ETN020 EN November 2019	**Thick Film Substrate Specification** Technical Delivery Instruction	ETO GRUPPE JOINTLY INNOVATIVE

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1 Scope

This specification is used for defining the delivery quality of thick film ceramic substrates. This instruction applies to all vendors (manufacturers) of sintered ceramic substrates printed on in thick film technology (TF-Substrates) who sell to the ETO GRUPPE. Supplementary agreements are permissible and must be documented as an attachment.

This ETN replaces the delivery instruction AA-11-01-103 from 01.04.2012.

Changes to the layout, the BOM structure etc. of existing products apply only when product or process changes are executed.

2 Change history

Issue	Change description
November 2019	English version of German issue from March 2012

3 Related documents

- Attachment to this delivery agreement
- Individual specifications[1] (product documents like circuit diagram, single circuit layout[2] in ETO-drawing frame, substrate drawing in ETO-drawing frame, BOM including manufacturer specification and resistance table including trim values – if not specified in the layout, etc.).
- Data sheets for the used thick film pastes and the used ceramics.

For the requirements, the following ranking applies for the documents:

- purchase order or delivery contract
- Quality Assurance Agreement (QAA)
- individual specifications, definition see above
- present technical delivery instruction
- ETN005 – Testing Technical Cleanliness
- MIL-STD-883 in the current version

4 Terms and definitions

- Main faults: deviations from the desired condition that are not acceptable (1 or more main faults = reject).
- ETO: Client, representing the single companies of the ETO GRUPPE, see internet site: http://www.etogruppe.com

5 Confidentiality

The documents given by ETO to the vendor must not be distributed to third parties by any means. The manufactured products may not be shown to third parties, unless under consultation with ETO.

[1] The layout of the single circuit released by ETO applies (in ETO drawing frame with SAP document number).

[2] Single circuit layout, including following additional information: list of the used pastes in printing order and recommended screen data like mesh coating thickness, definition of the trimming cuts (like L-cut, shadow/vernier cut, …), side of the scoring line (front side or backside scoring line), number of the respective substrate drawing with coordinates and placement positions, if possible.

6 Execution and Changes

The manufacturing of the TF substrates must be executed using the materials described in the individual specifications under the process conditions specified by the respective material manufacturers. The ability of the processes must be ensured and documented consistently. The results can be viewed by the client on request.

The substrate must be marked on the edge strip with the following minimum requirement: ETO material number and production batch.

The used materials and manufacturers must be agreed upon and released. Changes require announcement (see also QAA), authorization by ETO and release via PPF and/or PPAP.

ETO-standard: substrate material 96% AL_2O_3, substrate dimension 4“x4“, substrate thickness 1.0mm or 0.8mm, laser cut scoring line of the substrate: backside scoring line, conductor path palladium/silver 3:1, insulation paste DP 6444 or DP QM44D, Au-Paste C5007.

7 Evaluation of printed substrates

7.1 Handling

TF-substrates must be free of contamination on delivery, especially dust and finger sweat. (magnification for visual inspection: 80x). Therefore wearing of suitable gloves for each handling is mandatory and must be ensured. Prophylactic changing of the gloves must be adapted to the conditions and has to be specified in writing.

Protection against mechanical damage, including micro-fissures, must be ensured for transport and storage.

7.2 Substrate

7.2.1 General

Material, dimensions with tolerances, scoring lines, maybe boreholes are defined in the individual specification, substrate drawing.

The permissible tolerance for the single circuits, that is, after singling, is defined, dependent on the substrate thickness, as follows:

substrate thickness	lower tolerance	upper tolerance
0.508 mm	-0.05 mm	+0.15 mm
0.635 mm	-0.05 mm	+0.15 mm
0.762 mm	-0.05 mm	+0.20 mm
0.889 mm	-0.05 mm	+0.20 mm
1.020 mm	-0.05 mm	+0.20 mm
1.270 mm	-0.05 mm	+0.20 mm

7.2.2 Edge chipping / cracks in the ceramics

- Edge chipping is not permissible. Cratering (conchoidal fractures) is permissible, if:
  a) fracture depth < 50% of the substrate thickness, and
  b) fracture area < 2 mm x 2 mm.
- no thick film layers (prints) are damaged thereby, with a maximum area of 2mm x 2mm and a maximum depth of 50% of the substrate thickness.
- Cracks are not permissible.
- It must be possible to single the panel substrates in compliance with the dimensions and tolerances for single circuits, given in the substrate drawing, manually as well as automatically.

7.2.3 Deflection

The deflection of raw substrates must not exceed 0.2% of the respective length dimension, e. g. for substrate edge length = 4“, maximum deflection = 0.2mm. All substrates are inspected regarding this flatness requirement by the ceramics manufacturer.

