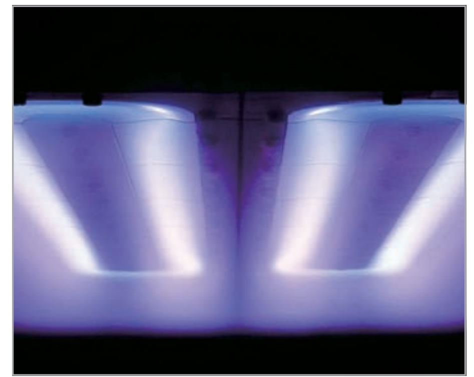
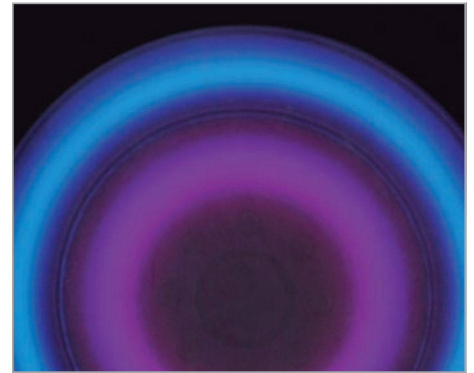




UBS-C2

Unipolar/bipolar switching unit
for two channel
Pulse Magnetron Sputtering

Fraunhofer
FEP

Special features

Pulse Magnetron Sputtering (PMS) technology enables superior reactive magnetron sputtering with

- high deposition rate
- long term process stability
- improved layer properties.

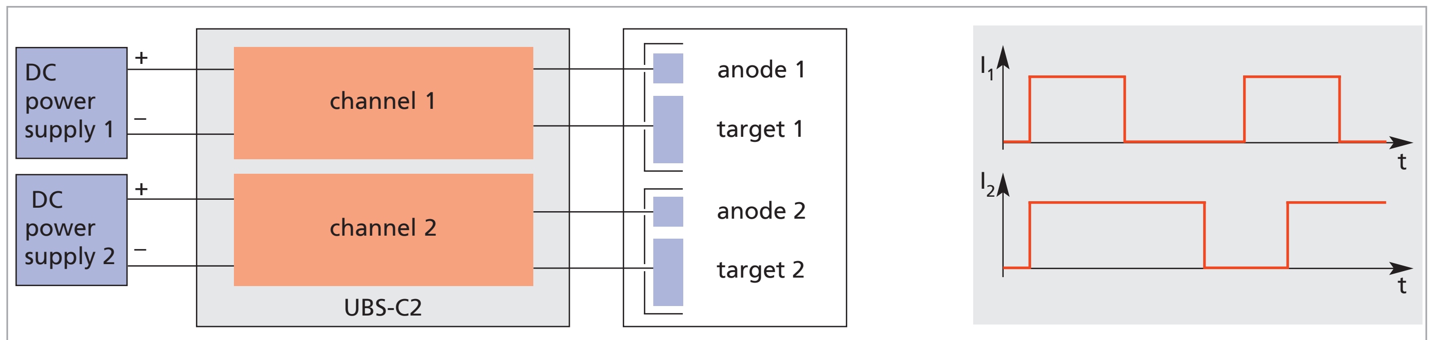
Based on a leading position in this technology the Fraunhofer-Institut für Elektronenstrahl- und Plasmatechnik develops customized layer systems and complete hardware and software packages to use PMS techniques in laboratory and industry on an advanced level. A key component of such integrated packages is the multi-functional fast switching unit UBS-C2 for both unipolar and bipolar pulse magnetron sputtering. UBS-C2 is one component of Fraunhofer FEP's innovative pulse power supply family i-PULSE®.

Pulse mode influences layer properties. A unique feature of UBS-C2 – the free choice of pulse mode and pulse parameters – allows to control the energy input into the growing layers and gives new degrees of freedom to optimize film properties, using similar effects as obtained by the »classical« optimization parameters process pressure, substrate temperature or substrate bias.

