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(12) **United States Patent**  
**Wang et al.**

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(45) **Date of Patent:** **Jul. 2, 2002**

(54) **PULSED SPUTTERING WITH A SMALL ROTATING MAGNETRON** 5,976,327 A 11/1999 Tanaka ..... 204/192.15

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(73) Assignee: **Applied Materials, Inc.**, Santa Clara, CA (US)  
Kouznetsov et al., "A novel pulsed magnetron sputter technique utilizing very high target power densities", *Surface and Coatings Technology*, vol. 122, 1999, pp. 290-293.

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.  
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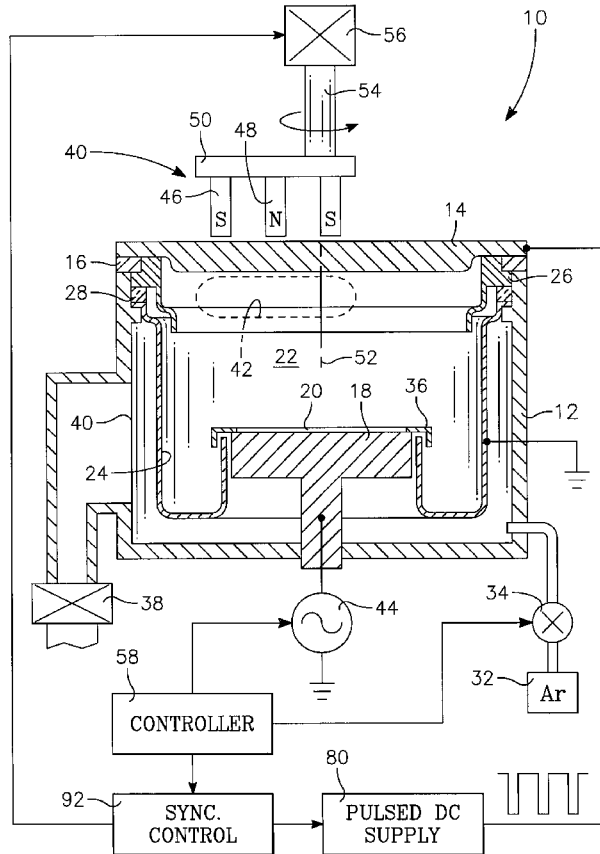
(57) **ABSTRACT**

A magnetron sputter reactor having a target that is pulsed with a duty cycle of less than 10% and preferably less than 1% and further having a small magnetron of area less than 20% of the target area rotating about the target center, whereby a very high plasma density is produced during the pulse adjacent to the area of the magnetron. The power pulsing frequency needs to be desynchronized from the rotation frequency so that the magnetron does not overlie the same area of the magnetron during different pulses. Advantageously, the power pulses are delivered above a DC background level sufficient to continue to excite the plasma so that no ignition is required for each pulse.

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(22) Filed: **Nov. 3, 2000**  
(51) **Int. Cl.**<sup>7</sup> ..... **C23C 14/35**  
(52) **U.S. Cl.** ..... **204/192.12; 204/298.08; 204/298.17; 204/298.2; 204/298.22**  
(58) **Field of Search** ..... 204/192.12, 298.08, 204/298.17, 298.2, 298.22

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**27 Claims, 4 Drawing Sheets**



