SPIK3000A HiPIMS DC Power Controller

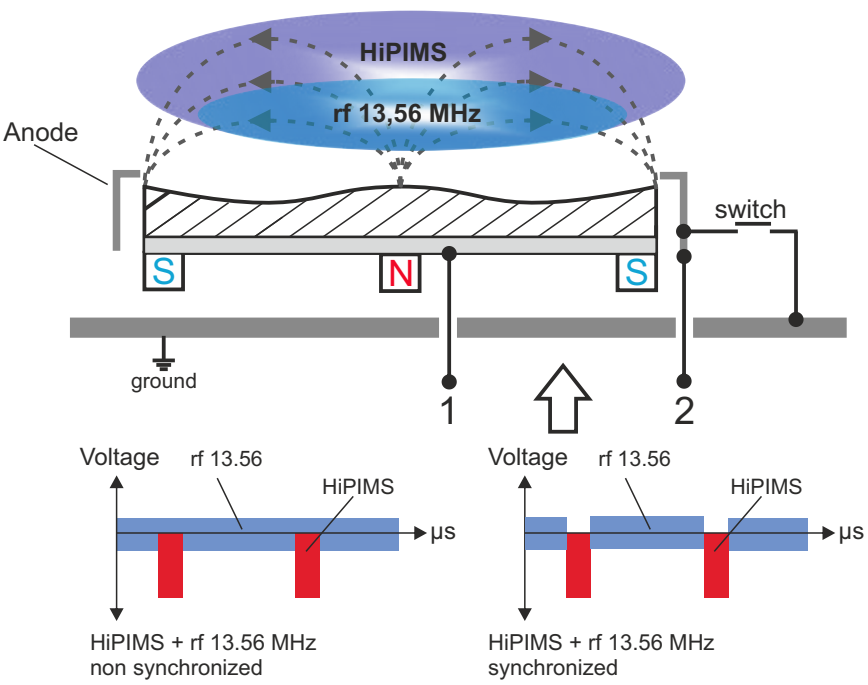
SPIK3000A: HiPIMS 5kW – 30kW , 60kW , 90kW

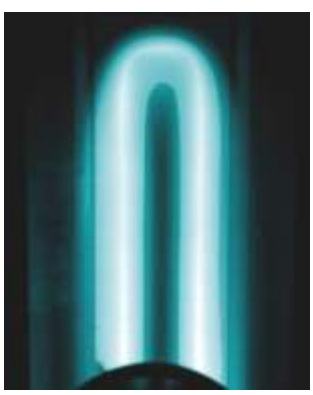
SPIK 3000A
Superior Plasma Instant Kinetics

Full Synchronization:
- HiPIMS & Mid.-freq.
- HiPIMS & rf 13.56 MHz
- BIAS rf 13.56 MHz

HiPIMS + rf 13.56 MHz combined on one Magnetron

NEW





Hybrid HiPIMS / rf plasma
using an aluminum target.
Fraunhofer-Institut für Werkstoffmechanik IWM
Wöhlerstraße 11, 79108 Freiburg

V2023 – European Society of Thin Films
September 18-21, 2023; Booth E4

ICMCTF 2023

HiPIMS 2023

Cutting-edge technology

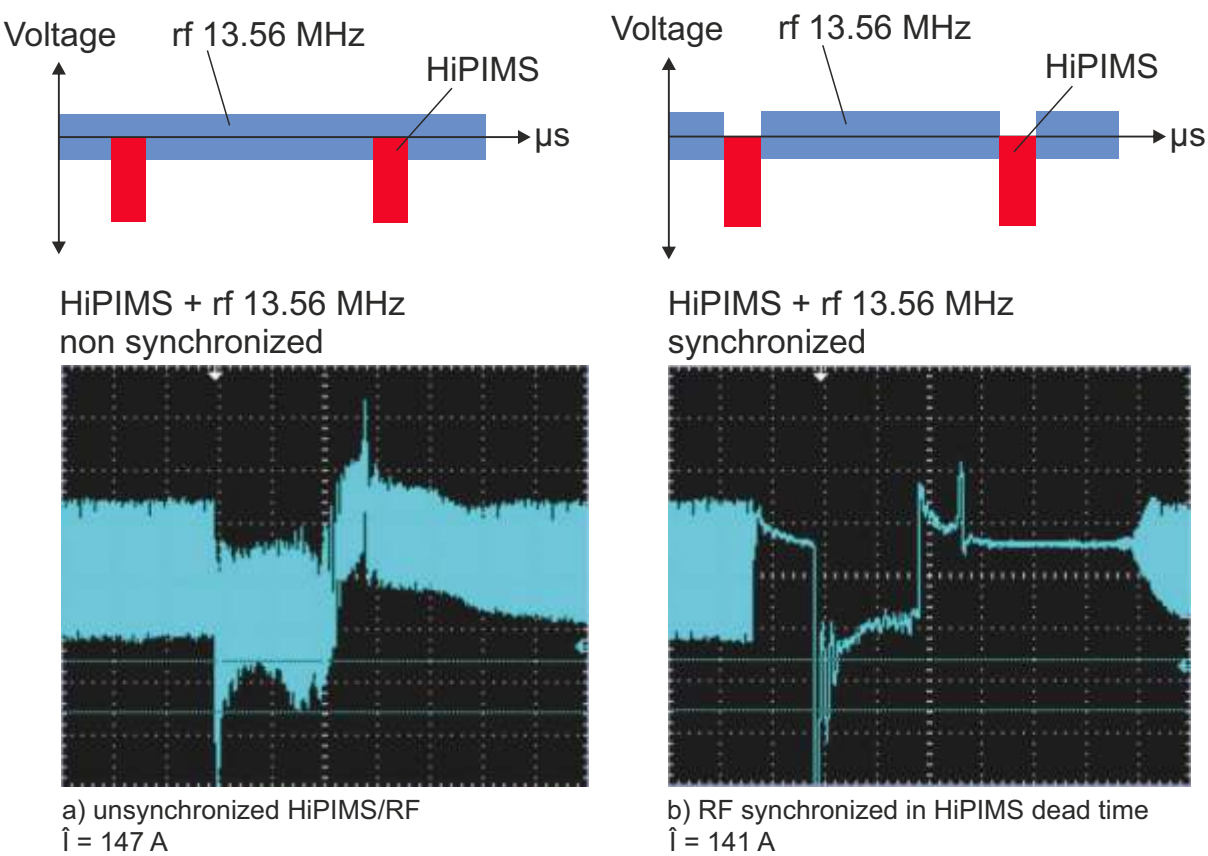
Hybrid HiPIMS/RF process on one magnetron

With the novel HiPIMS/RF process on only one magnetron, MELEC GmbH has gone beyond the known process using two cathodes. Two main objectives were to increase the deposition rate and enable more stable plasma condition, especially for reactive processes.

