

Film Deposition

Superconductors



HTS - films

THEVA fabricates all kinds of $REBa_2Cu_3O_7$ - films (RE = rare earths).

The properties of HTS – films required for certain applications can vary considerably and hence there is no standard HTS – film satisfying all the different specifications. However, THEVA offers different film types tailored for specific applications to allow an easy selection.

The following pages give an overview of technical details which are helpful for making a decision on which film to use.

Each HTS - film leaving our production is thoroughly checked and accompanied by a quality inspection certificate.

and a lot more

Metal oxides with complex composition

THEVA's proprietary coating technique has been developed for the deposition of complex, multi-component metal oxide films on large area.

Typical examples are perovskites with special ferroelectric or –magnetic properties or dielectric films for high temperature fuel cells.

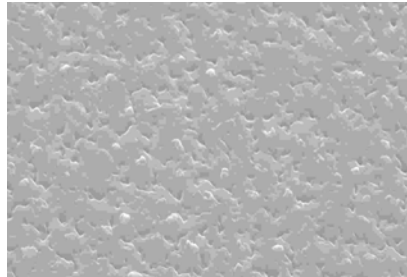
Contact us to discuss your desired custom - designed layer architecture and choice of material.

Adhesion, buffers, metalization

With years of experience in thin film coating THEVA has the experts to address all related crucial issues such as adhesion, diffusion and electrical contacts.

THEVA offers assistance and expertise to solve material related problems, and develops layers to prevent interdiffusion, or metal coatings with extremely low contact resistance.

HTS - Film Types



M-type

Excellent microwave performance, porous surface, enhanced pinning

Typical superconducting specs:

$$T_c = 88 \text{ K}$$

$$j_c(77\text{K}) \geq 2.5 \text{ MA/cm}^2$$

$$R_s < 300 \mu\Omega \text{ (@77K, 10 GHz, 700 nm)}$$

Suggested application:

Microwave devices, high j_c -applications, FCL

Warranted specs

$$T_c > 87 \text{ K}$$

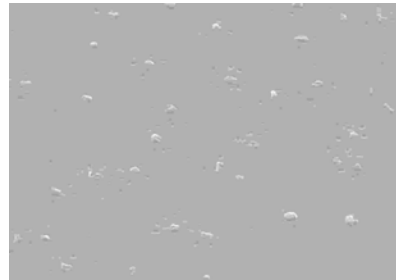
$$j_c(77\text{K}) > 2 \text{ MA/cm}^2$$

$$R_s < 500 \mu\Omega \text{ (@77K, 10 GHz)}$$

Warranty conditions

Guaranteed specifications for films (thickness > 200 nm):

This warranty holds for 6 months after delivery (proper storage in a desiccator) or until processing of the films by the customer.



S-type

Smooth matrix, small CuO_x -segregations

Typical superconducting specs:

$$T_c = 87 \text{ K}$$

$$j_c(77\text{K}) \geq 2 \text{ MA/cm}^2$$

$$R_s < 500 \mu\Omega \text{ (@77K, 10 GHz, 700 nm)}$$

Suggested application:

Squids, micron - linewidth patterning

Warranted specs

$$T_c > 86 \text{ K}$$

$$j_c(77\text{K}) > 1.5 \text{ MA/cm}^2$$



E-type

Extremely smooth, no segregations
Rms roughness 6-10 nm

Typical superconducting specs:

$$T_c \geq 83 \text{ K}$$

$$j_c(77\text{K}) \geq 1 \text{ MA/cm}^2$$

Suggested application:

Low temperature electronics, multilayers, submicron structures

Warranted specs

$$T_c > 80 \text{ K}$$

Characteristics

General warranty

No scratches or line defects,

No sticking particles or point defects > 50 μm in diameter

<2% a-axis per volume

Substrates

Characteristics

Substrate wafer materials

The most important ingredient for obtaining high quality films are high quality substrates. For this reason we are collaborating only with qualified substrate suppliers.

Substrate materials as listed in the table with their most important parameters are readily available for HTS deposition.

Substrate	Maximum size	Buffer layer	ϵ	$\tan \delta$ (1GHz, 77K)*	Max. film thickness
LaAlO ₃	3"	CeO ₂	23.6	10 ⁻⁵	1.0 μm
MgO	3" or 70x70 mm ²	---	9,7	2x10 ⁻⁶	> 3 μm
YSZ (ZrO ₂ :Y)	100 mm	Y ₂ O ₃ or CeO ₂	27	10 ⁻³	1.5 μm
Sapphire	200 mm	CeO ₂	11,6/9,4	< 10 ⁻⁶	350 nm
SrTiO ₃	1"	CeO ₂	2000	10 ⁻³	1.0 μm
NdGaO ₃	2"	CeO ₂	23	3x10 ⁻⁴	1.0 μm
YAlO ₃	2"	CeO ₂	15,5	2x10 ⁻⁶	< 500 nm
LSAT	2"	CeO ₂	22,7	2x10 ⁻⁴	1.0 μm

* Values taken from literature

The film thickness limit (here for YBCO) is a consequence of the thermal expansion mismatch between film and substrate. Thicker films tend to relax stresses by cracking.

