

MELEC's PULSE BOOK

circuits and applications

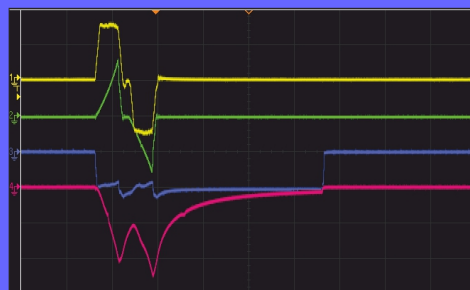
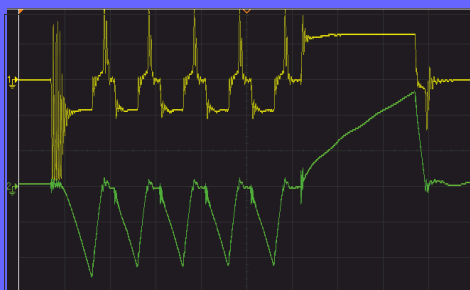
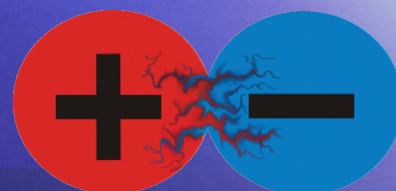
first EDITION, June 2014

DC Pulse Power Controller for synchronized pulse applications:

- HiPIMS
- Mid Frequency
- Pulsed Bias

Superimposed Processes:

- HiPIMS + DC
- HiPIMS + MF
- HiPIMS + MF + Pulsed Bias



Company



Located in south Germany, MELEC produces and develops since 1998 DC-Pulse-Controller for plasma applications. With the experience of more than 15 years in power electronics and thin-film technology, MELEC sets standards in R&D and industrial applications.

MELEC products are utilized for the generations of highly ionized plasma discharges, often called “High Power Impulse Magnetron Sputtering” or HiPIMS. Our generators have become the standard tool for customers to meet their demanding requirements for pulsed plasma applications. They are designed for the future, having great flexibility and process robustness in mind. The integrated Free-Pulse-Pattern Generator (FPPG) makes it possible to develop, adjust and stabilize wide ranges of innovative processes.

Based on its international patents, MELEC is involved in various publications resulting from cooperation's with a large number of well-known research institutes and universities.

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Some projects and collaborations
were supported by



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MELEC`s Know How Fits Customers Needs

Consulting

MELEC provides products for high performance pulse-power-applications but also plasma consulting for research and development of industrial applications worldwide.

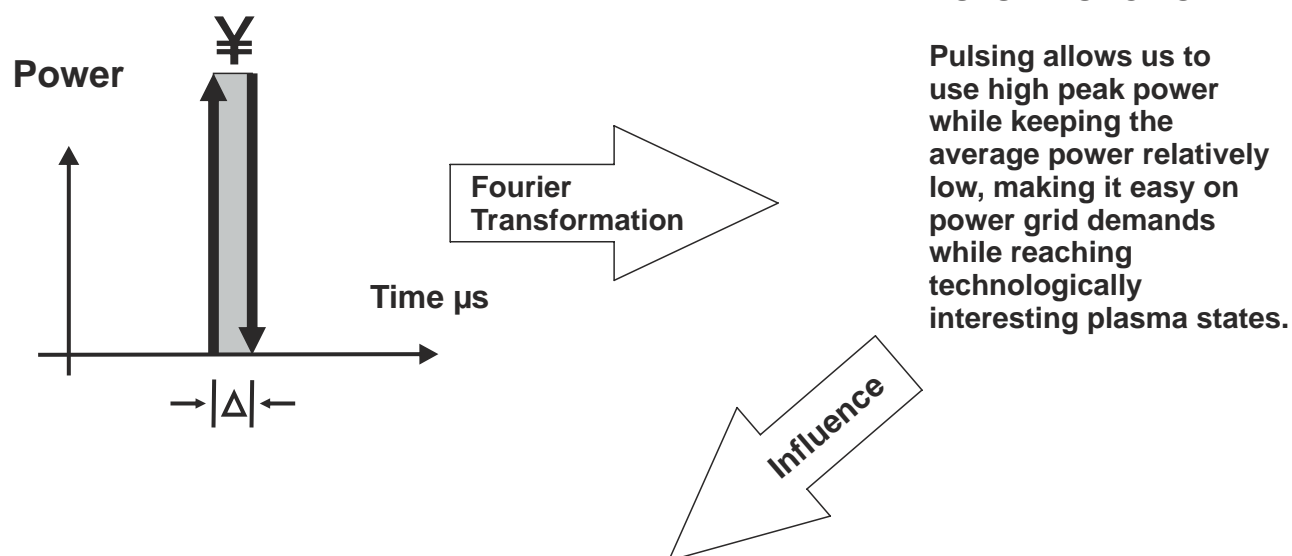
Our Mission

MELEC`s SIPP-Technology (Superimposed Pulse Power-Technology) using HiPIMS (High Power Impulse Magnetron Sputtering) combined with DC, Mid-frequency or radio frequency 13.56 Mhz (bias) opens a new horizon in pulse plasma technology. The development of MELECs pulse power controller continues and is focused on advanced technology to create new additional features and advantages.

Our Quality Aspirations

MELEC is a synonymous for quality meeting a high level of expectations. Our goal is to be a reliable business base for our customers by providing and implementing innovative pulse-plasma-solutions centered around our SIPP Technology. We arrive at those solutions in close collaboration and ensure that solutions are sustainable and robust.

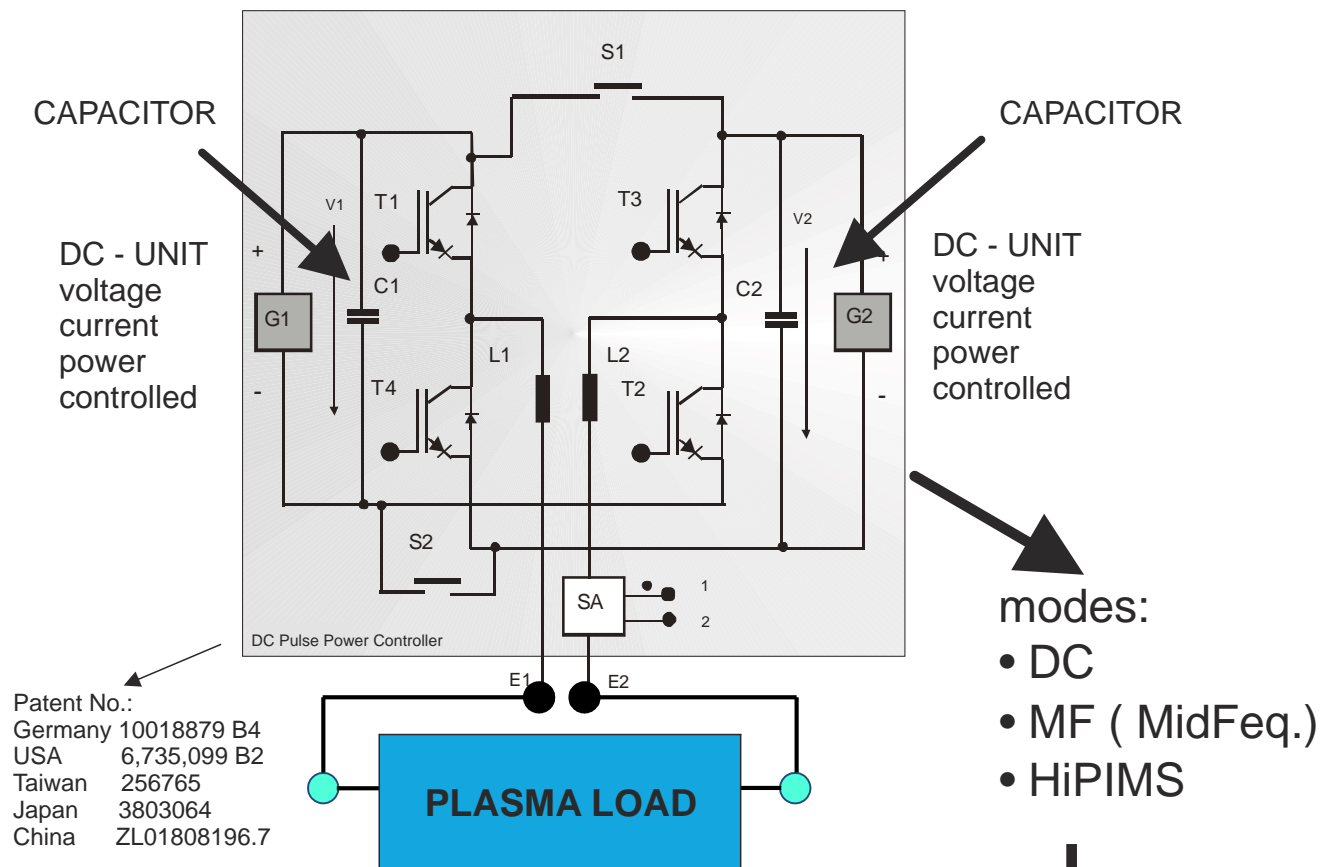
Our Philosophy About High Pulse Power Plasma Implementation