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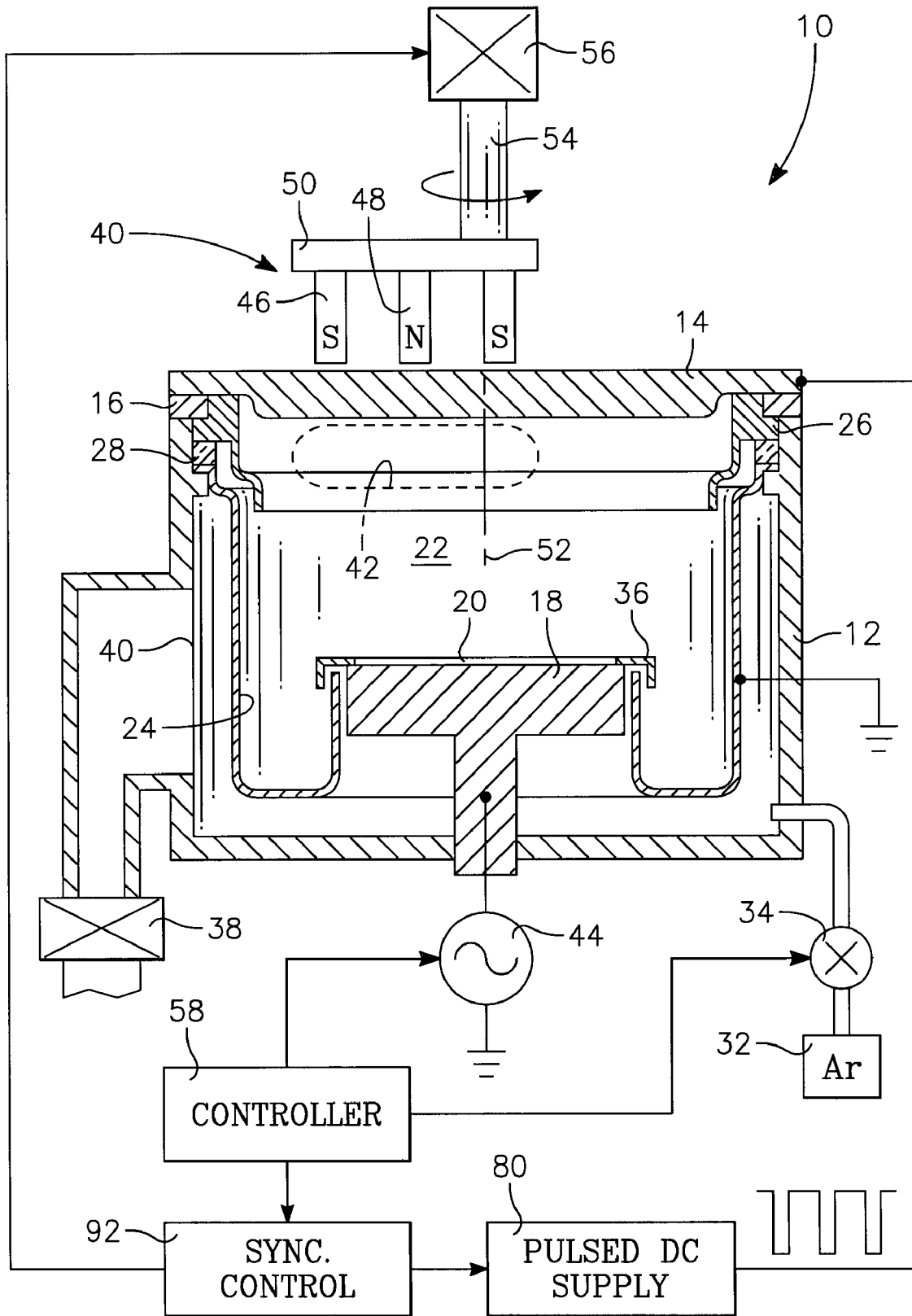