Standard dimensions

Substrate sizes

We can accommodate practically every substrate size and shape fitting into the deposition area of 22 cm diameter. Standard substrate holders together with the maximum number of substrates per batch of deposition

(batch size in the parenthesis) are listed below:

Circular wafers: 200 mm (1), 150 mm (1), 100 mm (3), 3" (5), 2" (12), 30 mm (30)

Rectangular wafers: 190x100 mm² (1), 100x100 mm² (1), 75x75 mm² (4),

50x50 mm² (8), 60x30 mm² (10), 40x40 mm² (12),

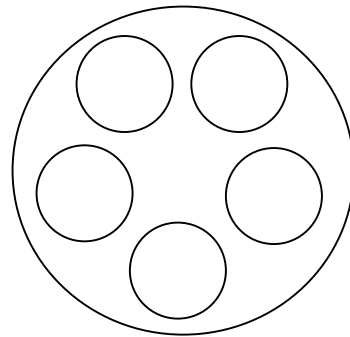
120x10 mm² (20), 30x30 mm² (20), 20x20 mm² (48)

Other dimensions are available on request. In some cases it may be more economic to cut larger wafers into the desired shape after deposition.

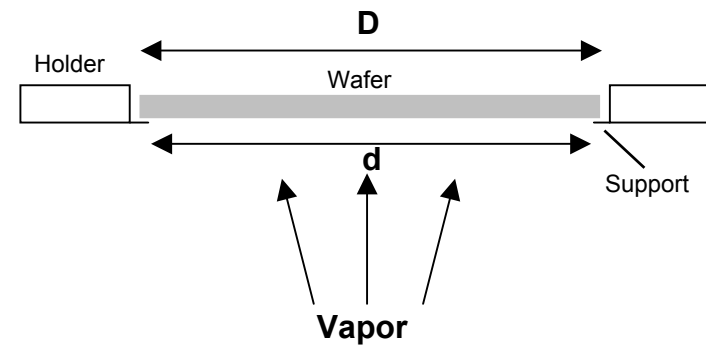
Coating area

Substrate wafers are mounted in a circular effective deposition area of 22 cm diameter !

Wafer holder



Typical wafer holder plate
(here: 3" wafer configuration)



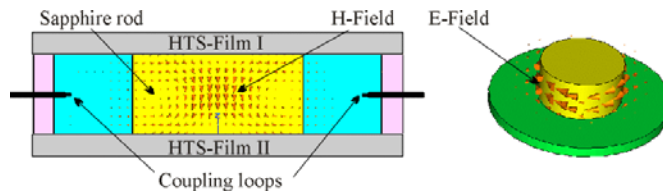
Wafer mounting in holder plate

Note: Since we need some supporting rim around the wafer edge, the coated film area (d) is smaller than the wafer size (D). For small chips ($< 1''$) this difference is about 1 mm, for larger wafers ($> 1''$) it is up to 1.5 mm in total. Due to the centrifugal force wafers are moved to the outer edge of the holder during deposition and this uncoated rim is not concentric (e.g. 0.5/1.0 mm on opposite sides of larger wafers).

Communication applications require low RF surface resistance

High frequency filters for satellite and cellular communication with extremely sharp skirts and selectivity are realized by HTS - films with low surface resistance.

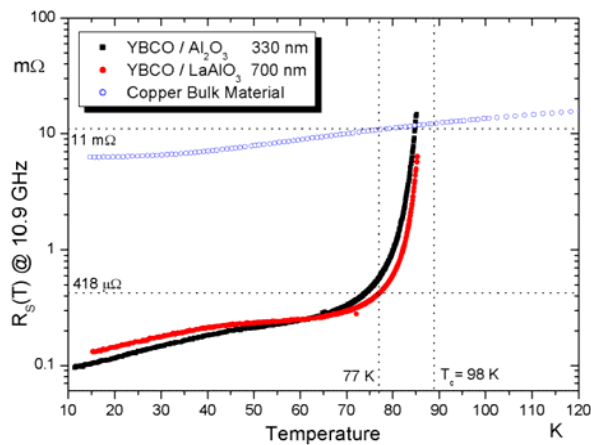
Quality control



Characterization technique

The surface resistance of our films is routinely checked in a dielectric resonator as sketched here.

Two HTS - films act as mirror end plates of a cavity. The RF field (10 GHz) is concentrated by a sapphire rod in the center of the film.



Temperature dependence

The temperature dependence of the microwave surface resistance at 10.9 GHz is depicted on the left.

Two typical M-type YBCO films of different thickness are shown on LaAlO₃ (700 nm) and sapphire (330 nm).

The R_s of copper is shown for comparison.