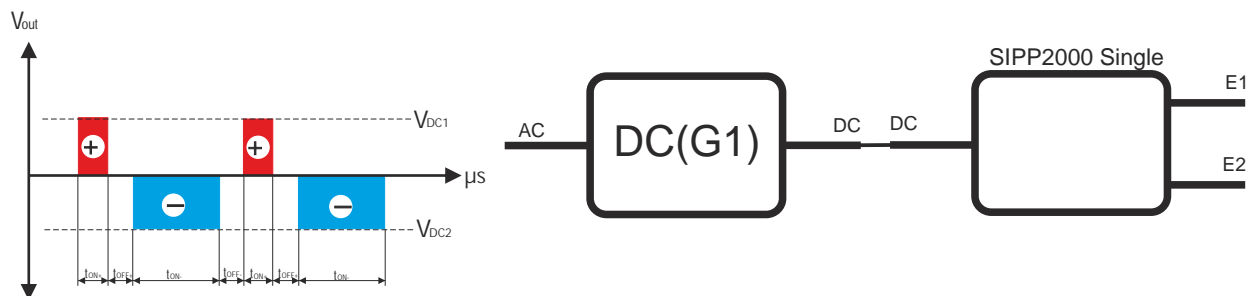
THIN FILM PROPERTIES

Advantages

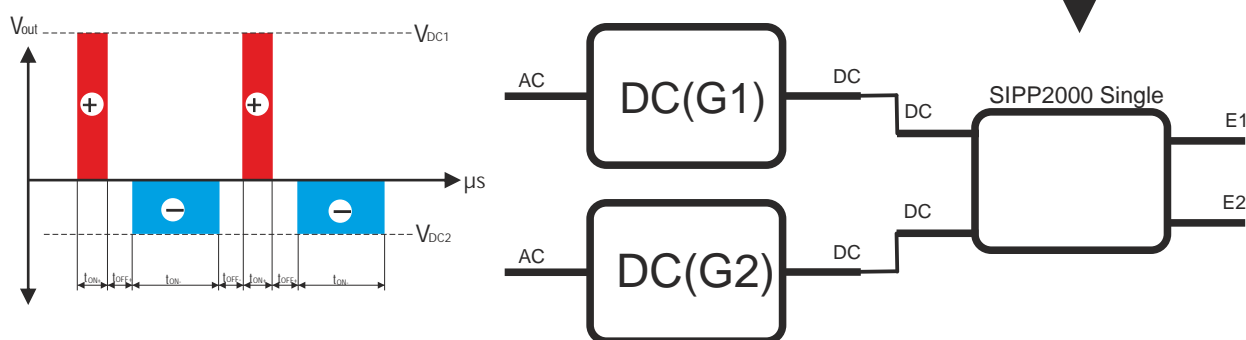
Symmetric / Asymmetric bipolar pulse pattern



SYMMETRIC: S1/S2 closed - G1 only



ASYMMETRIC : S1/S2 open- G1/G2



Single or Dual Magnetron applications

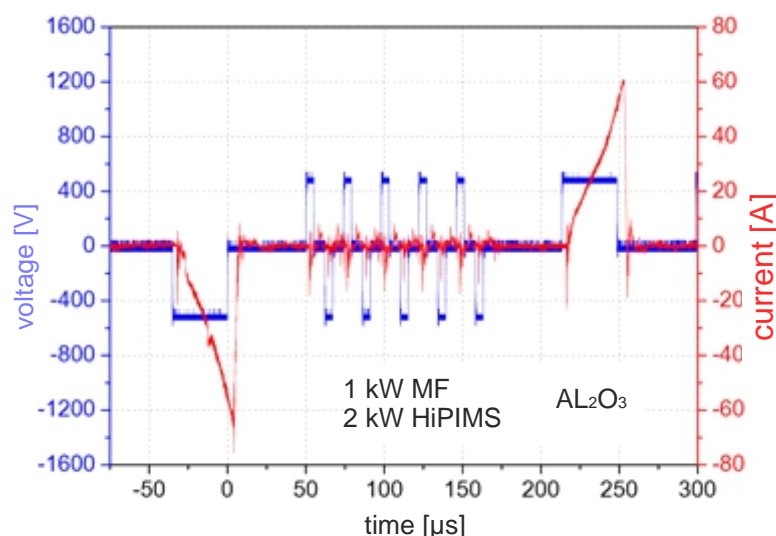
Applicable to CO – SPUTTERING (different target materials)

DC , unipolar , bipolar pulse patterns.

Pulse patterns are freely adjustable for both positive and negative pulse parameters through a graphic user interface of the interactive software.

MELEC's SIPP – Technology

- Highest deposition rate using HiPIMS combined with DC or Mid-Frequency so called **SIPP** – Technology **S**uper **I**mposed **P**ulse **P**ower Technology.
- Opens new horizons in pulsed plasma technology.
- Reducing of ARCING using pulse package mode instead of pure HiPIMS–mode only.
- Avoidance and prevention of poisoning using HiPIMS–BP combined with Mid-Frequency-BP



Superimposed bipolar HiPIMS (BP) and bipolar MF

Separation of metal and gas ions:

Synchronization or phase shift of pulsed bias voltage in relation to the HiPIMS Pulses – large power applications are ready utilizing to separate metal- and gas-ions treatment.

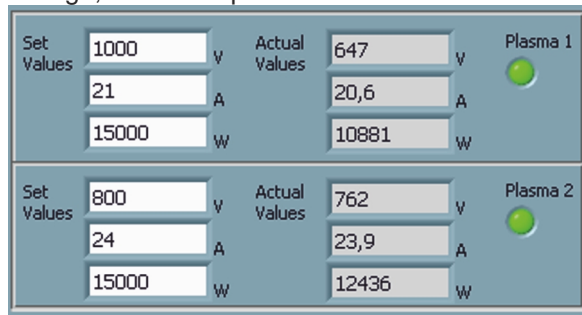
Synchronization or phase shift of pulsed radio frequency 13.56 MHz voltage in relation to the HiPIMS pulse. First tests were done with several 100 Watts on a laboratory PVD coater. This process is still under development.

Closed loop control

External pulse pattern input on each channel of the MELEC pulse power unit using for a closed loop control is possible. For example using an external OES-System, etc.

Software Modules of SIPP2000_USB Version using LabView

DC 1, DC 2 controlled by setting values of voltage, current or power



Features of software:

Full control of HiPIMS Pulse Unit

- Interactively configurable pulse waveform
- Saving and loading of pulse waveforms
- Freely adjustable arc management
- Monitoring of all status signals

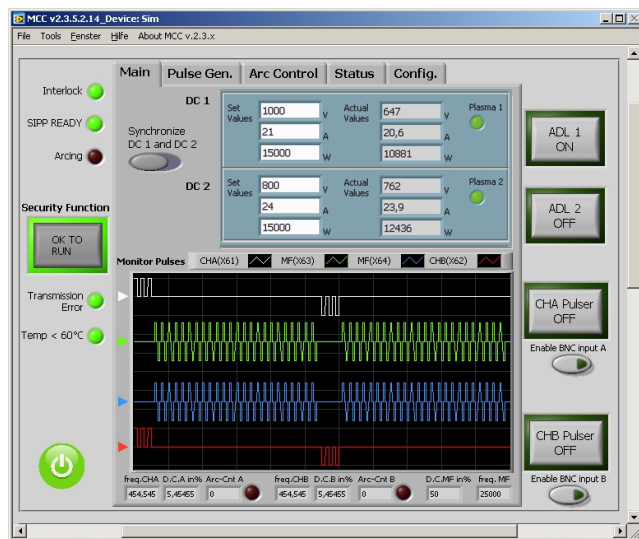
Synchronized pulse generation output for external triggering of additional MF unit

Full control of ADL GmbH DC-Units or alternatively PNCL DUAL® DC-Units

- Symmetric ON-OFF of two DC-Units
- Set point for voltage, current and power
- Reading of DC-Unit working parameters