FIG. 1

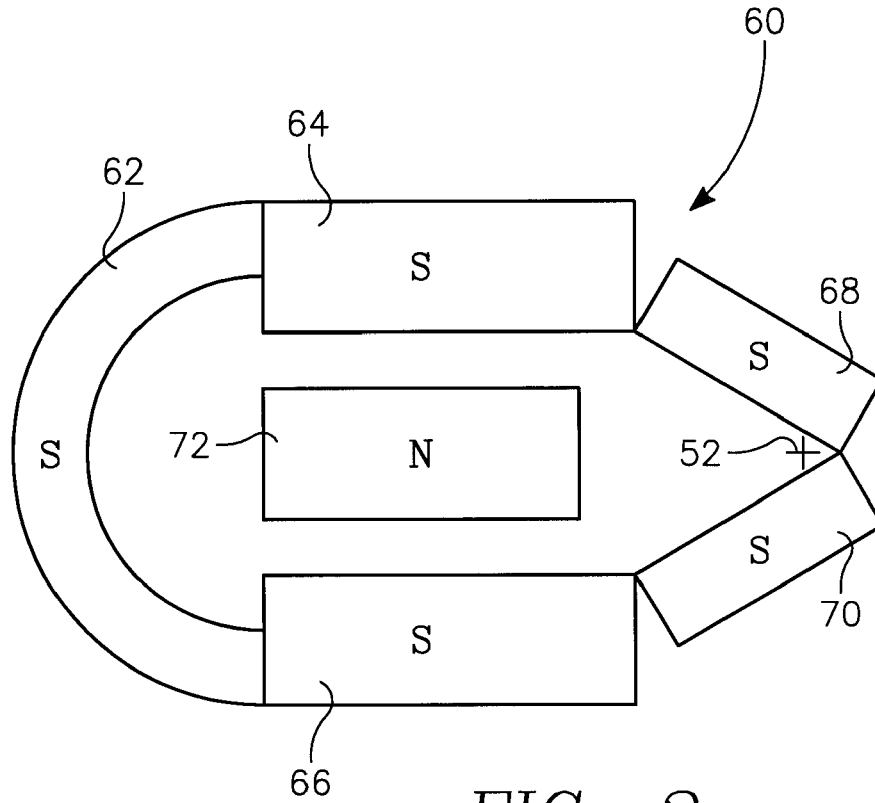


FIG. 2

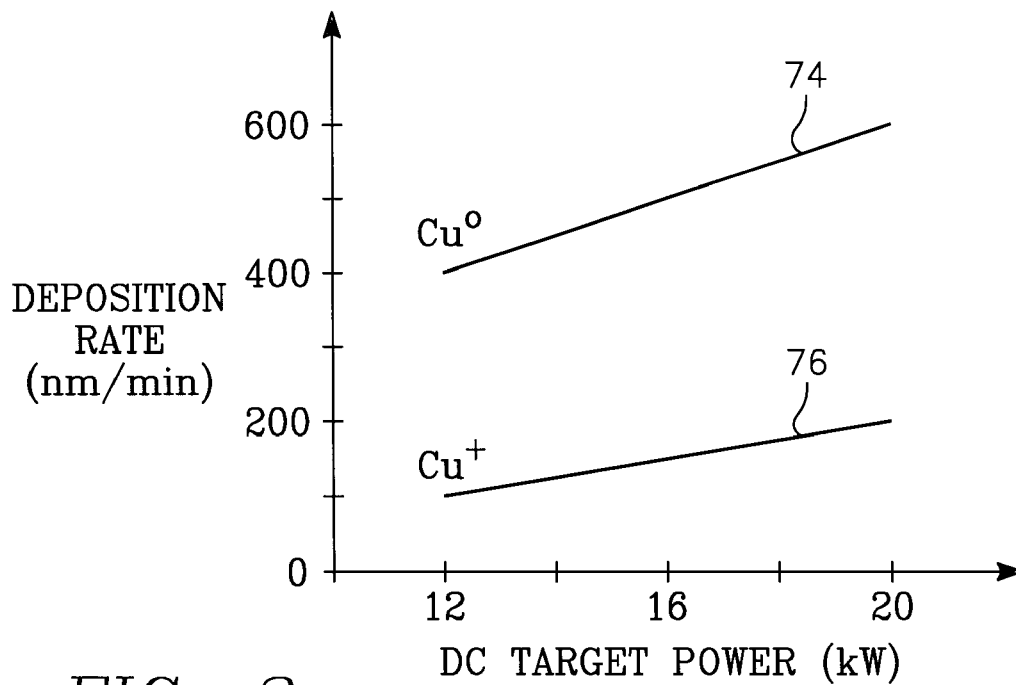


FIG. 3