Technical features:

- freely selectable power ratio due to separate energy supply of RF (radio frequency, mostly 13.56 MHz) and HiPIMS (High Power Impulse Magnetron Sputtering)
- no pre-ionization pulse needed: RF plasma provides pre-ionization
- no dead time in deposition, higher deposition rates achievable
- higher HiPIMS currents at stable plasma conditions possible: stabilization by RF plasma
- RF generator often already available in coating laboratories

The RF excitation can be applied continuously or in synchronization in the dead time of the HiPIMS pulse.



a) unsynchronized HiPIMS/RF
Î = 147 A

b) RF synchronized in HiPIMS dead time
Î = 141 A

Figure 1: Hybrid HiPIMS/RF voltage as schematic and on the oscilloscope.

Reactive sputtering process

Reactive sputtering, especially of dielectric films, remains to be a challenge. The effects that occur, target poisoning and hysteresis, lead to a lower deposition rates and more difficult process stabilization.
For dielectric films, arcing is an issue. This can occur if charges accumulate on the dielectric film on the target, resulting in arcs that fling large amounts of target material onto the substrate. This can damage the growing film, creating a higher roughness, short-circuits in insulating films or reduced barrier properties.

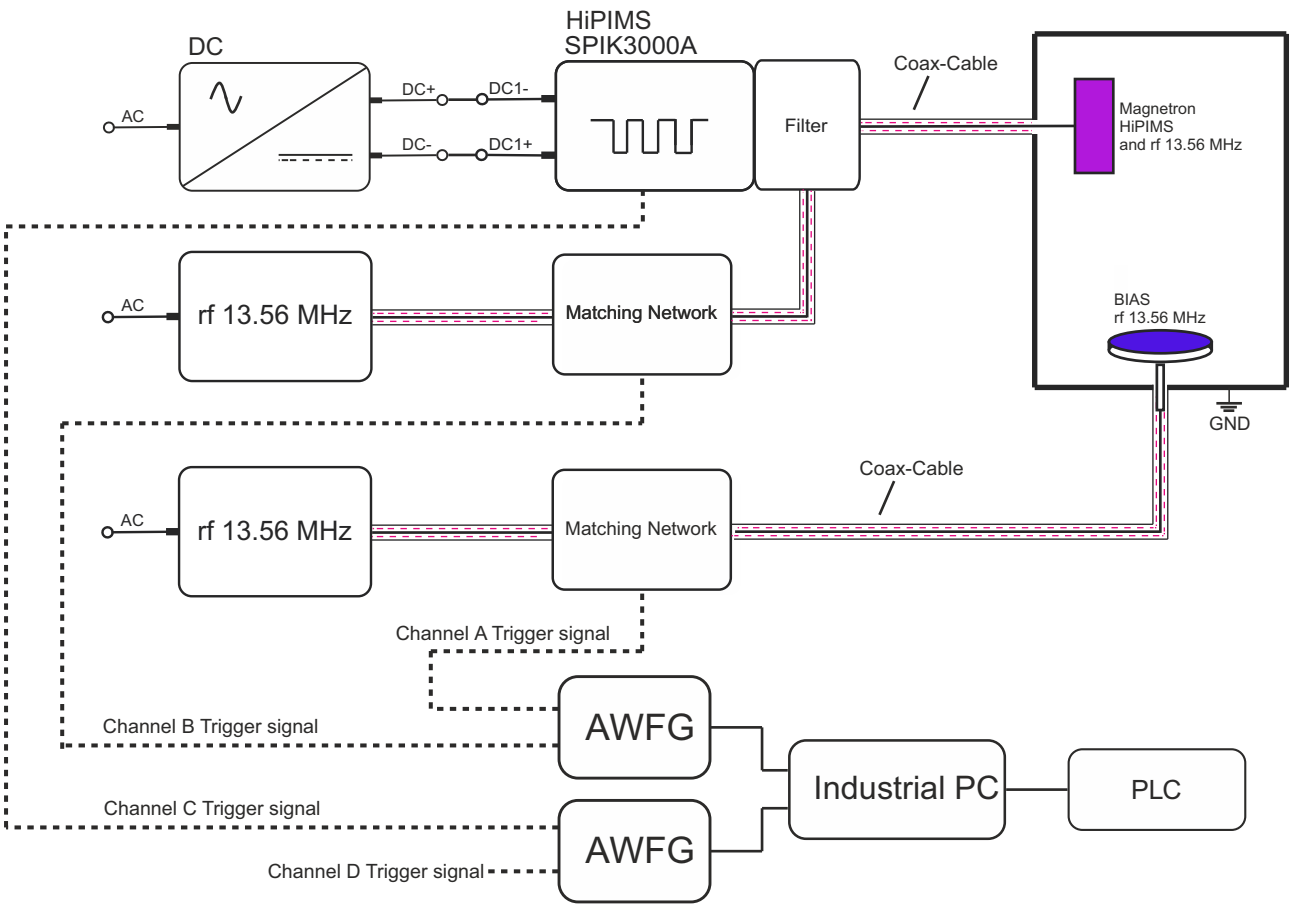
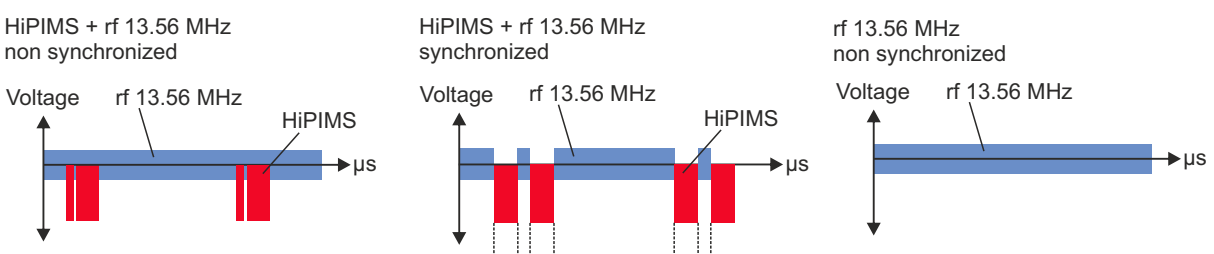