Industrial security functions

- Control software runs on Windows XP or higher versions



DC 1 ON/OFF

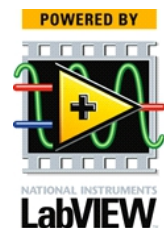
DC 2 ON/OFF

Pulse Channel A ON/OFF

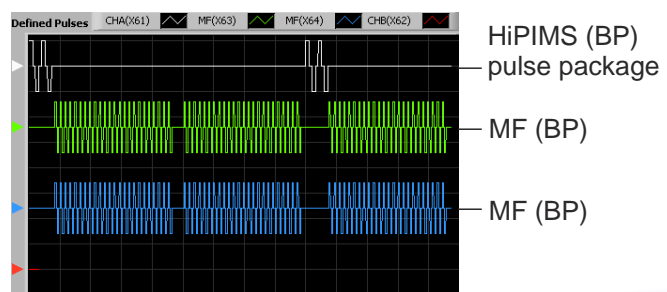
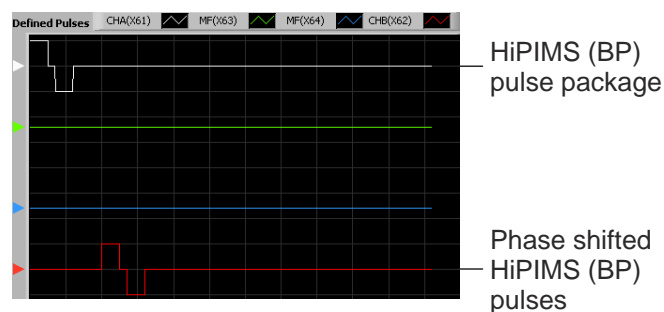
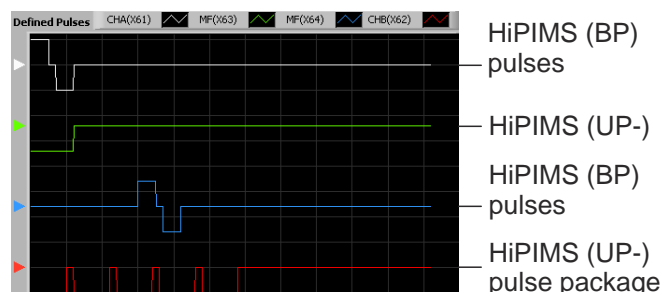
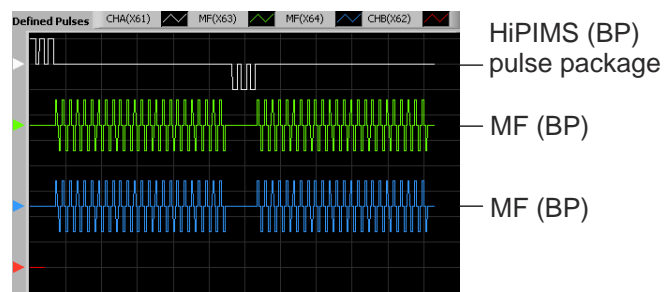
Enable external pulse pattern Channel A

Pulse Channel B ON/OFF

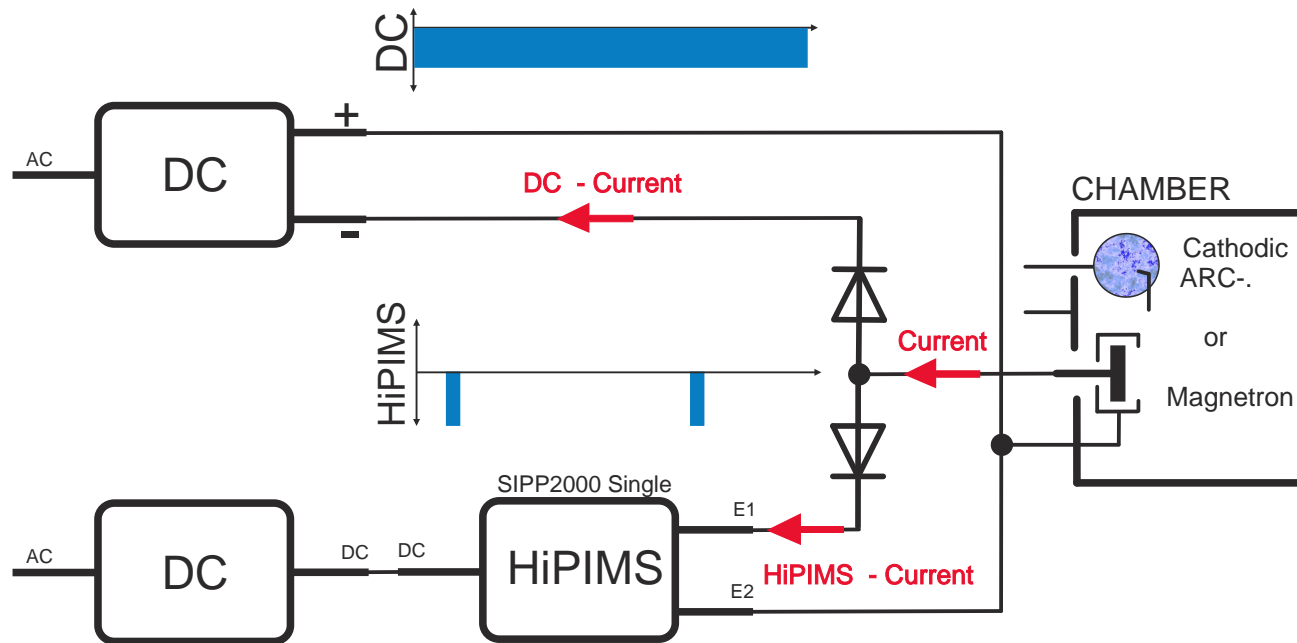
Enable external pulse pattern Channel B



Example:



Superimposed DC / unipolar HiPIMS (UP) using Single Magnetron and Cathodic Arc

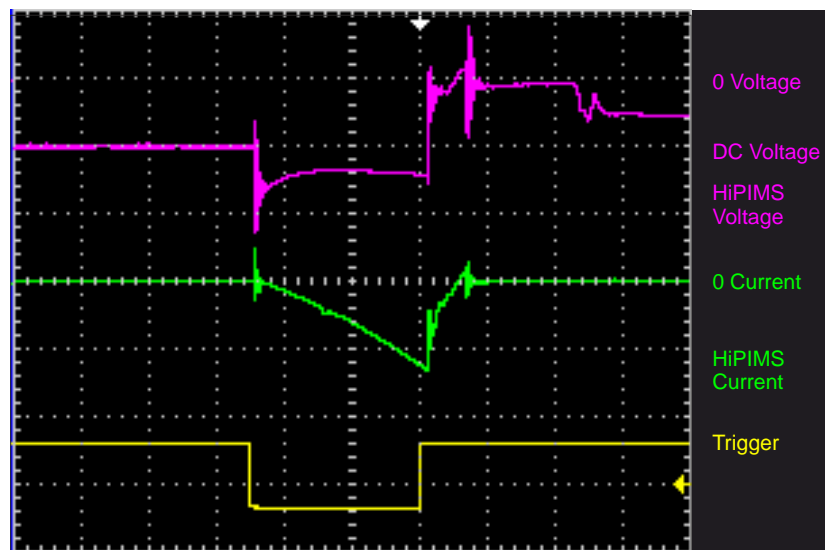


EXAMPLE OF APPLICATIONS:

- Large area coating on glass
- Retrofit of existing inline coating systems
- applicable using single magnetron or cathodic arc deposition

ADVANTAGES:

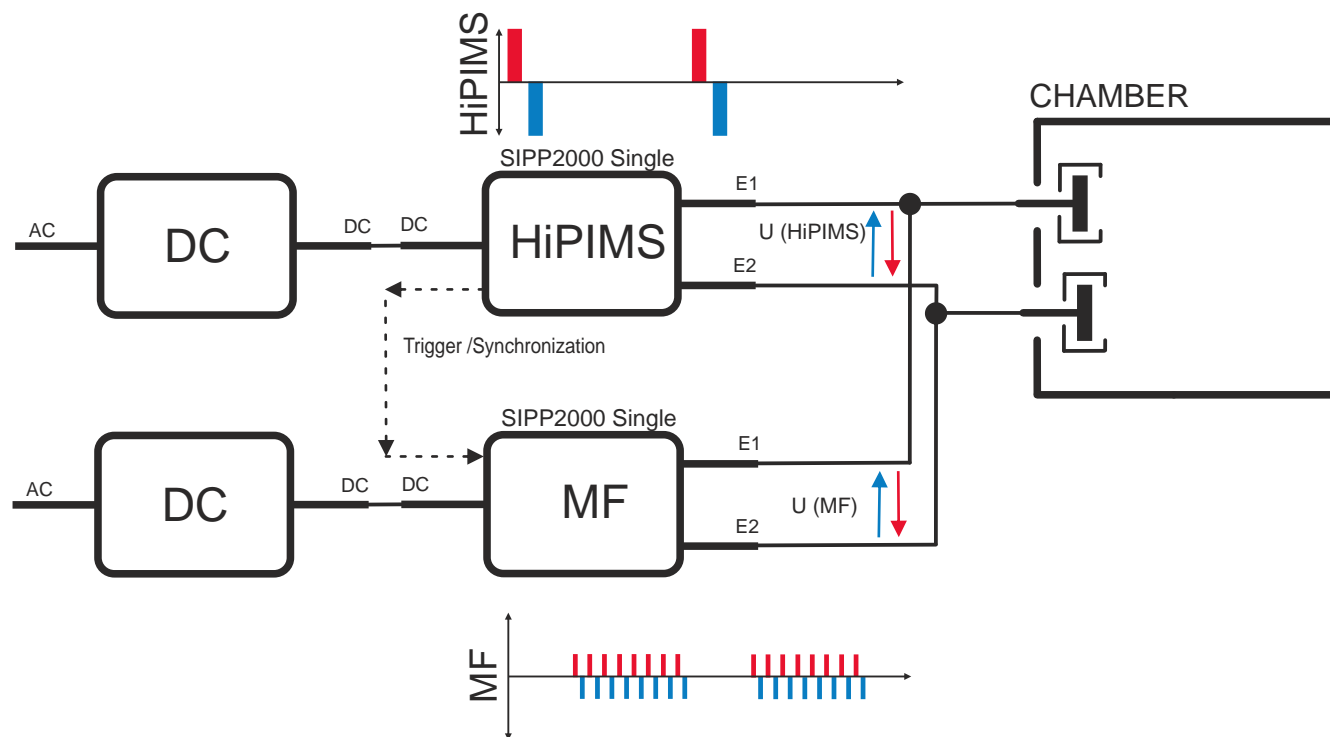
- Superimposed DC/HiPIMS(UP) with high depositions rate
- Smoother and denser films compared to DC sputtering
- low cost of retrofit
- easy control of single pulse or pulse packages