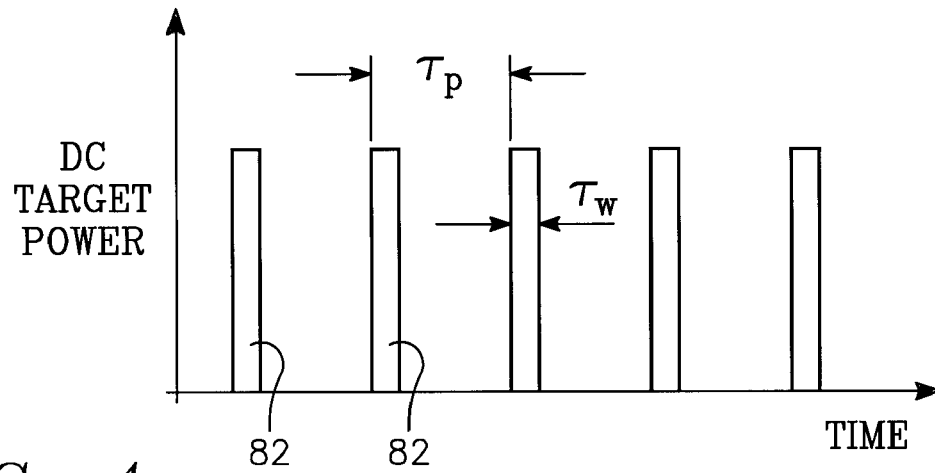


FIG. 4

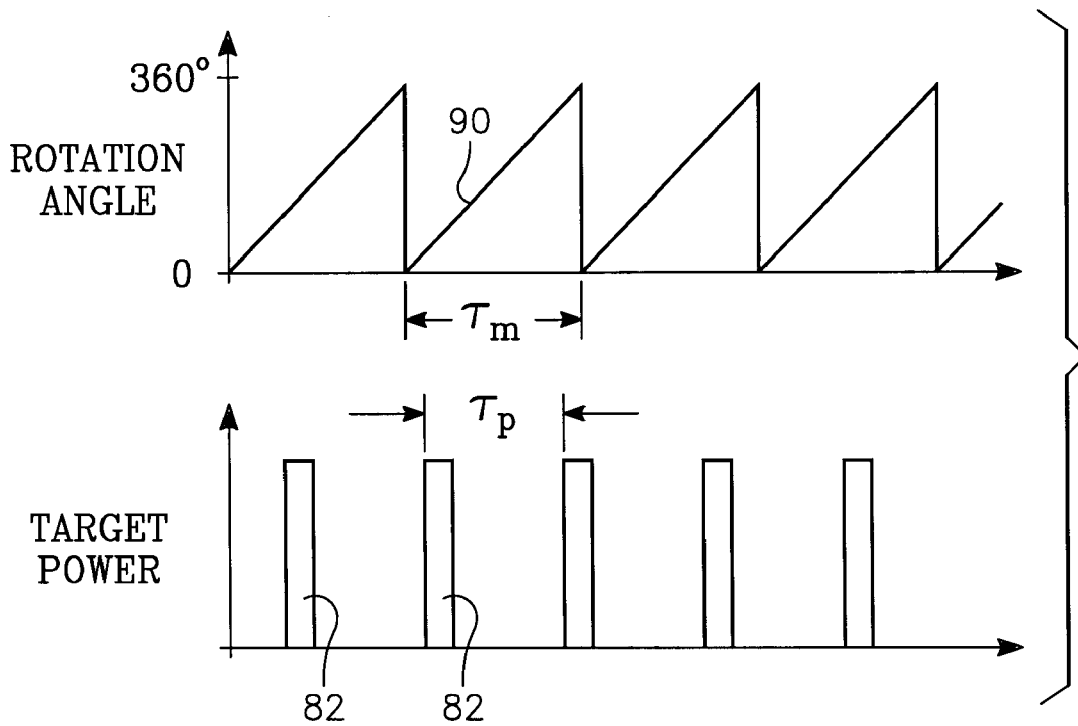


FIG. 5

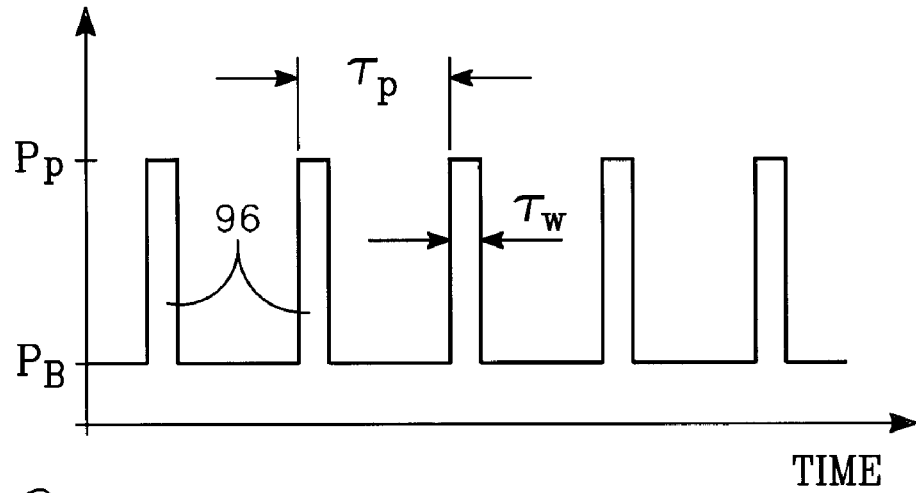


