogen Light 100-200W
Light Intensity	1500 Lux	1500 Lux	1500 Lux	1500 Lux	10000 Lux
Conditions	In a dark clean room	In a dark clean room	In a dark clean room	In a dark clean room	In a dark clean room
Inspection Method	Visual Inspection reflected light	Visual Inspection reflected light	Visual Inspection reflected light	Visual Inspection reflected light	Visual Inspection reflected + transmitted light

**2.1 Quality Areas After Coating:** (area inspected; except for chip and crack)



### 3.0 SCRATCH & DIG MEASUREMENT:

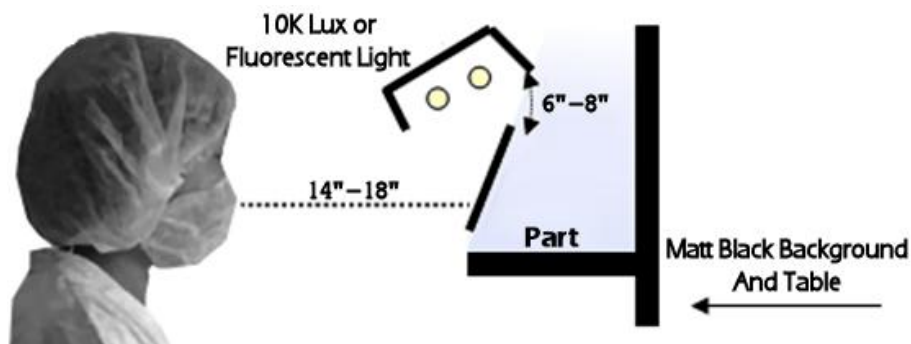
For the Displays, Optical Filters and Solar Cells, defects are extremely important. Early on, the military specifications required methods of inspection to quantify the defects allowed for appropriate product applications. Typically, the application defines the level of defects allowed.

This document will describe the standard developed from the Military code. Industry wide, it is useful for identification of small defects located on, or in, an optical surface, and classifies as "pass/fail" purposes.

The MIL specification 13830A equivalent (ISO 10110) are routinely used to check visual defects in Flat Panel Displays, Optical Filters and Solar industries, world wide.

### 3.1 **Inspection Setup:**

Unless the environment for inspection is properly prepared, the inspection will not be reliable and accurate. Here is the layout specified by Mil-13830A, (ISO 10110):



Notice the need for a black background and a Non-Reflective black table top. This setup provides the contrast enhancement needed to see as small as  $2\mu\text{m}$  defects. The intensity of light is also very important. The 2 fluorescent lights with 30 watts each can allow defects both scratch/digs to be seen as small as  $20\mu\text{m}$ , but using 200 watt halogen can allow defects seen as small as  $2\mu\text{m}$ . The light must be focused on the part in inspection, about 6 inches away. The distance, between the eye and the part in inspection, should be 14" – 18" away.

### 3.2 'Scratch' & 'Dig' Eye Loupes / Microscopes:

For the last 50 years, loupes were the only tools to measure the defects of a scratch or dig. Now calibrated, automated microscopes are routinely used, but inspection criteria remains the same.

If the eye loupes are used, which is held gently against the inspected part where the flaw was seen. Looking through the eye loupe, the inspector sees both the flaw and the eye loupe scale. The defect is matched and calculated against the defects allowed. The inspection loupes are magnified up to 10X.

The microscopes can inspect up to 500X. This inspection method is slow, but very accurate and reliable for patterned glass, or when specs are very tight.

### 3.3 Measurement Technique:

Using the Inspection Arrangement noted above, the part is held at a 14"-18" distance and rotated 90° so the flaw causes the light to reflect back to the inspector's eye. Once found, the artifact or defect is inspected with the calibrated Loupes to determine its size, record the artifact as required, and continue the inspection until completed. The inspection should only be limited to the "active area" or "clear aperture".

The chart below gives the scratch width in microns and digs in mm, per MIL-13830A. The flaws are typically 'paired' to identify the part 'flaw' level and are called 'Scratch' and 'Dig'.

Scratch Width (µm wide)	Dig Diameter (x 0.1 mm)	Light Source
80	50	2 Fluorescent 30 Watts Each
60	40	
40	20	
20	10	
10	5	Green Light 100 – 200 Watts
5	2	

### 3.4 Measurement Guidelines: (example)

If a Scratch / Dig specification is 80/50, here are guidelines to use for proper judgment of the part:

- 1) Any part with a Scratch wider than 80  $\mu\text{m}$  is unacceptable. ("Fail")
  - a. Only scratches in the clear aperture are considered.
  