HiPIMS and DC

Patent Pending

Superimposed bipolar HiPIMS (BP) / bipolar MidFreq. (MF)



EXAMPLE OF APPLICATIONS:

- Large area coating on glass

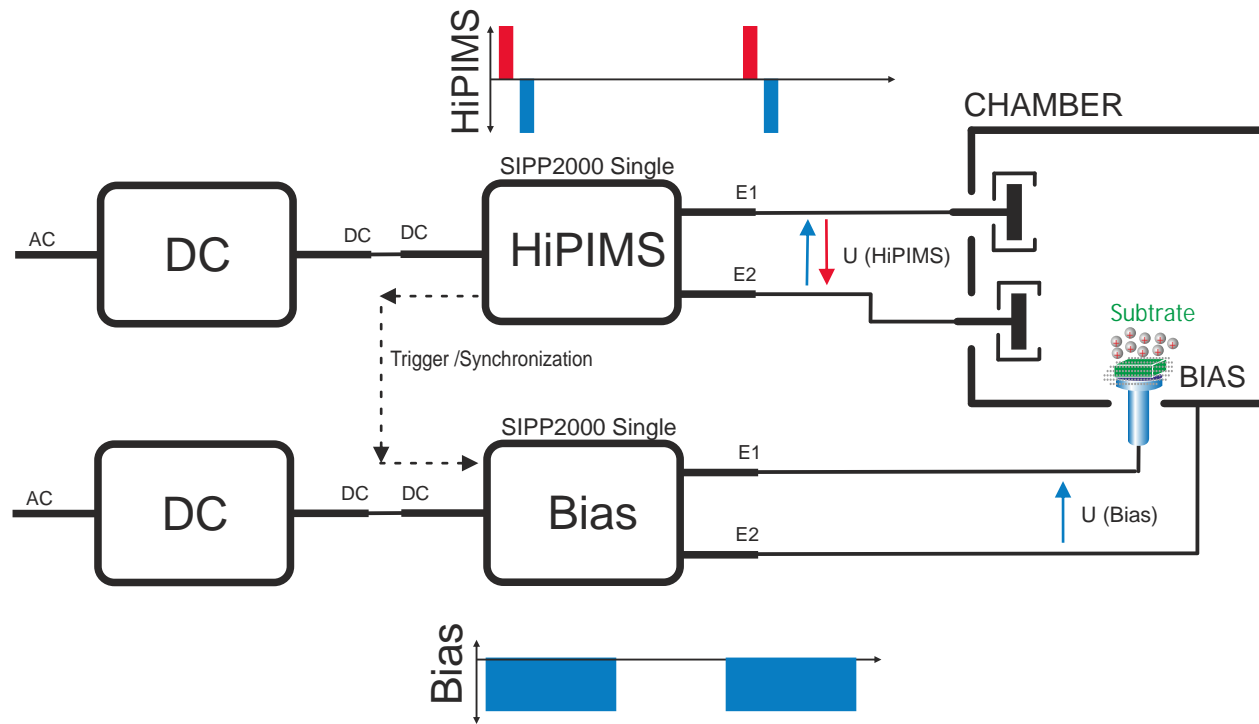
ADVANTAGES:

- Superimposed bipolar HiPIMS / bipolar Mid frequency (BP / MF) (MF-BP) with high depositions rate
- New pocess options
- Stable coating process
- Preventing of arcing and poisoning by control of bipolar Mid frequency (MF)



Patent Pending

Bipolar HiPIMS (BP) and unipolar pulsed synchronized bias using conductive substrate

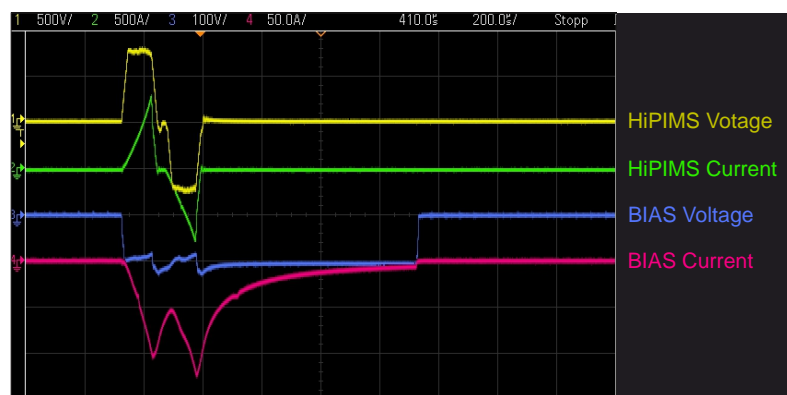


EXAMPLE OF APPLICATIONS:

- Hard and decorative coating using synchronized MF(UP) bias
- Synchronized or phase shifted to HiPIMS pulses

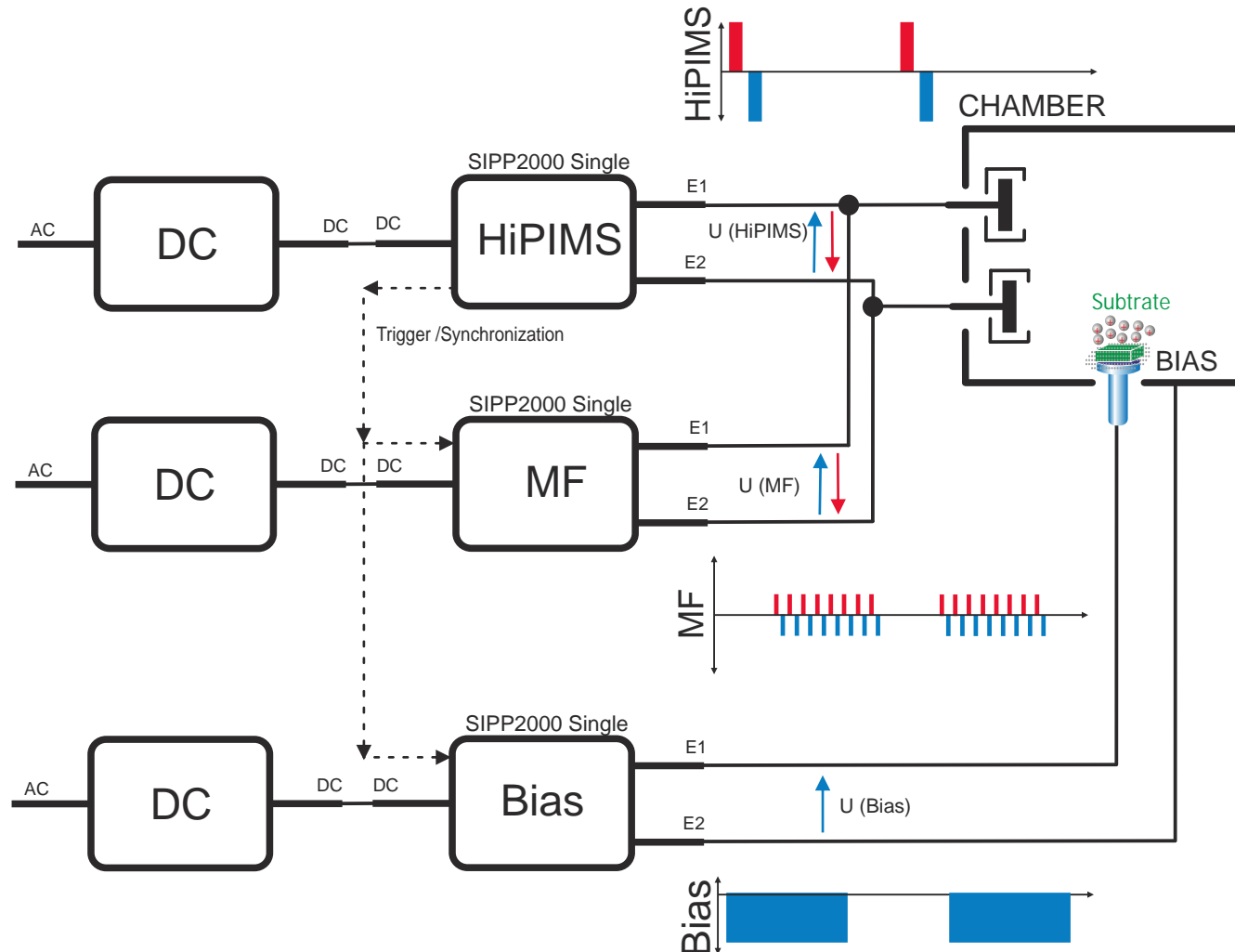
ADVANTAGES:

- Single- or Dual-Magnetron system application using conductive substrate allows a variation of the process and high performance of thin film via improved micro-structure
- Separation of metal and gas ions



Patent Pending

Superimposed bipolar HiPIMS (BP) / bipolar MidFreq. (MF) and unipolar MidFreq. (MF) synchronized pulsed BIAS using conductive substrate

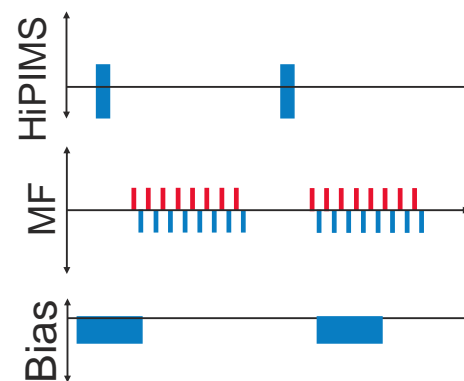


EXAMPLE OF APPLICATIONS:

- Hard and decorative coating using synchized MF(UP) bias
- Synchronized pulsed bias or phase shifted to HiPIMS pulses

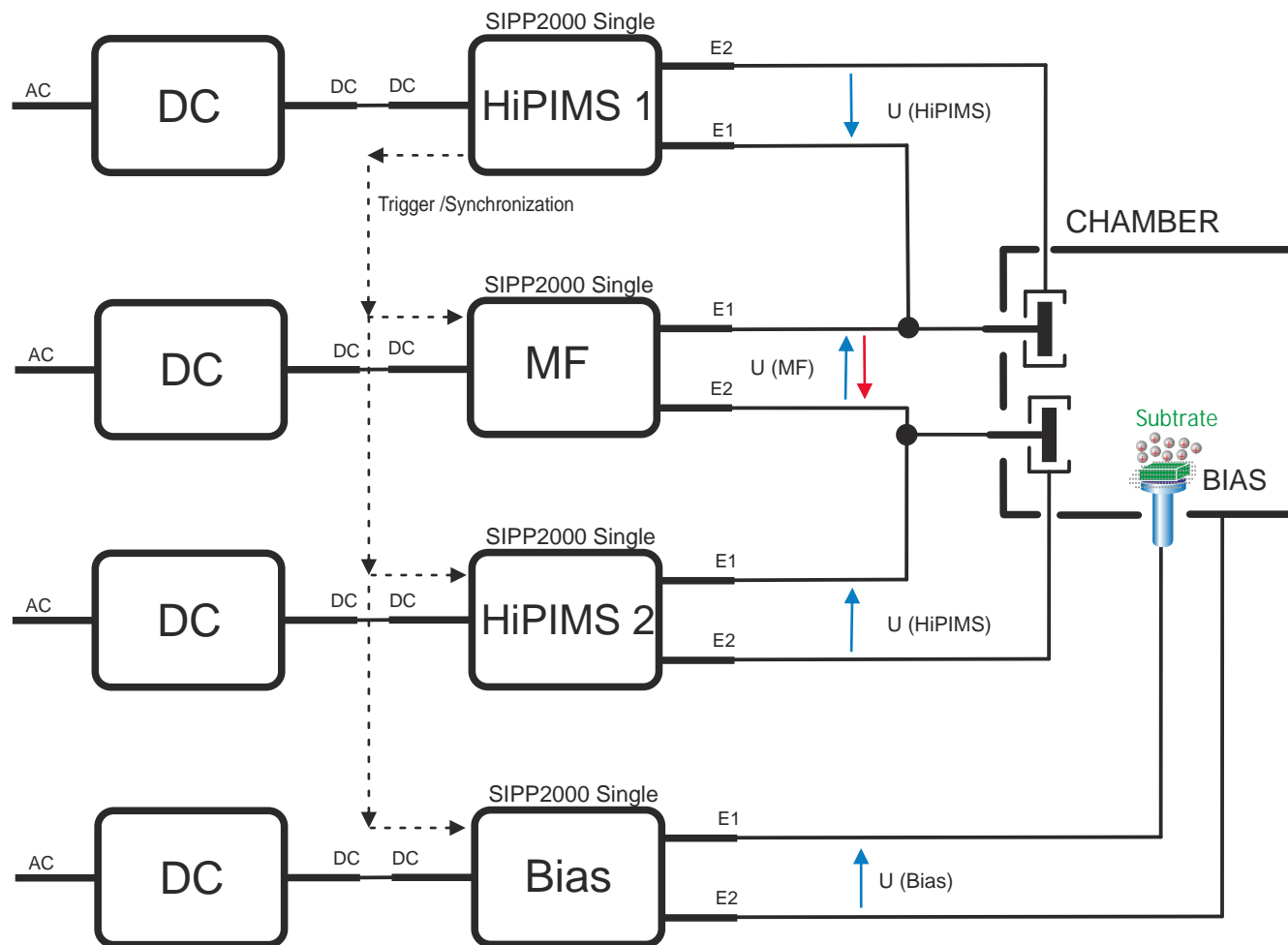
ADVANTAGES:

- Single- or Dual-Magnetron system application using conductive substrate allows a variation of the deposition process and high performance of thin film structures
- Superimposed HiPIMS(UP)/Mid Frequency (MF-BP) with high deposition rates
- New process options
- Stable coating process
- Preventing of arcing and poisoning by control of the Mid frequency parameters in bipolar (BP) mode
- Separation of metal and gas ions



Patent Pending

Superimposed unipolar HiPIMS (UP) / bipolar MidFreq. (MF) and unipolar pulsed synchronized bias using conductiv substrate

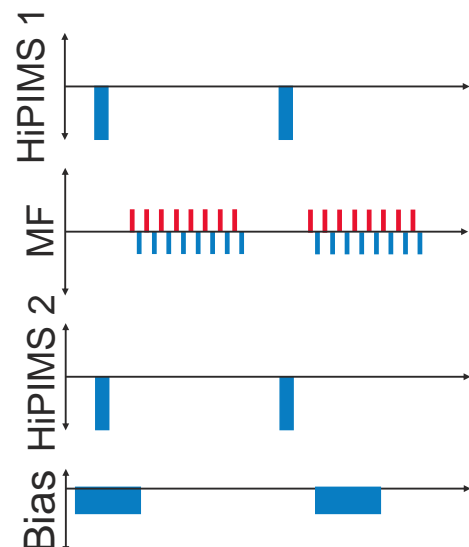


EXAMPLE OF APPLICATIONS:

- Hard and decorative coating using synchronized pulsed bias
- Synchronized pulsed bias or phase shifted to HiPIMS pulses