FIG. 6

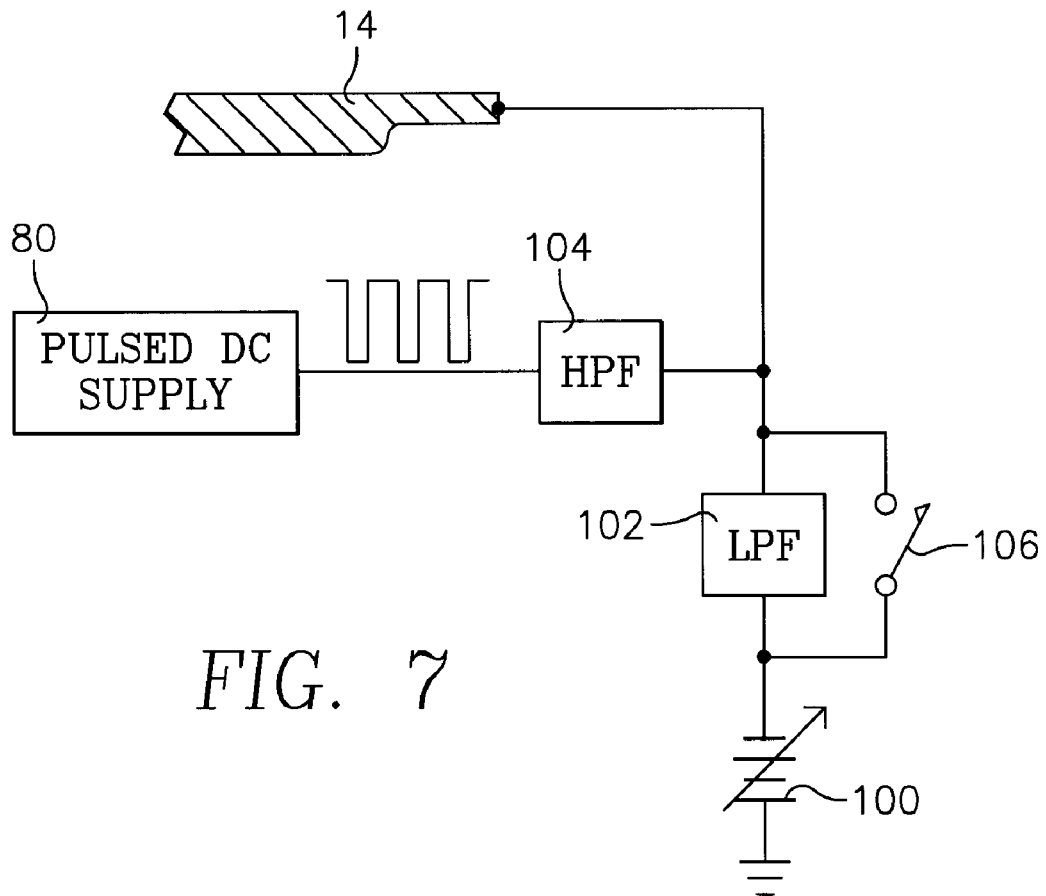


FIG. 7

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