- 2) Any Scratch found must be 80 $\mu\text{m}$  or smaller in **width** to be accepted. ("Pass")
  - a. With scratches of 80 $\mu\text{m}$ , the total ACCUMULATED LENGTHS of the scratches must be  $\leq \frac{1}{4}$  of the part diameter\*. The formula for the ACCUMULATED **LENGTHS** allowed is:

$$\sum L1 + L2 + L3 + L4 \dots\dots\dots \text{etc} \leq D/4$$

- b. When the predominant number of Scratches are smaller than 80  $\mu\text{m}$  (to 60 or 40),

Then follow this formula about accumulated lengths:

$$\sum L1 + L2 + L3 + L4 \dots\dots\dots \text{etc} \leq D/2$$

(\* = use the actual diameter or the D for a round part of the same area)

### 3.5 Specific Dig Criteria Related:

- 1) No Digs > 0.5mm are allowed. If greater than 0.5mm, the part is a "Fail".
  
- 2) If the part digs are less than 0.5mm, then the part is a "Pass" for this check.
  - a. If the part has Digs of 0.5mm (or less), 4 Digs are allowed. (= "Pass")
  - b. **Clear** Aperture = 20 mm diameter (0.8"): 1 Dig\* allowed, and the maximum sum of Dig diameters are 2 times the maximum Dig diameter.
  - c. **Clear** Aperture = 40 mm diameter (1.6"): 2 Digs\* allowed and the maximum sum of Dig diameters are 4 times the maximum Dig diameter.

**d.** Clear Aperture = 60 mm diameter (2.4"): 3 Digs\* allowed, and the maximum sum of Dig diameters are 6 times the maximum dig diameter.

(\* = maximum dig size)

**e.** Digs of a specified maximum size 10 (0.1mm), must be separated edge to edge, by at least 1 mm.

**f.** These formulae apply to the number and size of Digs.

**Permissible Number:**


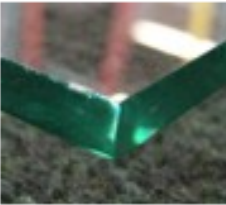

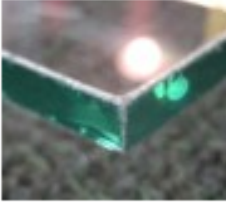



$$n \leq \frac{\text{Dig diam.}}{20 \text{ mm}}$$

**Sum of Dig Diameters:**

$$\sum D1 + D2 + D3 + \dots \leq 2 \text{ diam.}$$

- (Notes: 1. The diameter of an irregularly shaped dig is 1/2 x [length + width])  
 2. Ignore Digs less than 2.5 micron.  
 3. Clear Aperture is the portion used of the part being inspected.

**3.6 Bevel Edges:**

  <p><b>Scribe &amp; Break</b></p>	  <p><b>Swiped Light Bevel</b></p>	  <p><b>Medium Bevel</b></p>
 <p><b>Pencil Polish</b></p> <p><b>“C” Shaped Pencil Edge</b></p>		

**3.7 Chips:**

Unless or other wise mentioned, there should not be more than 3 chips  $\geq 0.020''$  or 0.5mm. Larger chips are allowed to be stoned to minimize stress and cracks.

**3.8 Handling of Substrates:**

The substrates must be handled with auto pick & place equipment or between the finger edges. The latex powder free gloves must be worn in class 100 hood with ionized atmosphere.

**4.0 MECHANICAL PROPERTIES:**

**Adhesion:** To test a coating lot, a test strip, approximately 1.250'' wide (30mm) is removed from one edge of one production sheet per run, and coupons = 1.0 Sq. inch is submitted to test from different areas of the coated sheet. The adhesion, abrasion and environmental, durability is treated. These coupons are representative of specific areas of the whole coated sheet. The samples of the coating shall show no evidence of deterioration from the surface of the substrate. The backside (adhesive side) of the #610 Tape and the area of the substrate that was tape tested shall be examined for evidence of coating material.

**5.0 ABRASION TEST PROCEDURE:**

Cleaned surface to be applied with 0.250'' diameter of rubber eraser tip per the following:

<b>5.1</b>	Light test	Cheesecloth 2.5 IG.	50 strokes
<b>5.2</b>	Moderate test	Rubber erasers 1.5 IG.	30 strokes
<b>5.3</b>	Severe test	Rubber erasers 1.5 IG.	80 strokes

Surface must be checked usually in the same light as defined per Grade 1 and 2.