Figure 2

Magnetron:



BIAS:

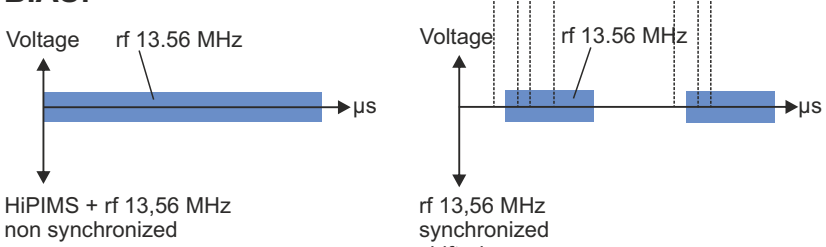


Figure 2: Example of full synchronization HiPIMS and rf 13.56 MHz and rf 13.56 MHz on BIAS

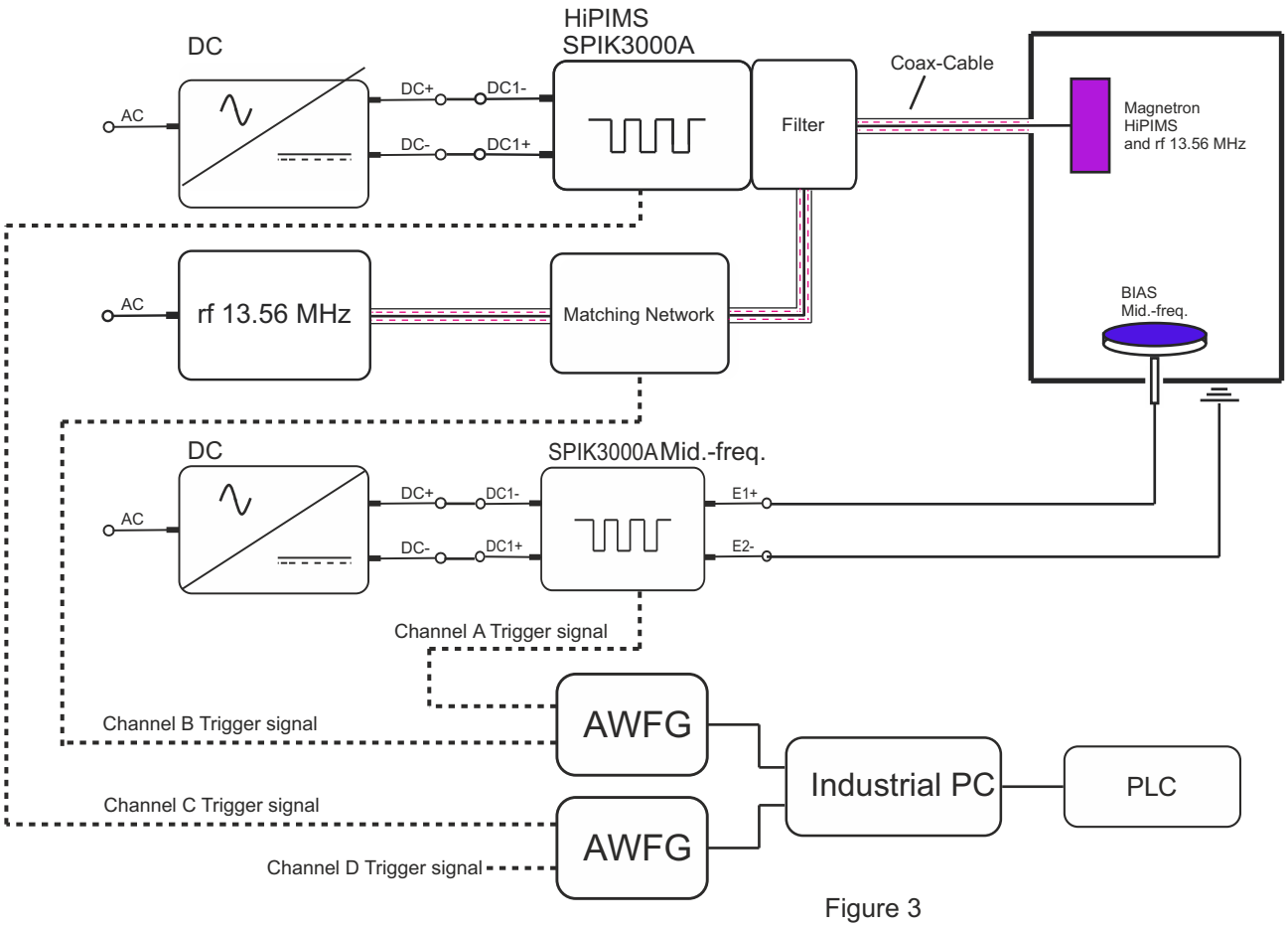
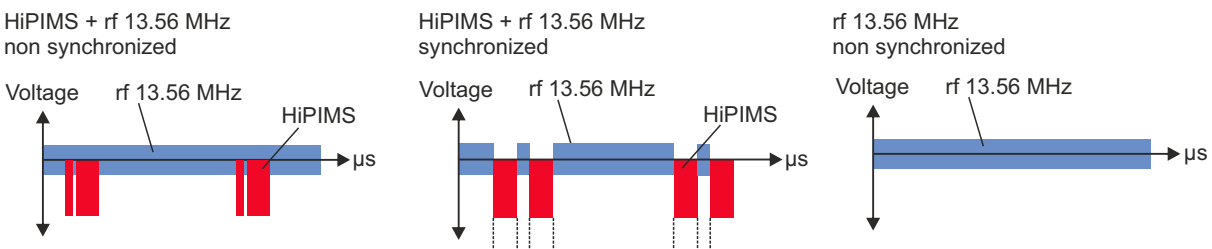


Figure 3

Magnetron:



BIAS:

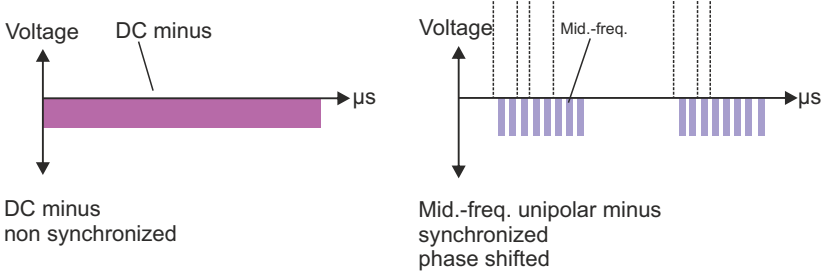


Figure 3: Example of full synchronization HiPIMS and rf 13.56 MHz and Mid.-freq. on BIAS