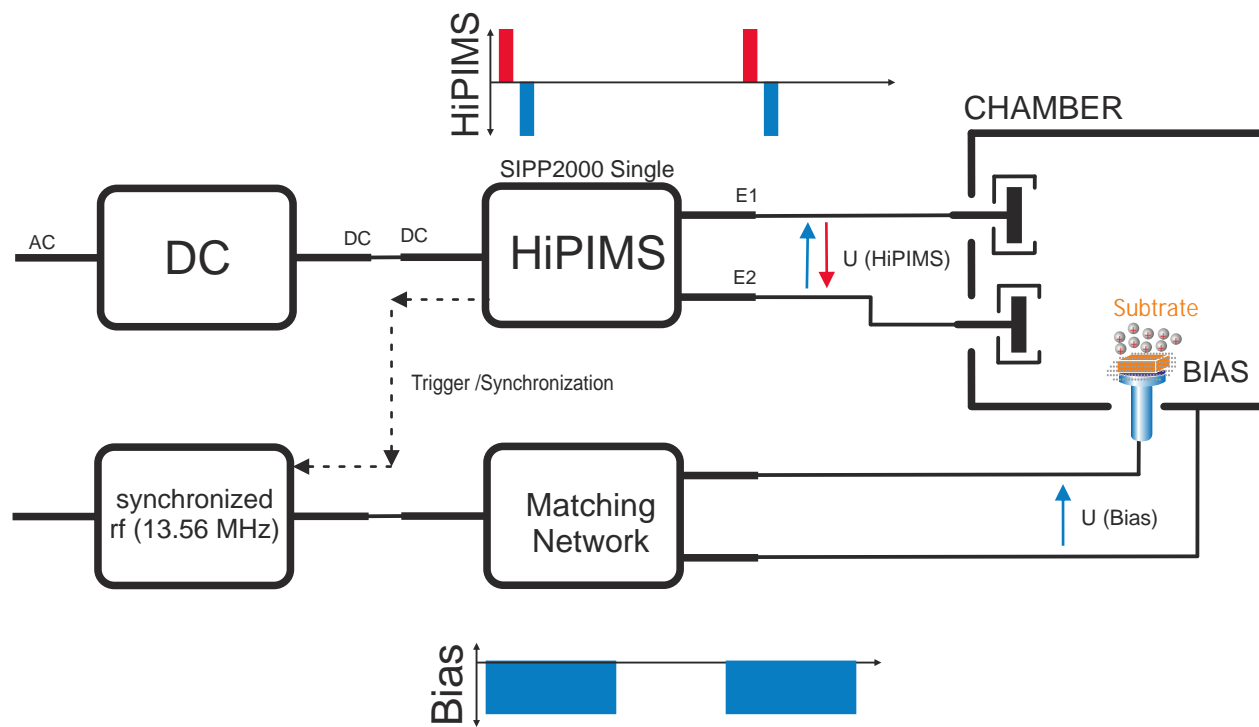
ADVANTAGES:

- Dual-Magnetron system application using conductive substrate allows a variation of the process leading to high performance of thin film
- Superimposed HiPIMS / Mid Frequency (UP / MF) with high deposition rates
- New process options
- Stable coating process
- Preventing of arcing and poisoning by control of Mid Frequency (BP)
- Separation of metal and gas ions



Patent Pending

Bipolar HiPIMS (BP) and synchronized pulsed radio frequency (13.56 MHz) (rf) bias using nonconductive substrate

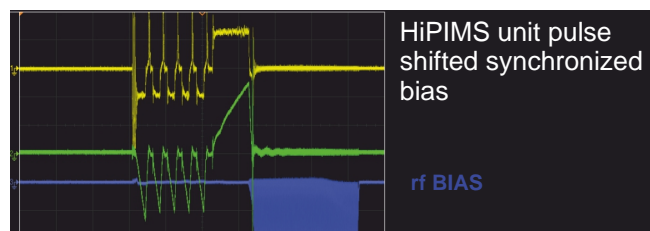
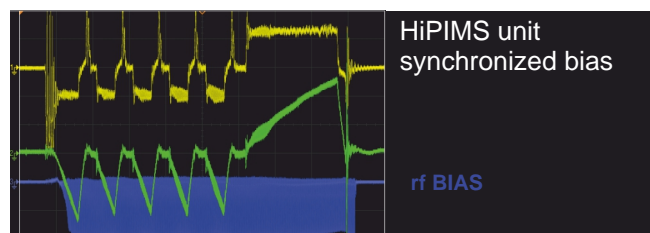


EXAMPLE OF APPLICATIONS:

- Co-sputtering with dual magnetron system using two different target materials (Al, Cr) in argon and nitrogen combined with synchronized pulsed rf (13.56 MHz) bias using a nonconductive substrate
- HiPIMS pulse waveforms fully synchronized with rf (13.56 MHz) bias pulse
- HiPIMS waveform phase shifts with rf (13.56 MHz) bias pulse

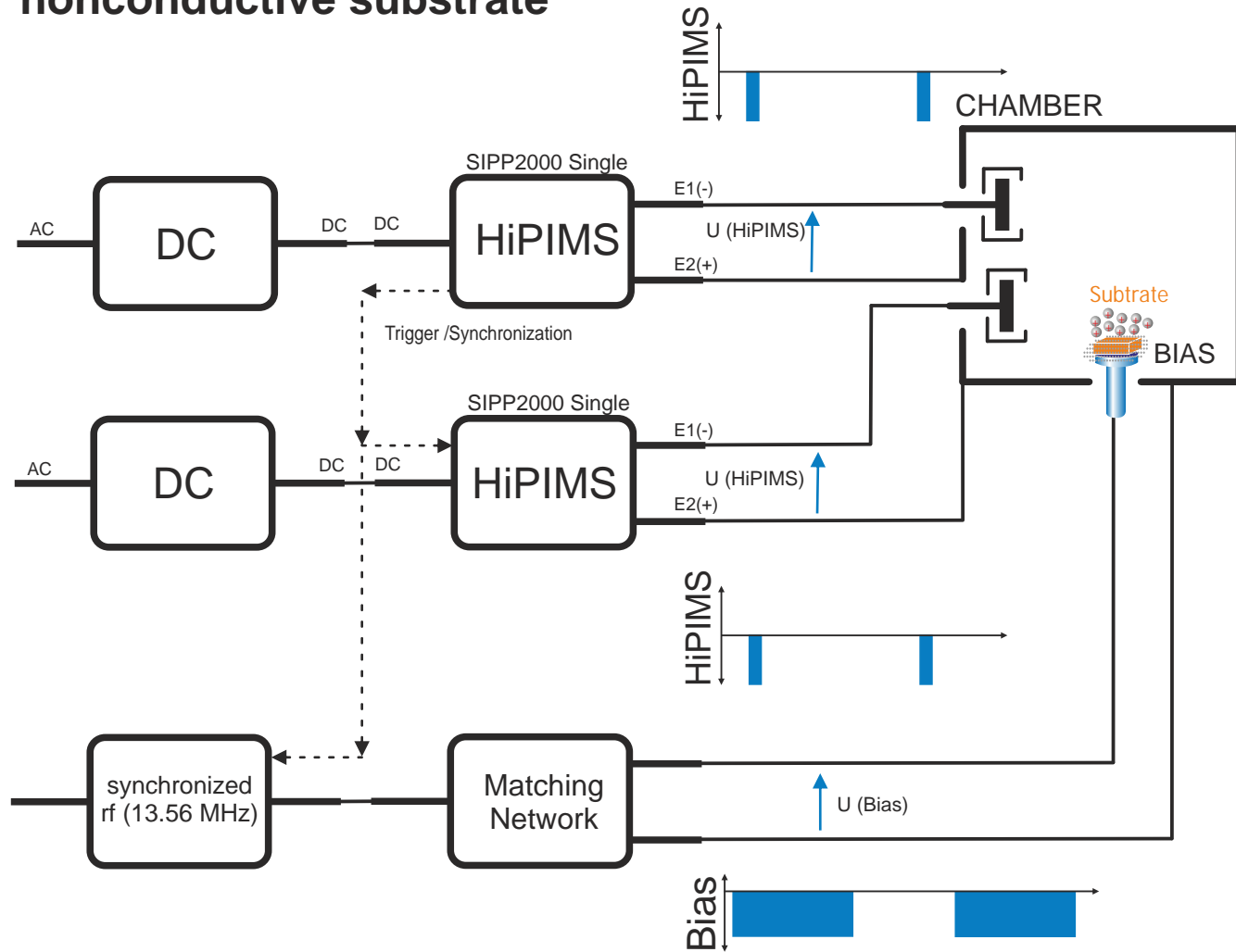
ADVANTAGES:

- New process options
- Stable coating process
- Preventing of arcing and poisoning by control of HiPIMS (BP) using pulse packages for Al deposition and single pulses for Cr deposition
- Separation of metal and gas ions



Patent Pending

Superimposed unipolar HiPIMS (UP) and synchronized pulsed radio frequency (13.56 MHz) (rf) bias using nonconductive substrate

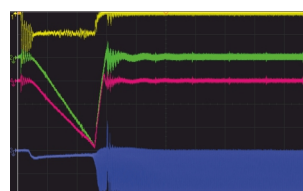
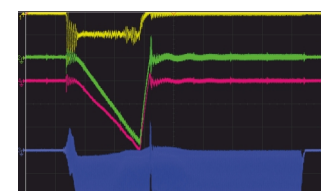


EXAMPLE OF APPLICATIONS:

- Co-sputtering with two dual magnetron system with two different target materials (Al, Cr) using argon and nitrogen combined with synchronized pulsed rf (13.56 MHz) bias using nonconductive substrate
- HiPIMS pulse waveforms full synchronized with rf (13.56 MHz) bias pulse
- HiPIMS waveform phase shifts with rf (13.56 MHz) bias pulse

ADVANTAGES:

- New process options
- Stable coating process
- Preventing of arcing and poisoning by control of HiPIMS (BP) using pulse packages for Al
- Separation of metal and gas ions