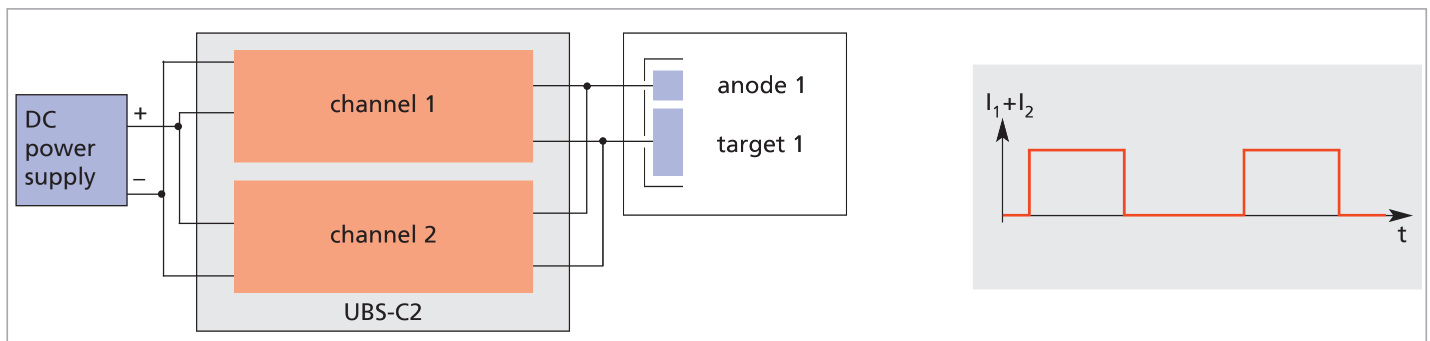
Using pulse sputtering technology films can be deposited with very high deposition rate on cold substrates with such properties that would require bias or high substrate temperature in case of DC or RF sputtering techniques.

The UBS-C2 with its ultimate flexibility to control essential plasma parameters exhibits a superior technological tool to produce optimized layers in research and production.

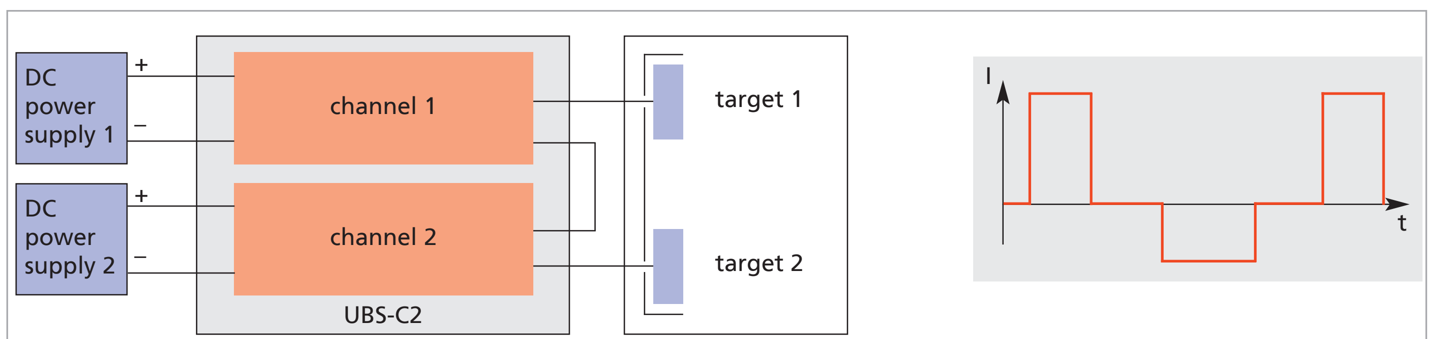
The benefit of using the pulse mode for optimization is obvious in the case of titanium dioxide. The crystalline structure of the films deposited at rates of up to 50 nm·m/min exhibits anatase phase in the unipolar and rutile phase in the bipolar pulse mode.