Potentials for thin film deposition

- higher deposition rate
- pre-ionization enables wider range of process parameters
- extended parameter space for tailoring coating properties/crystal structure
- effects on stress, stocheometry, hardness, barrier properties

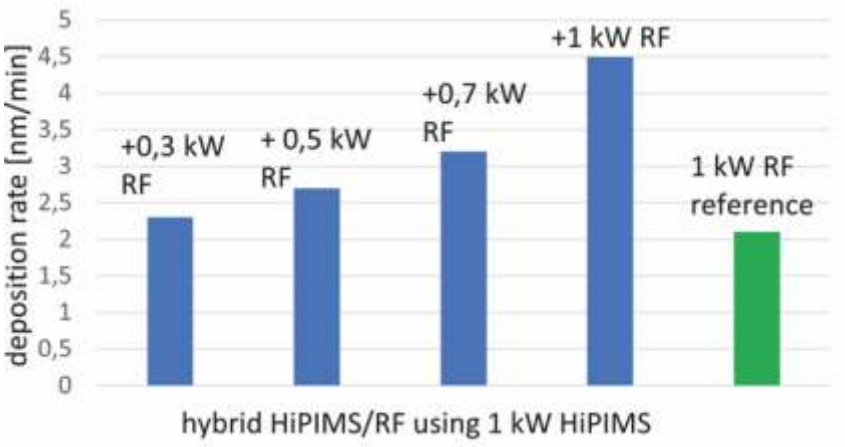


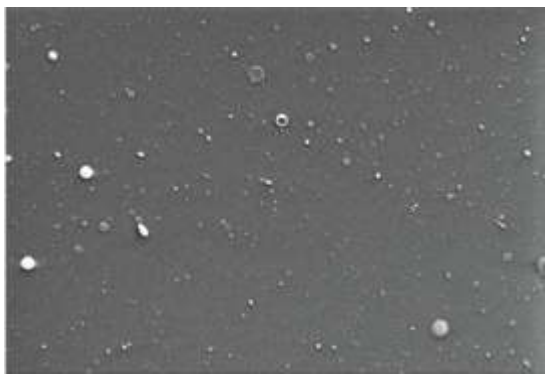
Figure 4: Deposition rates of a coating system in research. The HiPIMS power was kept constant at 1 kW with increasing RF power in the hybrid process. In addition, the RF reference process was performed at 1kW power.

Advantages of hybrid HiPIMS/RF sputtering one magnetron

· target is always sputtered; target poisoning can be reduced

· dielectric films: rf is bipolar process, can prevent arcing by regular discharge of dielectric films → droplet-free deposition

· more resource-efficient than other established configurations often used for process stabilization (dual setup with two cathodes, bipolar pulsing, complex plasma monitoring systems)



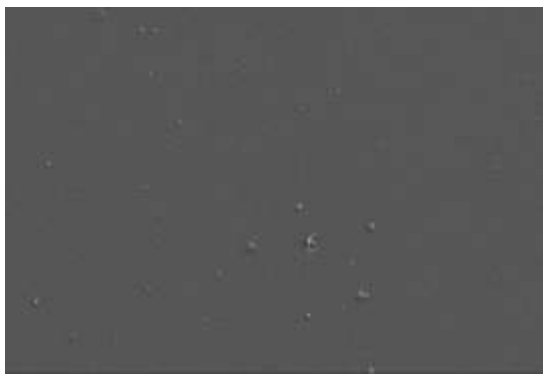


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Figure 5: SEM pictures of Al_2O_3 thin films deposited by reactive HiPIMS (left) and HiPIMS/rf (right). The reduced arcing due to the additional bipolar RF excitation of the plasma results in smoother films with less droplets.

Applications

· applications with temperature sensitive substrates (e.g. polymers)
· thin film sensors
· glass coating
· decorative coatings
· wear resistance coatings
· epitaxy at lower substrate temperatures
· isolation and barrier coatings (H_2)

Synchronized pulsed substrate bias

The physical background of this technology is based on the time dependence of the composition of the particle flux onto the substrate. That means that the ratio of argon ions, metal ions and reactive gas ions varies during the HiPIMS pulse. Using a pulsed substrate bias can cause either mainly Ar^+ or metal ion radiation of the growing film, resulting in changes of the film properties.

- substrate bias is applied in short pulses synchronized with the HiPIMS pulse with adjustable phase shift
- pulsed voltage can be either DC or RF (especially for dielectric substrates)
- can be used simultaneously with hybrid HiPIMS/RF excitation of the magnetron
- no constant etching (reduced deposition rate) as with continuous substrate bias

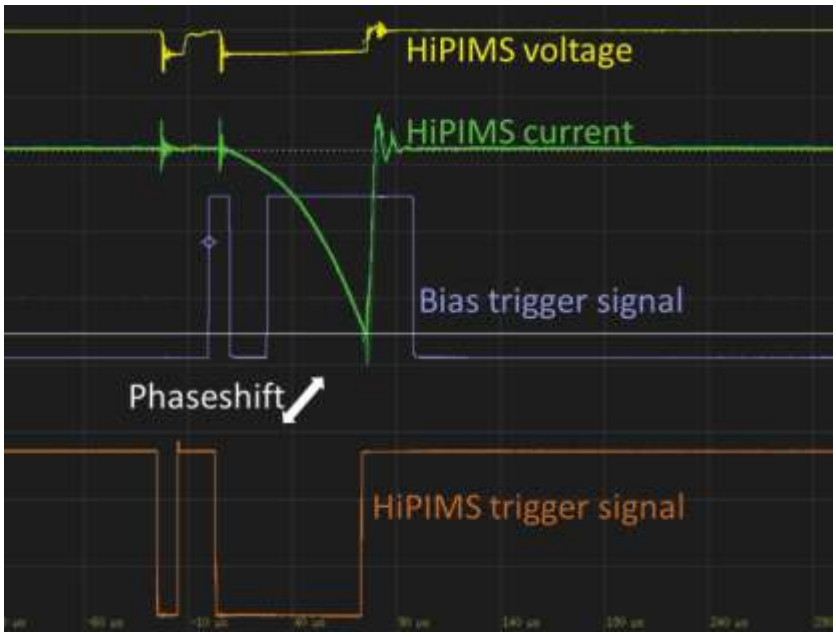

Figure 6: HiPIMS process with pulsed substrate bias on the oscilloscope, showing the trigger signal for HiPIMS and Bias pulse as well as the measured HiPIMS voltage and current. The pulses consist of a short pre-ionization pulse (10 µs on / 10 µs off) and the main pulse (75 µs on / 2500 µs off). The peak current density is here 0.4 A/cm^2, peak voltage 450 V .