7.3 Prints

Function, print image, pastes to be used etc. are defined in the individual specification, layout.

- tolerance print image to substrate edges: ± 0.15 mm
- tolerance print image to scoring lines: ± 0.10 mm
- tolerance print images to one another: ± 0.10 mm, also front- to backside

7.3.1 Conductor paths

Pastes, protruding and smeared by conductor path printing (for insulation distances according to the layout ≥0.3 mm) are permissible, if following minimum distances are kept towards neighboring conductor paths, contact surfaces, resistors, etc.:

- distance A to neighboring conductor ≥ A/2, but minimum 0.15 mm
- The maximum length of the protrusions must not exceed 2xB (B = width of the circuit path).
- Constrictions and voids must not exceed 50% of the conductor path width (B) and must not exceed 0.25mm The maximum length must not exceed 2mm.
- For insulation distances and conductor path widths < 0.3mm, separate regulations are required, e. g. by means of an additional text in the layout, attachment etc.

Furthermore, following issues apply:

- conductor path thickness according to paste manufacturer specification
- Special case back side shield area (LB) under insulation print or glass print: voids must not exceed maximum 1.0mm from the substrate edge with a width of maximum = 3mm.
- Special case active bond surfaces in gold prints: The bond surfaces marked in the attachment must not show any pores with a diameter >15µm. Scratches are not permissible.

7.3.2 Resistors

Film thickness according to the paste manufacturer specification. Voids are permissible. Limits for the length and width of the voids are maximum 15% each, but not more than 0.2mm. Limits for the length and width of cavities and pores are maximum 15% each, but not more than 0.2mm.

Trimming cuts in voids are not permissible (safety distance 0.1 mm).

The transitional zone to the contacting must be at least 0.1mm wide. The connection of the resistor to the conductor path must be executed over the entire resistor width. Pores within the contact zone are permissible up to a sum of maximum 10% of the width. Maximum pore size: 50 µm. The permissible print offset is specified in the printing and trimming plan.

Scratches on resistors are not permissible.

7.3.3 Insulation print

Insulation prints are always to be executed at least 2-layered with different screens. In insulation relevant places the insulation distance between upper conductor path and upper insulation print must be at least 0.2mm.

7.3.4 Through-hole contacts

The printed pad must cover ≥ 75% of the borehole edge of the through-hole contact. The width of the incoming conductor path applies as the minimal dimension for the diameter within the borehole cylinder.
The manufacturer must technically ensure that always a vacuum is applied on the through-hole contact after printing, so that the paste is sucked into the bore hole.
The electrical inspection of the through-hole contact is done by means of four wire measurement. The measuring contacts must be positioned on the planar part of the conductor path print outside the bore hole. The distance from the measuring tip to the hole´s edge should be 0.15mm.

The maximum permissible measured value is 100 mOhm for ∅ 0.3 mm and H=1 mm.

7.3.5 Laser trimming cuts

Following points must be complied with for laser trimming:

- cut configuration, especially shape and starting point according to layout.
- cut length maximum 70% of the resistor width, unless special conditions are specified.
- residual bridge minimum width (distance from the end of the cut to the resistor edge) = 0.2 mm.
- minimum distance from the cut to the contacting area = 0.2 mm.
- The minimum distance for multiple cuts between the single cuts is 0.1 mm.
- Cuts must start outside the resistor.
- Residuals (residual bridges) within the laser trim cut are not permissible, the ceramics base must be clearly visible.
- Molten material along the laser track as well as micro fissures caused by the trimming are not permissible (visual inspection 25x magnification).
- permissible laser cut width: 20 µm to 70 µm, waviness ≤25 µm.
- Mind laser cut positions of the following active trimming cuts.

7.3.6 Glass passivation

The glass passivation primarily serves for protection from environmental influences. Only the pads are devoid of glass, e. g. for SMD placement, fine wire bonds, thick wire bonds, die bonds or defined contact points (measuring pads). Following basic conditions apply:

- Connection and contact areas may be covered laterally covered maximum 0.2mm. Minimum 80% of the contact areas must be devoid of glass.
- The sum of all voids must not exceed 10% of the total possible area, as long as these voids affect only ceramics cover.

Should the glass serve for covering printed layers beneath, following applies:

- Voids above conductor paths are not permissible.
- Voids above resistors must not exceed 0.4mm.
- Voids between conductive layers must not exceed maximum 50% of the distance.

7.3.7 Lacquer passivation

The details stated under 7.3.6 “Glass passivation“ apply.

7.4 Electrical parameters

7.4.1 Resistance of conductor paths

Values according to the specifications of the paste manufacturer apply.