Patent Pending

SIPP2000 Single Version PLASMA DC PULSE POWER CONTROLLER

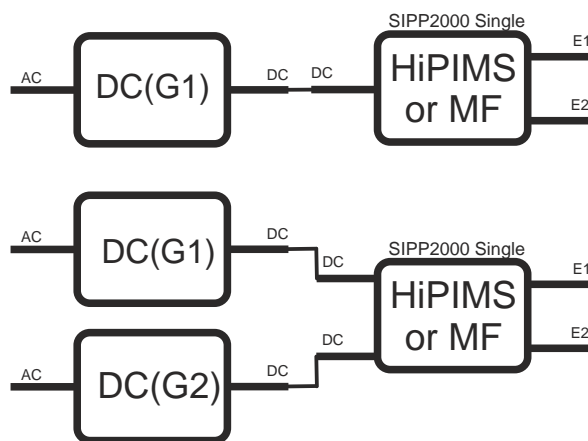


Features:

- Full control of MF Pulse Unit configured for 1 CH or 2 CH functionality
- Interactively configurable Pulse Waveform
- Saving and Loading of Pulse Waveforms
- Freely adjustable arc Management
- Monitoring of all status signals
- Synchronized pulse generation output for external triggering of additional MF unit
- Full control of ADL GmbH DC-Units or alternatively PNCL DUAL® DC-Units
- Set points for voltage, current and power
- Industrial security functions

Possibility:

Use one or two DC units for symmetric or asymmetric pulse mode



SIPP2000USB-HiPIMS

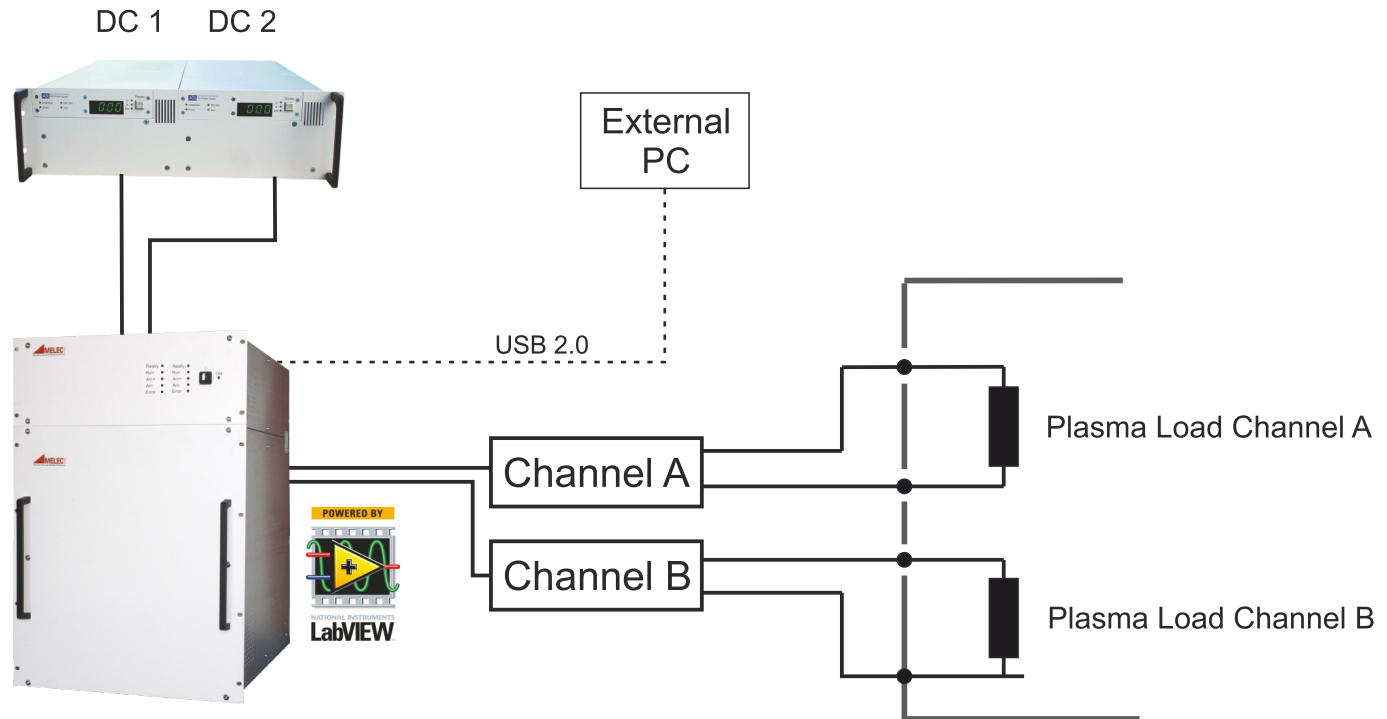
HiPIMS/HPPMS SIPP2000USB_...	...10_1000_S 10 kW	...20_1000_S 2x 10 kW = 20 kW	...30_1000_S 2x 15 kW = 30 kW or 1x 30 kW
Pulse Output Power	1000 kW (peak)		
Pulse Output Voltage	+/- 1000 V max.		
Pulse Output Current	+/- 1000 A max.		
Pulse Time Conditions	UP+ ; UP- ; BP		
ON-TIMES +/-	$T_{on}^{+/-}$ 20 μ s		
OFF-TIMES +/-	$T_{off}^{+/-}$ 20 μ s		
HiPIMS / HPPMS Frequency Conditions	$T_{on}^{+/-}$ and $T_{off}^{+/-}$ 500 μ s (2 kHz)		
MF (optional) ON-TIMES +/-	$T_{on}^{+/-}$ 5 μ s		
MF (optional) OFF-TIMES +/-	$T_{off}^{+/-}$ 5 μ s		
MF (optional) Frequency Conditions	$T_{on}^{+/-}$ and $T_{off}^{+/-}$ 20 μ s Current pulse peak +/-100 A (50 kHz)		

SIPP2000USB-MF

MidFrequency SIPP2000USB_...	...10_1000_S 10 kW	...20_1000_S 2x 10 kW = 20 kW	...30_1000_S 2x 15 kW = 30 kW or 1x 30 kW
Pulse Output Power	1000 kW (peak)		
Pulse Output Voltage	+/- 1000 V max.		
Pulse Output Current	+/- 500 A max.		
Pulse Time Conditions	UP+ ; UP- ; BP		
ON-TIMES +/-	$T_{on}^{+/-}$ 5 μ s		
OFF-TIMES +/-	$T_{off}^{+/-}$ 5 μ s		
MidFrequency Conditions	$T_{on}^{+/-}$ and $T_{off}^{+/-}$ 20 μ s Current pulse peak +/-100 A (50 kHz)		

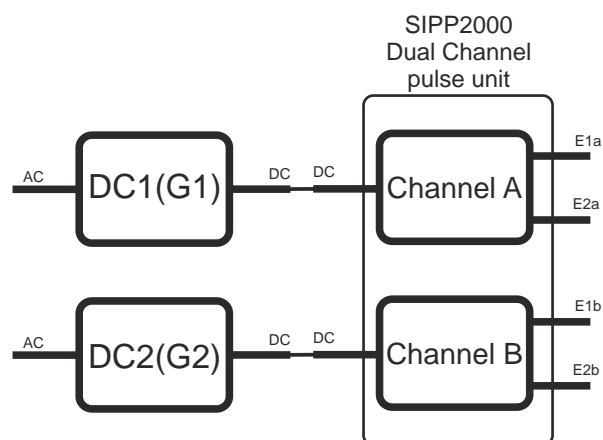
Patent Pending

SIPP2000 Dual Version PLASMA DC PULSE POWER CONTROLLER

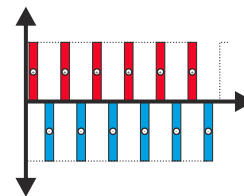


Features:

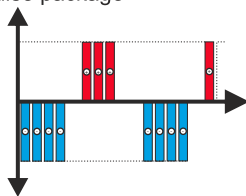
- Full control of two separated channels for HiPIMS, MF or Bias
- Synchronization of HiPIMS, Bias and MF
- Separated arc management for both channels
- Control of 2 DC units (2 x ADL GX or PNCL Dual)
- All parameters can be controlled via software
- Freely adjustable pulse pattern generator (FPPG)



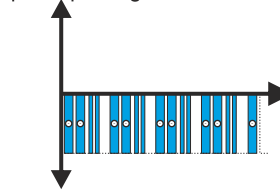
Bipolar HiPIMS/HPPMS



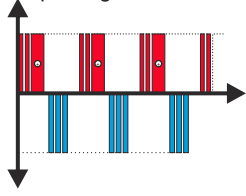
Unipolar HiPIMS/HPPMS pulse package



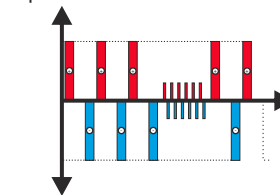
Unipolar HiPIMS/HPPMS pulse package



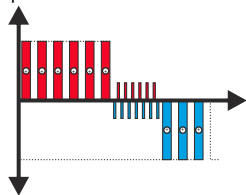
Bipolar HiPIMS/HPPMS pulse packages



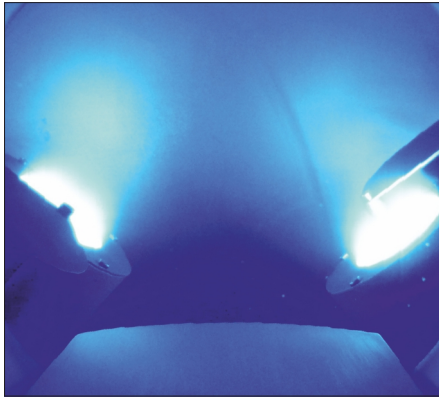
Superimposed bipolar HiPIMS/HPPMS and MF



