The application of a short positive voltage reversal in HIPIMS – Widening the process window and increasing deposition rate

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What do we do?

The industrial HiPIMS choice!

**HiPIMS-PS**

- **FLEXIBLE**
- **RELIABLE**
- **MODULAR**
- **MULTI-FUNCTIONAL**

**Features:**

- HiPIMS-PS Uni-Polar / Bi-Polar (with Superimposed / Sequential HiPIMS capability)
- DC-PS (for magnetron sputtering, PECVD, Etch...)
- DC-Pulsed-PS Uni-Polar / Bi-Polar (for magnetron sputtering, PECVD, Etch...)
- HiPIMS-Bias / DC-Bias / DC - Pulsed- Bias (synchronization possible)
- Single & Dual magnetron capability
- hiPLUS Option (Positive voltage reversal for boosted productivity) **NEW!**

Not only power supplies!
We do process development, system design, and on site commissioning and training.
Contract R&D available in Madrid, Spain (along with great food and wine!)
### What do we do?

#### Product Overview:

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Power</strong></td>
<td>1KW</td>
<td>6KW</td>
<td>10KW</td>
<td>10KW</td>
<td>20KW</td>
<td>20KW</td>
</tr>
<tr>
<td><strong>Peak Power</strong></td>
<td>0.1MW</td>
<td>0.5MW</td>
<td>1.2MW</td>
<td>1.2MW</td>
<td>2.4MW</td>
<td>2.4MW</td>
</tr>
<tr>
<td><strong>Voltage</strong></td>
<td>1200V</td>
<td>1200V</td>
<td>1200V</td>
<td>1200V</td>
<td>1200V</td>
<td>1200V</td>
</tr>
<tr>
<td><strong>Current max. HiPIMS</strong></td>
<td>100A</td>
<td>500A</td>
<td>1000A</td>
<td>2000A</td>
<td>2000A</td>
<td>1000A</td>
</tr>
<tr>
<td><strong>Current DC max.</strong></td>
<td>3A</td>
<td>18A</td>
<td>25A</td>
<td>25A</td>
<td>50A</td>
<td>50A</td>
</tr>
<tr>
<td><strong>Frequency max.</strong></td>
<td>40KHz</td>
<td>2KHz</td>
<td>2KHz</td>
<td>1KHz</td>
<td>1KHz</td>
<td>2KHz</td>
</tr>
<tr>
<td></td>
<td>$\text{P}_{\text{max}} \text{ @ 1KHz}$</td>
<td>$\text{P}_{\text{max}} \text{ @ 1KHz}$</td>
<td>$\text{P}_{\text{max}} \text{ @ 1KHz}$</td>
<td>$\text{P}_{\text{max}} \text{ @ 1KHz}$</td>
<td>$\text{P}_{\text{max}} \text{ @ 1KHz}$</td>
<td></td>
</tr>
<tr>
<td><strong>Time ON</strong></td>
<td>5-1000µs</td>
<td>5-1000µs</td>
<td>5-1000µs</td>
<td>5-1000µs</td>
<td>5-1000µs</td>
<td>5-1000µs</td>
</tr>
<tr>
<td><strong>ARC Control</strong></td>
<td>&lt; 3µs</td>
<td>&lt; 3µs</td>
<td>&lt; 3µs</td>
<td>&lt; 3µs</td>
<td>&lt; 3µs</td>
<td>&lt; 3µs</td>
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<tr>
<td><strong>Cooling</strong></td>
<td>Air</td>
<td></td>
<td></td>
<td></td>
<td>Water &amp; Air</td>
<td></td>
</tr>
</tbody>
</table>
What do we do?

- High peak powers (500-2000 W/cm²)
- Reasonable average power (up to 80kW)
- Low duty factors (0.5-5%)
What does it look like?

Active V+

Passive V+

hiPlus Option

no V+
HiPIMS with V+

High density of ions in HiPIMS, so.....

........any effect on plasma and coating properties?
HiPIMS with V+ - Negative phase

Voltage (V)

Floated substrate
HiPIMS with V+ - Positive phase

- Ion acceleration from the target surface
- Raise of plasma potential (bombardment of low V surfaces)
HiPIMS with V+

High density of ions in HiPIMS, so.....

........any effect on plasma and coating properties?
HiPIMS Carbon: Evolution of V+

The graphs depict the evolution of the floating potential and target voltage over time. The x-axis represents time in microseconds, and the y-axis represents voltage in volts. The graphs are divided into two sections: Plasma ON and Plasma OFF. Different voltages (45V, 80V, 110V, 160V, 215V, 325V, 430V, 60V, 120V, 190V, 220V, 254V, 333V, 485V) are shown with distinct colors and line styles.
HiPIMS with V+ : OES

V+ ON
No V+
HiPIMS Carbon : IEDF

![Graphs showing Counts vs Energy for Ar⁺ and C⁺ ions with different overshoot voltages.](image)
Example 1: pure C-DLC

Negative Bias at substrate = -40V
DLC coating on Glass

Hardness in the range of 20GPa for 400nm thick DLC layer

Patent applied with Gencoa Ltd.
Example 1: pure C-DLC

Hardness = 33GPa

Negative Bias at substrate = -150V
Example 2 (2015): Reactive TiN

TiN Planar rectangular magnetron (400x100mm)

<table>
<thead>
<tr>
<th>Hardness [GPa]</th>
<th>22.0</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive V reversal</td>
<td>YES</td>
<td>NO</td>
</tr>
</tbody>
</table>
Example 4: Reactive TiN at RT

Higher deposition rate at same magnetron poisoning condition!
Example 3: TaN in CFUBM cluster tool

4kW, 75 µs, 325Hz, $I_{peak} = 450A$, $V_{peak} = 950V$

<table>
<thead>
<tr>
<th>Dep. rate [µm/hr]</th>
<th>0.51</th>
<th>0.42</th>
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</thead>
<tbody>
<tr>
<td>Hardness [GPa]</td>
<td>21</td>
<td>17</td>
</tr>
<tr>
<td>POSITIVE</td>
<td>YES</td>
<td>NO</td>
</tr>
</tbody>
</table>

Magnetron in fully poisoned mode.
Similar at% composition
Critical loads above 100N!! – 1 micron thick DLC layer
Ready for Industry!

3 meters tool coating machine

80 kW HIPIMS!
Advantages / Improvements of HiPIMS V+

- Discharging the target - reduces Arcing.
- Higher deposition rates for metals and reactive processes
- Ion assistance on insulating substrates
- Can be used for **energetic deposition** – wider process window
- And for **substrate pre-treatment!!** (metal ion etching!)
Thank you for your attention !!