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Influence on coating properties can be: densification, increased crystallinity/changes in crystal structure, low-temperature epitaxy possible, higher hardness, lower stress.

Synchronization of Superimposed Pulse Power Technology with MELEC GmbH SYNC SOFTWARE

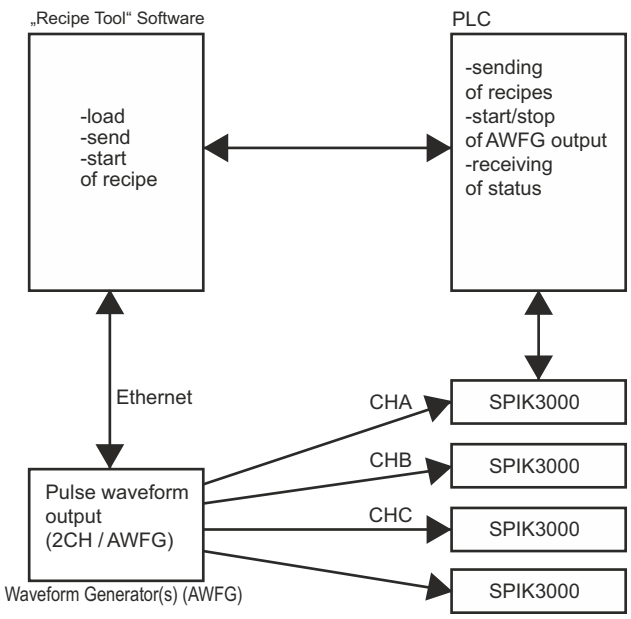


Figure 7

The SYNC system is designed to synchronize up to eight pulse devices using arbitrary function generators (AWFG). The AWFGs are controlled using the recipe tool software, which forms the link between the PLC and the AWFG. The pulse pattern is created using the Pulse Editor software.

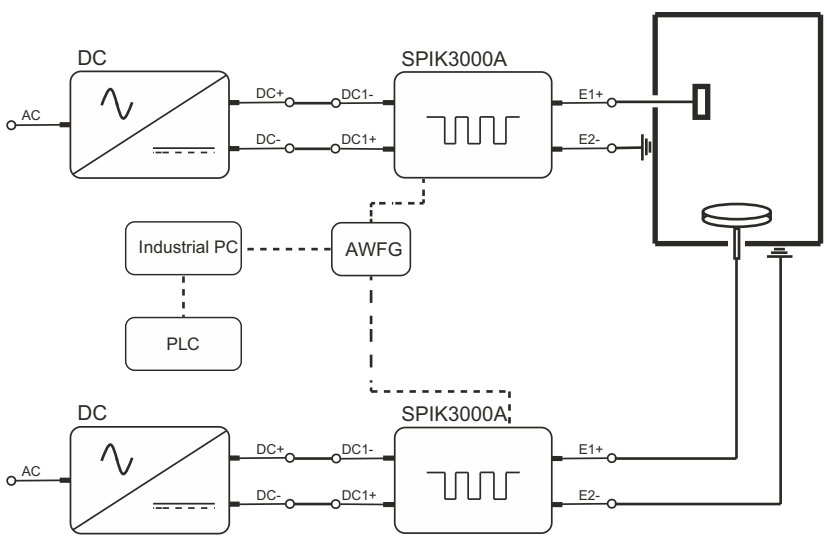


Figure 8

Figure 8 shows a HiPIMS set on a single magnetron with a pulsed BIAS supply which can be freely triggered by means of the synchronization unit using the MELEC GmbH SYNC software.

With non-conductive substrates, a triggerable rf power supply (13.56 MHz) can be used for the BIAS instead of the SPIK3000A-EF-05.

At the beginning of the HiPIMS pulse, gas IONS are predominantly present and afterwards the sputtered metal ions are formed.

When switching on the BIAS trigger signal with delay after the HiPIMS trigger signal, a decrease in gas content can be proven in the PVD layer.