Superimposed unipolar HiPIMS/HPPMS and MF



Patent Pending

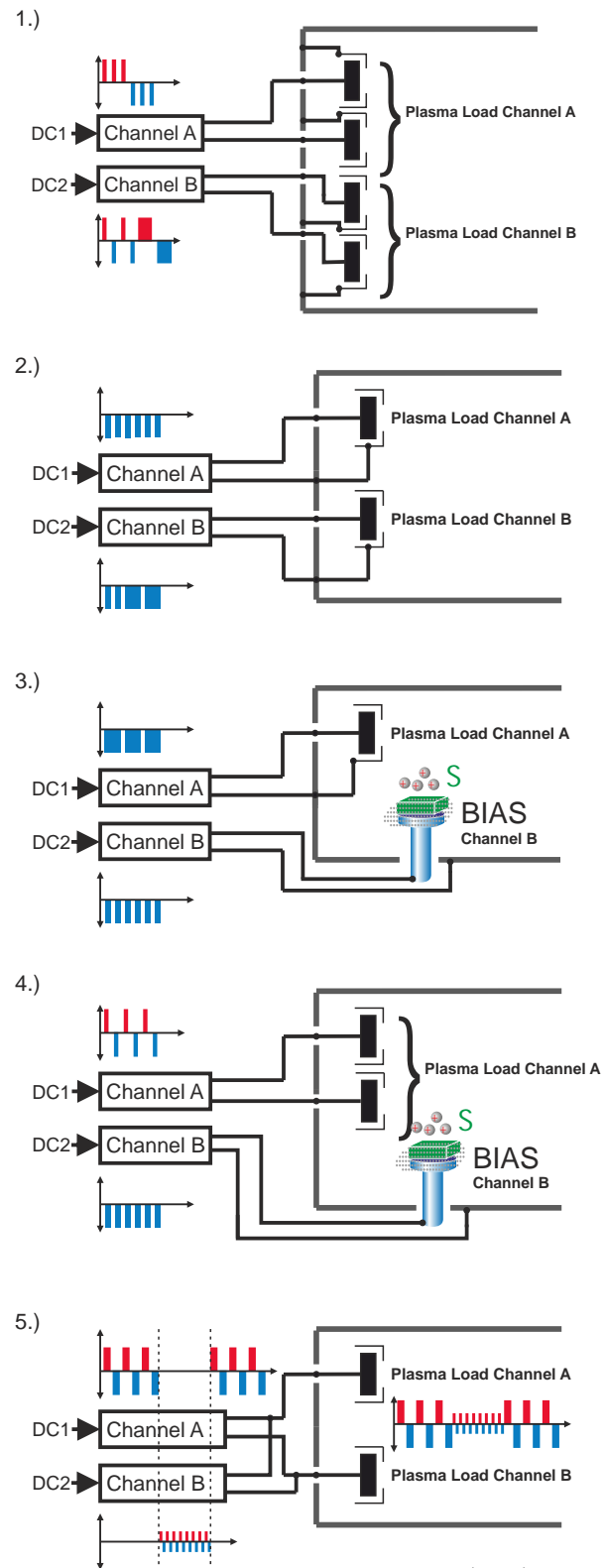


Source: Helmholtz-Zentrum
Dresden-Rossendorf
Germany

SIPP2000 DUAL

1x HiPIMS/HPPMS and 1x MF or 2x HiPIMS/HPPMS or 2x Mid Frequency(MF)	CHANNEL A 5 kW	CHANNEL B 5 kW
Pulse Output Power (peak Power)	500 kW	500 kW
Pulse Output Voltage	+/- 1000 V (max.)	+/- 1000 V (max.)
Pulse Output Current	+/- 500 A (max.)	+/- 500 A (max.)
Pulse Time Conditions	UP+ ; UP- ; BP	UP+ ; UP- ; BP
HiPIMS/HPPMS ON-TIMES +/-	$T_{on} \pm 20 \mu s$	$T_{on} \pm 20 \mu s$
HiPIMS/HPPMS OFF-TIMES +/-	$T_{off} \pm 20 \mu s$	$T_{off} \pm 20 \mu s$
HiPIMS/HPPMS Frequency Conditions	$(\tau_{on} \pm \text{and } \tau_{off} \pm) 500 \mu s$ Current Pulse Peak +/-500 A (2 kHz)	
MF ON-TIMES +/-	$T_{on} \pm 5 \mu s$	$T_{on} \pm 5 \mu s$
MF OFF-TIMES +/-	$T_{off} \pm 5 \mu s$	$T_{off} \pm 5 \mu s$
MF Frequency Conditions	$(T_{on} \pm \text{and } T_{off} \pm) 20 \mu s$ Current Pulse Peak +/-100 A (50 kHz)	

Applications...



patent pending

DC Power Supply GS- and GX-Models, ADL GmbH



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Type	DC Output		
ADL GmbH GS Class			
GS15/1000	1000V	2,4 A	1,5 kW
GS15/1000	1000V	2,8 A	2,0 kW
GS15/1000	1000V	4,2 A	3,0 kW
ADL GmbH GX Class			
GX50/1000	1000V	10,0 A	5,0 kW
GX80/1000	1000V	16,0 A	8,0 kW
GX1000/1000	1000V	20,0 A	10,0 kW
GX150/1000	1000V	30,0 A	15,0 kW

DC Power Supply HX- Models, ADL GmbH



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Type			
HX 150/1000	15 kW	1000 V	25 A
HX 200/1000	20 kW	1000 V	35 A
HX 250/1001	25 kW	1000 V	40 A
HX 300/1001	30 kW	1000 V	50 A

MELEC Measurement System

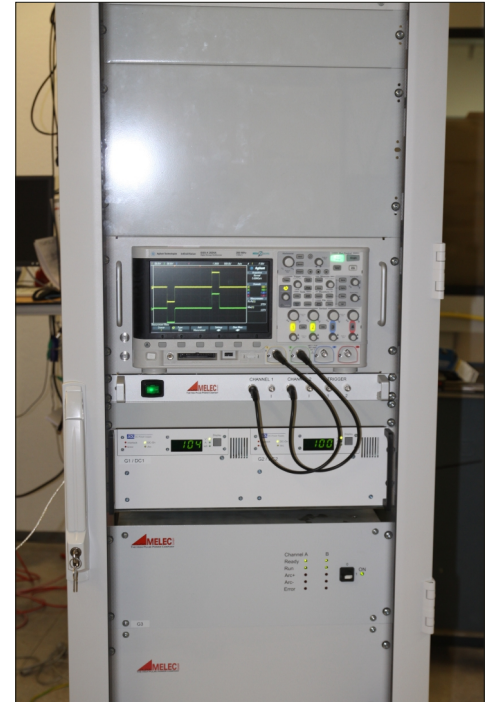


Measurement System	
MS-500-S	2 Channels (1 x 500 A, 1 x 1000 V)
MS-500-S-TB	2 Channels (1 x 500 A, 1 x 1000 V, 1x housing for Transducer Model)
MS-500-D	4 Channels (2 x 500 A, 2 x 1000 V)
MS-500-D-TB	4 Channels (2 x 500 A, 2 x 1000 V, 2x housing for Transducer Model)
MS-1000-S	2 Channels (1 x 1000 A, 1 x 1000 V)
MS-1000-S-TB	2 Channels (1 x 1000 A, 1 x 1000 V, 1x housing for Transducer Model)
MS-1000-D	4 Channels (2 x 1000 A, 2 x 1000 V)
MS-1000-D-TB	4 Channels (1 x 500 A, 1 x 1000 V, 2x housing for Transducer Model)

System Rack



Source: Materials Chemistry, RWTH / University Aachen,
Prof. Jochen M. Schneider



Cabinet System with Dual Channel Pulse
Unit set with a 4-Channel Measurement
System

System Racks can be configured to mount:

- SIPP2000 units
- DC units
- Measurement applications
- Industrial personal computer
- etc.

Additional components for superimposed pulse applications, such as high power, high speed diodes for DC-superimposed pulses can be optionally added into the system rack.

Advantages:

- Easy to install, ready to use
- All Components mounted compact and safely

Further Applications:

Plasma CVD
Plasma Nitriding
Atmospheric Plasma
Plasma Oxidation



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