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# MAGNETRON SPUTTERING WITH HIGH POWER SUBMICROSECOND PULSES*

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Ultra-short HIPIMS is a type of high power pulse magnetron sputtering technology, in which the pulse duration is 4-10 μs, while the discharge pulse power can reach several tens or hundreds of kW. Due to the use of short pulses, it is possible to reduce the number of electrical arcs and increase the deposition rate, while maintaining a high ionization rate of the sputtered material [1, 2]. We have previously shown that reducing the pulse duration to 5-7 μs leads to an increase in the average ion current density to a substrate [3]. This paper presents the results of experiments in which the duration of discharge current pulses during high power pulse magnetron sputtering of copper was reduced to 2 μs. Figure 1 shows the oscillograms of discharge current and voltage pulses in the submicrosecond pulses mode (s-HIPIMS). Due to the high pulsed voltage (1500 V) and the low inductance of the generator, the discharge current has time to increase to 300 A within 2 μs, while the pulsed power density on the target exceeds 5 kW/cm$^2$. Table 1 presents the results that allow comparing the s-HIPIMS mode with the DCMS and HIPIMS with a longer pulse duration modes. As in the case of HIPIMS, the deposition rate in s-HIPIMS mode is significantly reduced compared to DC. However, s-HIPIMS mode provides a significantly higher ion current density to a substrate compared to the DCMS and HIPIMS. The paper considers the possible causes of the observed ion current growth in the case of submicrosecond pulses.

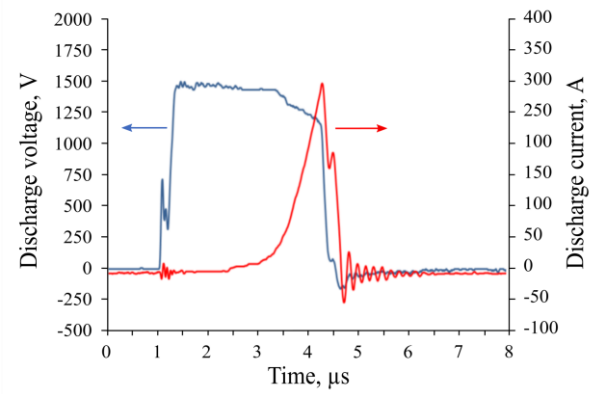


Fig. 1. Discharge current and voltage pulses in the s-HIPIMS mode

Table 1. Parameters of sputtering processes.

| Mode | DCMS | HIPIMS | s-HIPIMS |
|---|---|---|---|
| Pulse voltage, V | 372 | 871 | 1400 |
| Average current, A | 2.7 | 1.2 | 0.7 |
| Average power, kW | | 1000 | |
| Peak pulse current, A | - | 200 | 350 |
| Pulse frequency, kHz | - | 1.7 | 7.0 |
| Voltage pulse duration, μs | - | 20 | 3 |
| Current pulse duration, μs | - | 15 | 2 |
| Deposition rate, nm/s | 302 | 24 | 31 |
| Average ion substrate current, mA/cm2 | 0.7 | 1.0 | 6.5 |

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