Figure 9: Fully synchronized Bias Basic Form

Figure 10: Synchronized Bias + Delay

Example of PVD Coating System

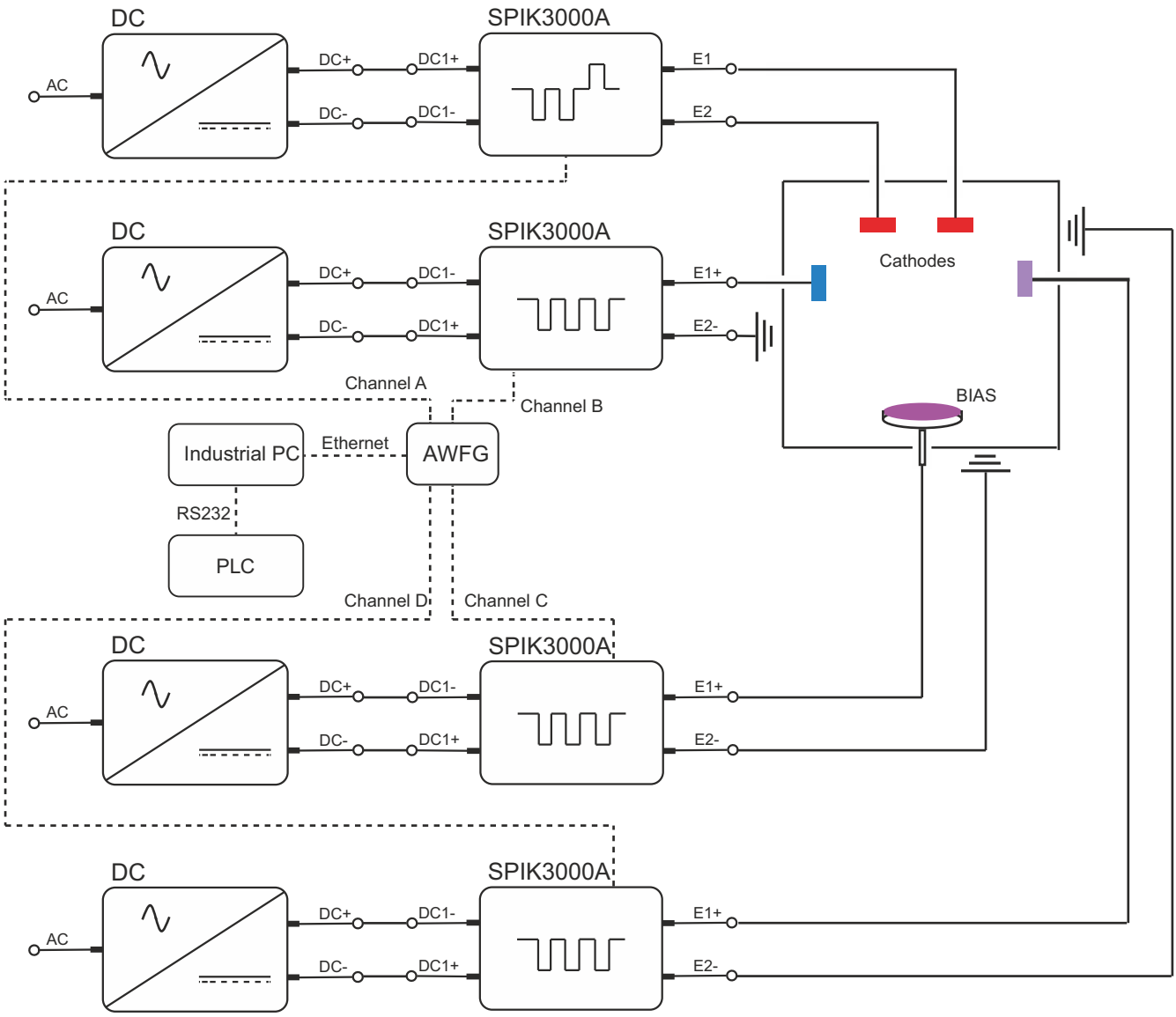


Figure 11

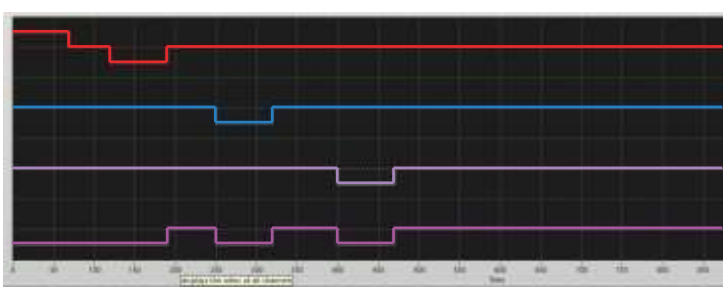


Figure 12

Figure 11 shows a PVD device with two single magnetrons and one dual magnetron system and a pulsed BIAS power supply. All magnetrons are operated using a trigger system in HiPIMS mode.
A phase shift of HiPIMS pulses may be necessary not to overload the BIAS power supply.
Other applications could be for example co-sputtering or combinations with HiPIMS and Mid-frequency.

Superimposed Pulse Power Technology
HiPIMS + Mid-Freq. (25/50 kHz)

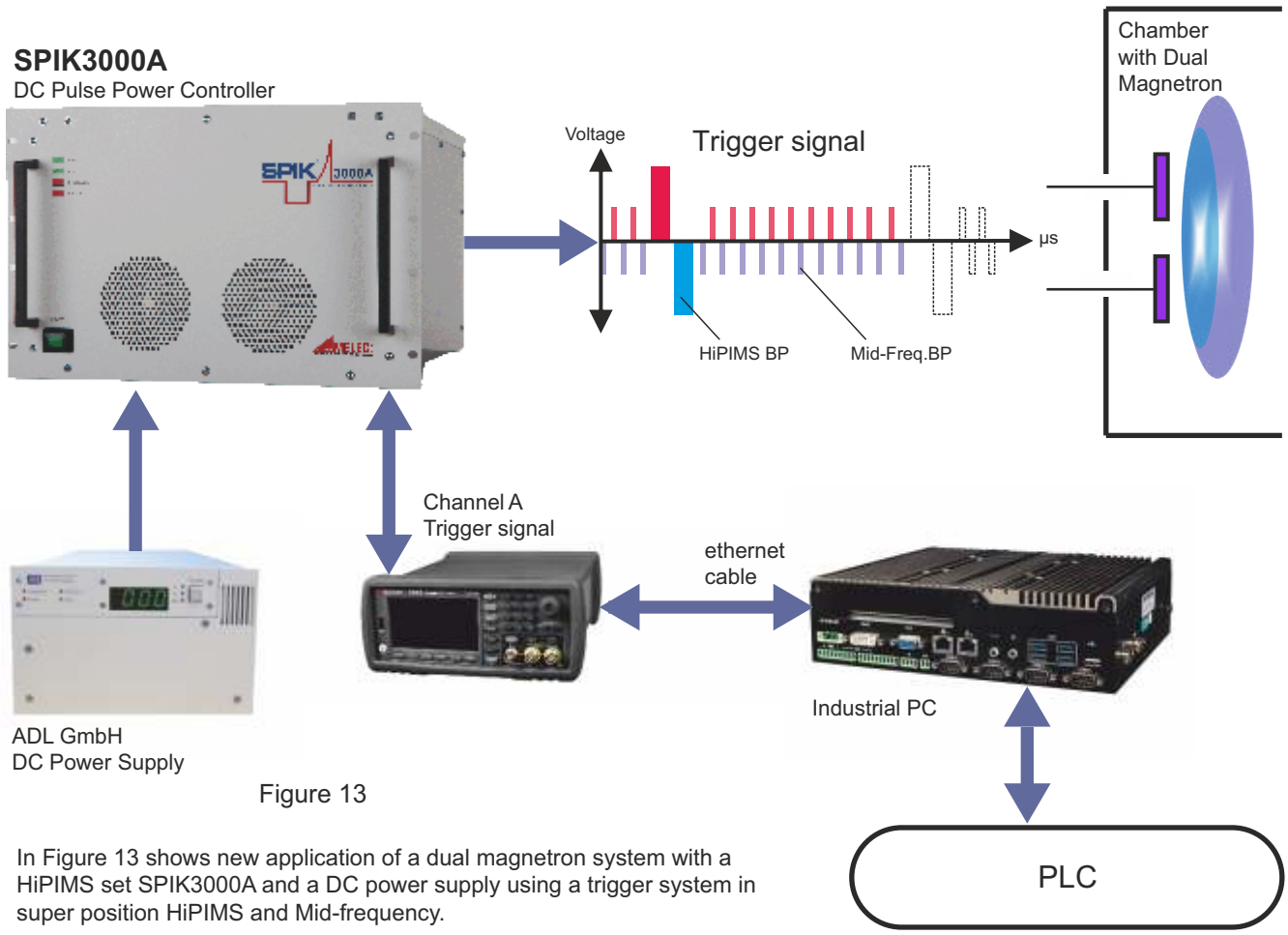


Figure 13

In Figure 13 shows new application of a dual magnetron system with a HiPIMS set SPIK3000A and a DC power supply using a trigger system in super position HiPIMS and Mid-frequency.