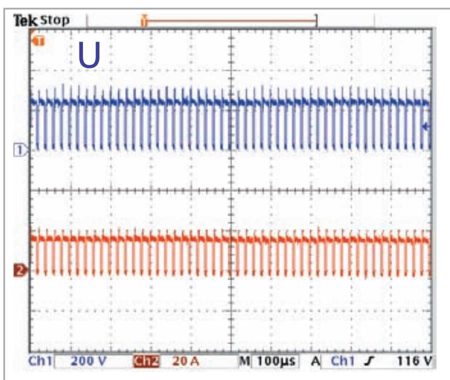
Independent unipolar pulse powering of two single magnetron sources using UBS-C2 and two DC power supplies



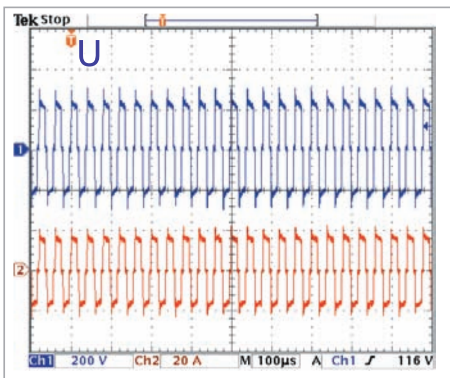
Unipolar pulse powering of a single magnetron source using UBS-C2 with the two channels connected in parallel and one DC power supply



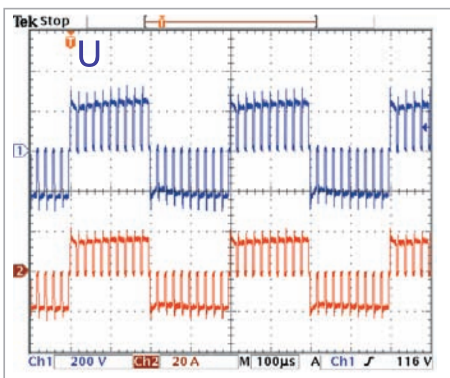
Bipolar pulse powering of a dual magnetron system using UBS-C2 and two DC power supplies



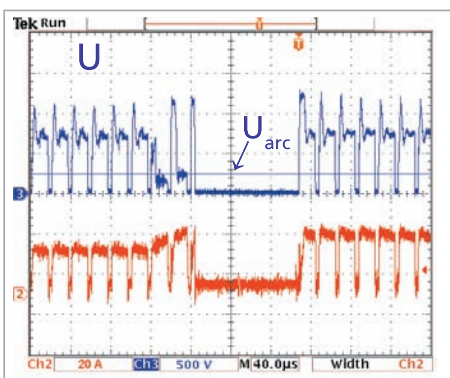
Unipolar sputtering technique



Bipolar sputtering technique



Pulse package sputtering technique



Arc handling with N_{arc} = 3 and U_{arc} = 250 V

Functions

The UBS-C2 converts dc power into square wave current pulses and ensures minimum energy input in case of an arc even at high discharge power through intelligent arc handling. This switching unit presents pulse powering with ultimate flexibility for different magnetron arrangements and pulse modes.

- unipolar pulse mode independent or synchronous powering of up to two single magnetron sources, also in different vacuum chambers (»hidden« anode recommended for insulating film deposition)
- bipolar pulse mode two channel powering with periodic polarity change to energize a dual magnetron system
- pulse package option of UBS-C2 for unipolar and bipolar mode opens up new technologies with enhanced stability and energetic efficiency.

Moreover the UBS-C2 enables further process options:

- co-sputtering of different materials in both pulse modes
- pulsed bias sputtering
- user port to process control unit e. g. PCU *plus*.

Applications

PMS technologies entered into many fields of application like

- reactive deposition of insulating compound layers such as Al_2O_3, SiO_2, TiO_2, ZrO_2, Nb_2O_3, SnO_2, ZnO_2 e. g. for architectural glass coating, optics, hard decorative and wear resistant coating and sensor technology
- deposition of improved special layers e. g. aluminum or carbon for microelectronics and recording media.