**5.4 Abrasion and Humidity Resistance:**

After test, the coating shall show no evidence of permanent deterioration when viewed from a distance of 12'' (30 cm) from the test specimen under 5K, 10K Lux illumination.

**6.0 CHEMICAL RESISTANCE:**

The coating shall show no deterioration after a puddle of each of the agents is allowed to remain on the surface for 24 hours. Chemical agents which can only be removed by acetone will not be considered for testing as this would destroy the plastic substrate.

**6.1 Extended Humidity:**

Samples will be placed in humidity chambers and examined after 24 hours, 96 hours, and 240 hours of exposure. Acceptance of each coating batch will occur after the initial 24 hours of exposure.

**6.2 Definition of Lot:**

One lot shall consist of the identifiable product of the same type manufactured continuously from the same materials under the same manufacturing condition.

**6.3 1<sup>st</sup> Article: TFD, Inc. performs 1<sup>st</sup> article on all manufacturing steps.**

**6.4 Inspection by TFD, Inc.:**

All samples, from each lot, are inspected in a Class 1000 area after the surface cleaning.

Several other Product Qualification Tests are performed during the qualification phase of a new product. These tests are performed on an as needed basis for product quality.



**Table I**

<b>Properties</b>	<b>Requirement</b>	<b>Frequency</b>
Chemical Resistance	The coating will be tested for durability against the following chemical agents: Acetic acid (50% by volume) Artificial perspiration Gasoline Ball-point pen ink Citric acid (10% by volume) Coffee Cola Ethanol Felt tip pen Grease pencil Isopropanol Lipstick Liquid detergent (0.5% by volume) (Triton X-200 and water) Methanol Pencil lead Rubber cement Sodium chloride (10%) by volume Stamping ink	These tests will be performed on a qualification basis. (1 <sup>st</sup> Article only)

**7.0 Test Methods:**

**7.1 Cosmetic Appearance (Scratch/Digs):**

Visual inspection. Defects (pinholes in the coating) shall be measured visually at a distance of approximately 30 cm from the specimen under 5K Lux or 10K Lux illumination, using black background. (See section 3.0).

**7.2 Reflected Color: (uniformity of coatings)**

The reflected color of substrates coated with any of the coatings, shall be calculated from the measured reflectance using a 1931 XY CIE Color Coordinate System with a 2° observer and an illuminate C light source on 1<sup>st</sup> article only.

### 7.3 Coating durability:

“The durability tests described shall be performed only after the moisture content of the coating and the base substrate system has returned to a “normal” condition (typically 24 hours after coating) for every lot.

**Table II**

<b>Properties</b>	<b>Test Conditions</b>	<b>Test Method</b>
Adhesion	Snap tape with #610 cellulose tape pressed against coated surface and remove with snap of wrist	MIL-C675
Rub Durability	<b><u>Cheesecloth mandrel with a 2.5 lb. Weight</u></b> 50 rubs minimum for  <b><u>Rubber Eraser with a 1.5 lb. Weight</u></b> 30 rubs minimum for the coating 30 rubs minimum for the coating  80 rubs minimum for IMITO™/BBAR	MIL-C-675  Moderate  Severe
Humidity resistance	<b>24 Hours at 75°C, 95% RH for BBAR side</b> <b>24 Hours at 75°C, 93% RH for IMITO™ side</b>	MIL-810C

### 8.0 CERTIFICATION:

Shall include the key components of the following for each shipping lot, 100% inspected.

- a. Dimension – tolerance
- b. Surface, Scratch/Digs
- c. Bevel – Light, Medium, Heavy, Notch
- d. Flatness/Warp (on an as needed basis)
- e. Coatings – Both Sides
- f. Resistance – Ohms/Sq.
- g. Optical Transmittance
- h. Optical Reflection
- i. 1<sup>st</sup> Article Results
- j. Adhesion/Abrasion Testing
- k. Others – As Required.

**9.0 PACKAGING / LABEL:**

- a. Packaging will be performed in Class 1000 or 10,000 for paper wrapped material.
- b. 20 pc / package for square or rectangular shape or customer advised.
- c. 25 pc / package for round wafers or customer advised.
- d. Each box or package will be plastic wrapped.
- e. Labels to be applied inside/outside per each customer request.
- f. Label will consist of ship date, lot number, quantity, inspector, customer PO number, and other information.