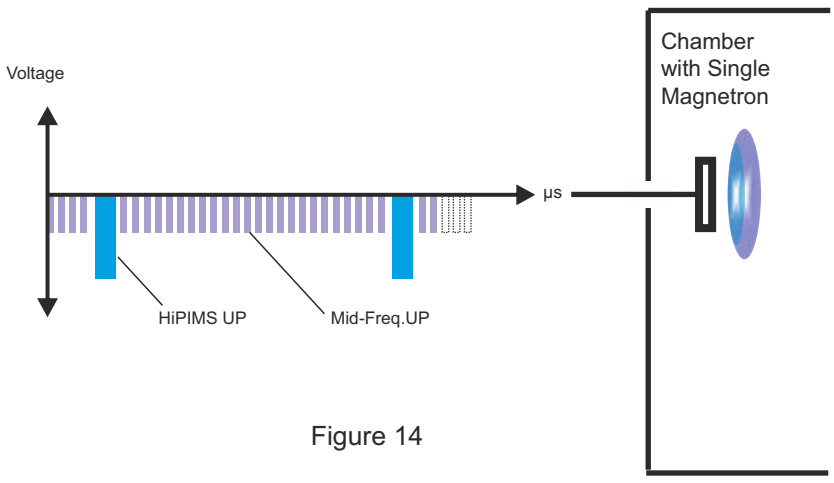


Figure 14

Advantages of SIPP-HiPIMS Technology unipolar and bipolar pulsing:

- highest deposition rate
- reduce/prevent arcing/poisoning
- highest process stability
- tuning
- reproduceable
- low cost retrofit applications

Improvements of SIPP-HiPIMS Technology unipolar and bipolar pulsing:

- higher ion bombardment
- better coating adhesion
- harder coating
- denser films
- Thin film structure is easily controllable in SIPP Technology

SPIK3000A HiPIMS DC Power Controller

SPIK3000A: HiPIMS 5kW – 30kW, 60kW, 90kW

Applications:

- HiPIMS
- HiPIMS + MF
- HiPIMS + Bias
- Bias (unsynchronized)
- Pulsed DC
- Plasma CVD
- Plasma Diffusion
- Plasma Nitriding
- Plasma Etching
- Plasma Cleaning
- Plasma Electrolytic Oxidation PEO

Features:

- DC – 25/50kHz pulse frequency range
- Fast arc detection and suppression less than 2 µs
- Pulse on-time 5µs – 16ms
- Pulse off-time 5µs – 32ms
- Output modes: DC-, UP+, UP- and BP
- Symmetric voltage output
- FPPG (Free Pulse Pattern Controller up to 8 pulses)
- 2 x Trigger output / 1x Trigger input
- Water cooled
- 19“ 7U Rack Mount
- Remote interface (Profibus / RS485)

Type	DC Power (kW)	DC Voltage (V)	DC Current (A)	Pulsed Peak Power (kW)	Frequency range
A-05-EF	5 kW	1000 V	10 A	500 kW	DC – 50kHz
A-10	10 kW	1000 V	25 A	1000 kW	DC – 25kHz
A-20	20 kW	1000 V	35 A	1000 kW	DC – 25kHz
A-30	30 kW	1000 V	50 A	1000 kW	DC – 25kHz

ADL GmbH DC Power Supply
GS – Type: 0.5kW – 3kW

Features:

- Output power 0.5 -3.0 KW
- Air cooled
- ½ 19″–case, 3 HU
- Interchangeable Interfaces
- Display for voltage, current and power
- Manual operation via frontpanel
- Automatic Arc Handling

ADL GmbH DC Power Supply
GX – Type: 5kW – 15kW

Features:

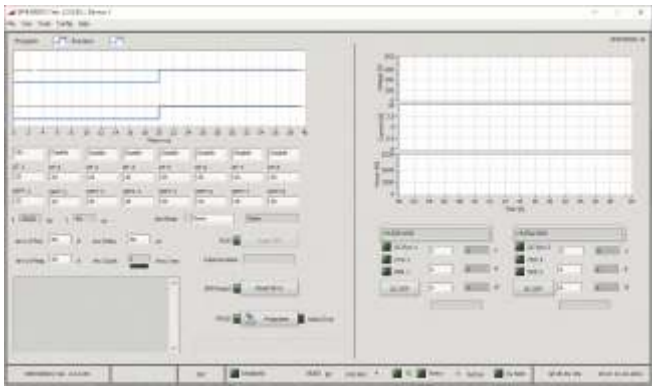
- Output power 5 – 15kW
- Water cooling
- ½ 19″–case, 3 HU
- floating output
- Display of actual value for U,I or P
- Automatic Arc Handling

ADL GmbH DC Power Supply
HX – Type: 15kW – 35kW

Features:

- Output power 15 kW – 35 kW
- Parallel operation up to 280 kW
- Water cooling
- Magnetic valve control
- Housing ventilation with integrated particle separator
- ½ 19”- case, 5 HU
- Flange mounting
- M8-female thread for crane eye
- Replaceable, rotatable display
- Automatic Arc Handling

MELEC GmbH
SPIK3000A-CC Software



MELEC GmbH
Measurement System

Features:

- U Ratio: 0V-1000V = 0V-5V attenuation: x200
- Voltage BW: DC-300kHZ
- I Ratio: 0A-500 A / 1000A = 0V-5V attenuation: x100 (500A) / x200 (1000A)
- Current BW: DC-200kHZ
- 1 U/125mm depth
- TB (Terminal Box) include voltage and current transducer (option)