7.4.2 Resistors

The resistance values of all printed resistors must be verified by measuring and must comply with the specifications in the layout. If not specified there in detail, following tolerances apply: trimmed R ± 1%, non trimmed R ± 30%.

7.4.3 Memristors (if applicable)

All memristors[3] of the substrate must be trimmed according to the tolerances given. Incorrectly trimmed memristors are not permissible, as all memristors of all circuits are read out during laser trimming (passive/active).

(-> otherwise no allocation between substrate and tunnel data is possible)

[3] All memristors: bad circuits included.

7.5 Special inspections

The execution of these inspections is performed after special special agreements and is defined in the order documents, or in case one of the basic conditions apply that are described below, or that has additionally been agreed upon.

7.5.1 Solderability (wetting)

The solderability inspection (wetting) of the connection areas is performed by dipping. specifications are:

- soldering bath composition **Sn96,5Ag3,0Cu0,5** (or for plumbiferous soldering joints: Sn62Pb36Ag2)
- soldering bath temperature **265°C ± 5°C** (or 235°C ± 5°C)
- flux 1.2.3 according to DIN EN 29454 part 1
  Note 1: corresponds to REHO according to DIN EN 61190-1-1
  Note 2: corresponds to F-SW 33 according to DIN 8511 Teil2/05.88 (no longer valid)
- immersion speed 5 mm/s
- time in soldering bath 5 s

Evaluation: The wetting percentage of all soldering surfaces must at least be 90%.

7.5.2 Bondability wire bonding

7.5.2.1 Ball bonding with Au-wire

Per delivery batch, 60 bond connections must be assembled to the intended bond pads in the agreed upon bonding process (typically TS ball bond at 150°C, wire-∅ 25 µm, US-f= 60 kHz), and be subjected to the pulling test. The respectively agreed upon pull-off strength must be stable and process reliable (c_{pk} > 2.00), Separation within the welding spot (lift ups) are not permissible.

7.5.2.2 Heavy wire bonding

Per delivery batch, 20 bond connections must be assembled to the intended bond pads in the agreed upon bonding process (typically US bond, wire-∅ 250 µm, US-f= 60 kHz), and be subjected to the pulling test, and shear test, if required. The respectively agreed upon pull-off strength and shear level must be stable and process reliable (c_{pk} > 2.00), Separation within the welding spot (lift ups) are not permissible.

Regarding bond pads, mind, that „darker" connection pads can result in limited bondability. Should deviations in the brightness of bond surfaces come up in a production batch or entire batches, these conspicuous parts must definitely be tested for bondability and ETO must be provided with samples for their own bonding test runs.

7.6 Cleanliness

Technical cleanliness does not have to be complied with for substrates in any case. This requirement is given in the ETO drawing. In this case the ETO-standard ETN005 is used on the drawing.

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For the use of ETN005, the following CCC[4] applies: CCC = A(D14/E11/F7/G6/H5/i4/J3/K00).

7.6.2 Contaminations

In case of contaminations sintered into the substrate, like textile lint, dust, hair lint from cleaning cloths, paste spatters, etc., the security distance (insulation clearance) of 0,15mm between the single prints (e. g. between conductor paths, resistors, connection pads, etc) must be ensured for different potentials. If foreign particles are sintered into prints, or color deviations are visible, that indicate burnt out foreign particles, the affected spots are considered faults.

Non printed ceramics surfaces of the circuits must not show contaminations such as paste spatters, metal abrasion, etc. > 0,5 mm², exception: edge strips and other overhang areas.

[4] CCC = Component Cleanliness Code

Contaminations by handling (e. g. finger prints) are not permissible.

Visible contaminations on the back side of the circuits, inspected at 20x magnification, must not be present around the press hole, in an area with a diameter of the width of the substrate (smaller dimension of the single circuit).

Outside the said areas contaminations may be present, if they do not impair the planarity of the surface, if they do not exceed 5µm and if they consist of materials that the circuit consists of.

Finger prints and such are not permissible at all.