Hard- and software

- **arc detection**
  Arcs are detected, when an output current flows and the output voltage falls below the arc trip level value U_{arc} set in the device.
- **arc classification**
  There are three adjustable classes of arcs available: class A (micro arcs), class B (medium arcs) and class C (hard arcs). In certain applications it is useful to allow a number of self-extinguishing arcs to clean the target. The intelligent arc handling gives the user the ability to define the three arc classes A, B and C represented by the number N_A and N_B of consecutive pulses with detected arc. If the number of consecutive pulses with $U_{pulse} < U_{arc}$ is between 1 and N_A than this event is counted as a class A arc, if it is larger but does not exceed N_B than this event is counted as class B arc. Otherwise it is counted as class C arc that will be suppressed, if arc handling is enabled.
- **arc duration**
  The arc duration time is determined either by the parameter t_delay (time until the power will be switched off in the case that arc classification is disabled) or otherwise by the allowed number of consecutive pulses with detected arc. Thus the user is able to adapt the arc duration appropriate to the application, e. g. dc-process, low pulse frequencies or high pulse frequencies. If the counted number of pulses with detected arc reaches the set parameter N_{arc}, pulsing will be interrupted by the UBS-C2 for an adjustable time t_arcoff.
- **arc current limitation**
  If the current increases significantly in case of an arc (e. g. for large value of N_{arc}) its value is limited to the set value I_{max}.
- **arc counting**
  Arcs are counted separately for each class and polarity. The counter readings are available at the Profibus interface.
- **pulse package arc handling**
  In the pulse package mode the UBS-C2 offers a specific arc handling. If an arc is detected within pulse package of a certain polarity the UBS-C2 switches to the other polarity to suppress the arc. The number of pulses of this inserted arc suppression package can be set by the user. Process stability is being increased because pulsing is not interrupted. To achieve balance between the channels the number of pulses of the inserted arc suppression package is added to the number of pulses of the same polarity after switching back.

Features and specification of the UBS-C2:

- add on device to customary dc sputter equipment
- current source characteristic
- two channel device for both independent and coupled power input
- choice of pulse mode:
  - unipolar with two single magnetrons
  - bipolar with one dual magnetron system
- bipolar pulse mode with symmetric or asymmetric pulses possible
- pulse package mode available (option)
- pulse frequency and pulse width repetition ratio adjustable between 0.3 % … 99.7 % (1 kHz) and 15 % … 85 % (50 kHz), respectively
- pulse current up to 80 A
- double output current by parallel wiring of the two channels
- high peak output voltage up to 1.6 kV
- power input into UBS-C2 via one or two dc power supplies in both pulse modes
- arc detection and counting
- arc extinction within less than 1 µsec
- arc energy below 5 mJ
- profibus DP interface for remote control

control mode	current control (power or voltage control via DC supply)
modes of operation	DC, unipolar, bipolar, pulse package (optional)
maximum input voltage (from DC power supply)	• 1000 V (standard) • up to 1500 V (on request)
number of channels	2
output current	• unipolar max. 80 A per channel • bipolar max. 60 A per channel
output voltage	max. 1600 V (pulsed)
switched power	up to 30 kW per channel depending on the process impedance
pulse rate	1 … 50 kHz
duty cycle	range according to frequency and pulse mode • min. 15% … 85% (50 kHz) • max. 0.3% … 99.7% (1 kHz)
arc handling	• arc suppression • arc classification • pulse package arc handling
interfaces	• profibus DP • analog user port (average values of pulse current and pulse voltage for direct input to process control unit, e. g. PCU *plus*) • analog output voltage for scope and multimeter
dimensions (length x height x depth)	480 mm x 400 mm x 400 mm (19“, 9 HU, 84 DU)
weight	100 kg
ambient conditions	min. 10 °C, max. 45 °C, humidity < 80 %
mains	• 230 VAC, 2.5 A • 115 VAC, 5 A } 50 / 60 Hz

Attention: The specification defines parameters and limits of the UBS-C2 that have been verified in operation with sputter equipment of Fraunhofer FEP and other users operating with different target materials under various process conditions. It cannot be guarantied, that all parameters and limits can be achieved with all sputter equipment, all target materials, reactive gases and under all process conditions. Please contact us for assistance.

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