Figure 15: Single magnetron, unipolar pulsing

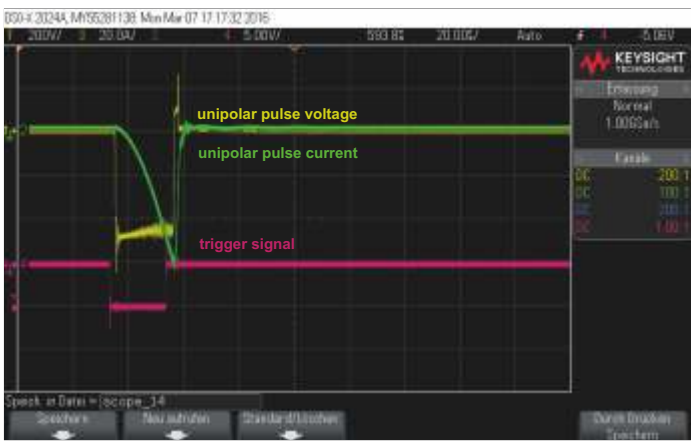


Figure 16: Single magnetron,
unipolar pulsing with pre ionisation

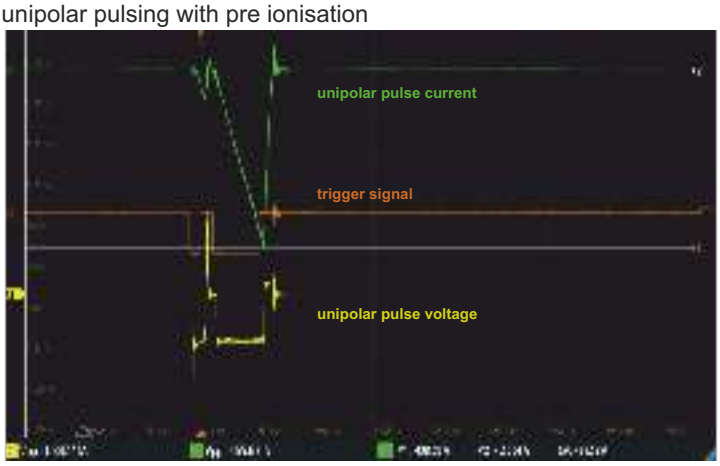


Figure 17: Two single magnetrons, unipolar pulsing

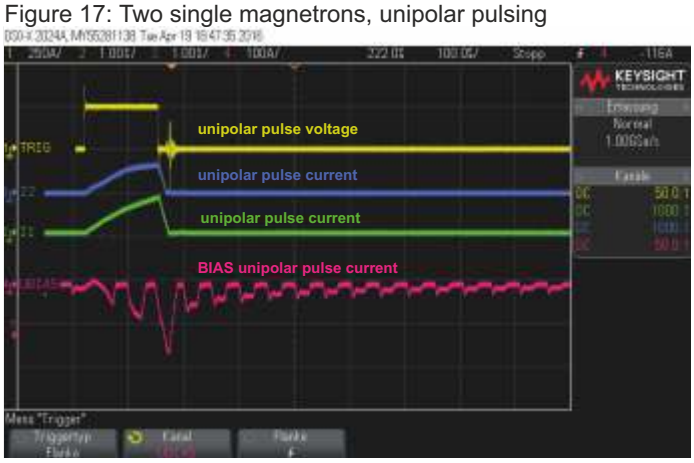
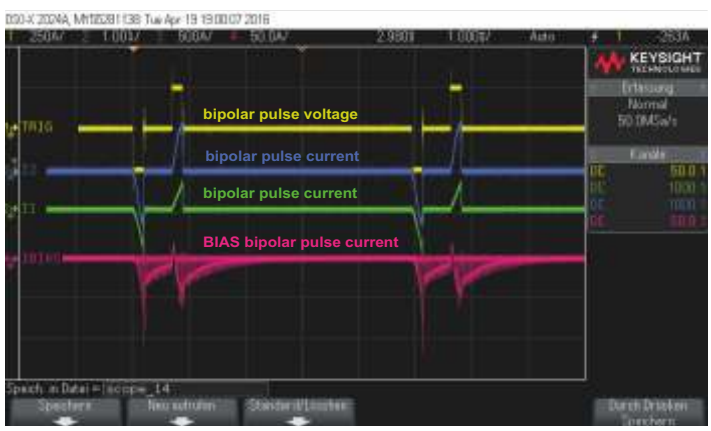


Figure 18: Dual magnetron, bipolar pulsing



Sales and distribution

Europe & USA

MELEC GmbH

Dr.-Rudolf-Eberle-Str. 27
76534 Baden-Baden, Germany
Phone: +49 7223 28 14 5 – 01
Fax: +49 7223 28 14 5 – 09
Email: info@melec.de
Web: www.melec.de

Contact Person:
Mr. Günter Mark
Phone: +49 7223 28145 – 10
Email: guenter.mark@melec.de

China

Shanghai Triplewins Vacuum Technology Co., Ltd

Contact person: Lane Bao
Address: 7th Floor No 14#,Mindong Road 166,
Pudong,201209,Shanghai PRC
Mobile:0086-186 2191 7013
Wechat: 186 2191 7013
Email:sales@www-vacuum.com
Website: www.www-vacuum.com

Contact person: Lane Bao

Taiwan (R.O.C.)

Shen Chang Electric Co. LTD

114-1 Sagueirou Shan, Tamsui Dist.,
New Taipai City 25144, Taiwan (R.O.C.)
Phone: +886 2 2621 7650
Fax: +886 2 2623 5967
Email: sales@shenchang.com.tw
Web: www.shenchang.com.tw

Contact Person:
Mr. William Lin
Phone: +886 2 2621 7650 – 73
Email: williamlin@shenchang.com.tw

Korea Republic(R.O.C.)

ABM Co., Ltd.

89 Asanvalley-ro, Dunpo-myeon,
Asan-si Chungcheongnam-do,
31409 Korea
Phone: +82 41 546 8370
Fax: +82 41 546 8371
Email: sales@abmkorea.com
Web: www.abmkorea.com

Contact Person:
Mr. Nick Changwoan Noh
Mobile: +82-10-8514 1151
E-mail: cwnoh@abmkorea.com

India

3S Vactec LLP

21, Vaibhav Jasmine G-1, 13th Main,
Saraswathingagar Bengaluru,
560 040 India
Phone: +91 9740 92 3131
Email: srk@3svactec.com
Web: www.3svactec.com

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