8 Special conditions

Special specifications and inspections that apply for ETO are listed as follows:

- Co-Firing: Co-Firing is not permissible.
- Edge treatment: Substrates are treated (ground)[5] on at least 2 edges – the side edges - , to lower the wear on the guidances at ETO. Please note: the edge treatment SilkEdge™ , provided by the manufacturer COORS, is not permitted.
- Planarity of the substrates: All substrates are tested 100% for deflection according to 7.2.3.
- Dye Check: All 4"x4" substrates must be tested 100% for cracks, voids and conchoidal fractures by means of dye penetrant testing after laser scoring. Proven media for this test are ZYGLO Brand ZL4C (manufacturer Magnaflux) and Supercook Cochineal Colouring 10310, diluted with water. Everything else must be verified separately by ETO. After the dye penetrant test, the organic residues must be removed by burning out at 850°C.
- Sound test: all substrates must be subjected to a sound test before delivery to ETO SENSORIC. (sound test: Place substrate on the corner on a solid base and hit with a wooden rod, then valuate the sound: damp= n.i.o., crack in the ceramics)
- AOI: 100% of the substrate must be tested by means of an automated optical inspection before delivery. The inspection includes the visual criteria given under 7.2.2, 7.3, 7.5.2.2 and 7.6.2.

9 Dealing with faulty circuits / substrates

9.1 Fault definition

Substrates with main faults, that affect the entire substrate, must not be delivered. Single circuits with main faults are marked with an inkpoint as „bad". This „bad" mark must not cover the fiducials.

This mark is either performed with stickers or with a color pencil *Edding 30 Brilliant Black*:

- color → black
- size → ∅ 5 mm or □5 mm
- temperature → heat resistant up to 250°C without blur
- chemical resistance → ZESTRON VD at 52°C in liquid state an 1 hour at 80°C in vapor phase.

Main faults are:

- interruptions, short circuits, voids
- minimal distances fallen short of (insulation clearances)
- electrical functional and resistance values out of tolerance
- adhesive strength fallen short of (DIN 41850)
- insufficient flow on the small connection surfaces (soldering surfaces)
- insufficient solderability / tinning characteristic
- insufficient bondability
- dimensions / reference dimensions out of tolerance
- through-hole contact fault
- wrong, unreadable or missing marking
- finger and glove prints

5 Edge treatment: Minimum are 2 opposite edges.

9.2 Panel yield

The minimum yield within the panel is defined as follows:

in minimum 95% of the substrates:

a. ≥ 75 % for panel = 20 (max. 5 bad)

b. ≥ 75 % for panel = 40 (max. 10 bad)

c. ≥ 75 % for panel= 49 (max. 12 bad)

In maximum 5% of the substrates the yield may be between 50% and 75%. In any case, the substrates with bad circuits must be evenly dispersed within the delivery batch.

Substrates with a yield lower than 50% must not be delivered.

9.3 Batch yield

The minimum yield within a delivery batch must be >85%.

10 Miscellaneous

10.1 Inspection and delivery certificate

As a standard, no inspection certificate or COC is agreed upon. In special cases this must be arranged in the attachment.

The parameters, that are to be documented, if necessary, are agreed upon product specifically between the quality departments in writing. Excerpt of possible specifications: circuit type, SAP-material number, batch number, delivery quantity, date of delivery, initial sample size and sample test result for electrical and visual testing, including dimensions inspection.

The customer reserves the right to perform qualification testing.

Deviations from mandatory processes and materials: Product and process changes require an agreement in writing, must be announced timely and be released by the customer. Generally, sampling and PPAP/PPF are required. Agreed upon changes must be marked in the delivery documents for the first affected delivery.

10.2 Packaging, transport and storage

The packaging must eliminate damaging and contamination during transport. Especially humidity must be kept out and scratching by relative movement of the substrates against each other must be prevented.

The vendor names suitable storage conditions for substrates. The processability defined under 7.5 (solderability, bondability of wire bonds) must be ensured for at least 3 months under compliance with the agreed upon packaging and storage conditions.

10.2.1 Packaging and labelling for delivery to ETO SENSORIC GmbH

The smallest packaging unit is 20 substrates with interleaf papers (paper strength 100 grams, size 10 cm x 10 cm) and wrapped with Silver Safer®[6]. This unit is packed or shrink wrapped in harmless foil. Each of these packaging units must be labelled with bar code and plain text containing the following information:

- manufacturer (bar code not mandatory)
- material number
- batch[7]
- calender week[8]
- quantity of substrates (bar code not mandatory)
- quantity (of good single circuits)

The outer packaging to be used is agreed upon by customer and vendor. Each packaging unit must be labelled with a VDA goods tag.

For changes of the product a respective information note must be given on the delivery order and in each packaging unit, as well as on the outer packaging (e. g.: Attention: changed parts, see change document….).

[6] Silver Safer® is an oxidation protection for gold, silver and other precious metals.
[7] note: batch identification that contains relevant information for retraceability.
[8] calender week = start of the production order in the printing department

10.3 Environmental compatibility

All materials, even in small amounts, that are harmful to health or the environment, according to the state of the art, must not be used. Free from CFCs and cadmium is a requirement. The Global Automotive Declarable Substance List (GADSL) that is updated annually, applies, see: http://www.gadsl.org/.