

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

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(54) **HIGH-DENSITY PLASMA FOR IONIZED METAL DEPOSITION CAPABLE OF EXCITING A PLASMA WAVE**

2 241 710 \* 9/1991 (GB) ..... 204/298.19  
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63-282263 11/1988 (JP) .  
11-074225 3/1999 (JP) .

(75) Inventors: **Jianming Fu**, San Jose; **Praburam Gopalraja**, Sunnyvale; **Fusen Chen**, Saratoga; **John Forster**, San Francisco, all of CA (US)

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(73) Assignee: **Applied Materials, Inc.**, Santa Clara, CA (US)

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(\*) 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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(21) Appl. No.: **09/546,798**

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(22) Filed: **Apr. 11, 2000**

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**Related U.S. Application Data**

(63) Continuation-in-part of application No. 09/373,097, filed on Aug. 12, 1999, now Pat. No. 6,183,614, which is a continuation-in-part of application No. 09/249,468, filed on Feb. 12, 1999.

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(51) **Int. Cl.**<sup>7</sup> ..... **C23C 14/34**  
(52) **U.S. Cl.** ..... **204/192.12; 204/298.2**  
(58) **Field of Search** ..... 204/298.19, 298.2,  
204/298.22, 192.12

**ABSTRACT**

A magnetron especially advantageous for low-pressure plasma sputtering or sustained self-sputtering having reduced area but full target coverage. The magnetron includes an outer pole face surrounding an inner pole face with a gap therebetween. The outer pole of the magnetron of the invention is smaller than that of a circular magnetron similarly extending from the center to the periphery of the target. A preferred triangular shape having a small apex angle of 20 to 30° may be formed from outer bar magnets of one magnetic polarity enclosing an inner magnet of the other magnetic polarity. The magnetron allows the generation of plasma waves in the neighborhood of 22 MHz which interact with the 1 to 20 eV electrons of the plasma to thereby increase the plasma density.

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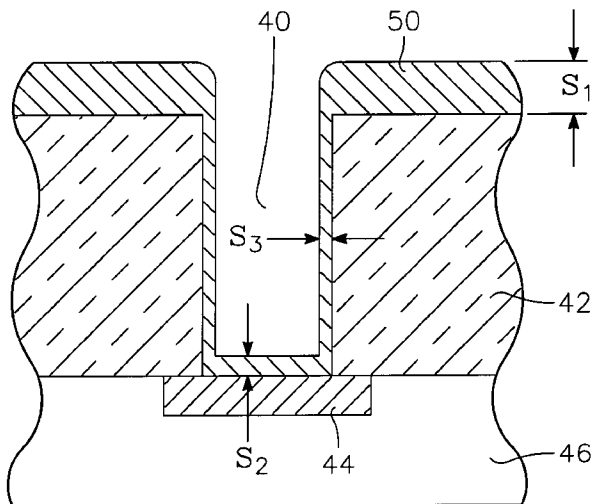
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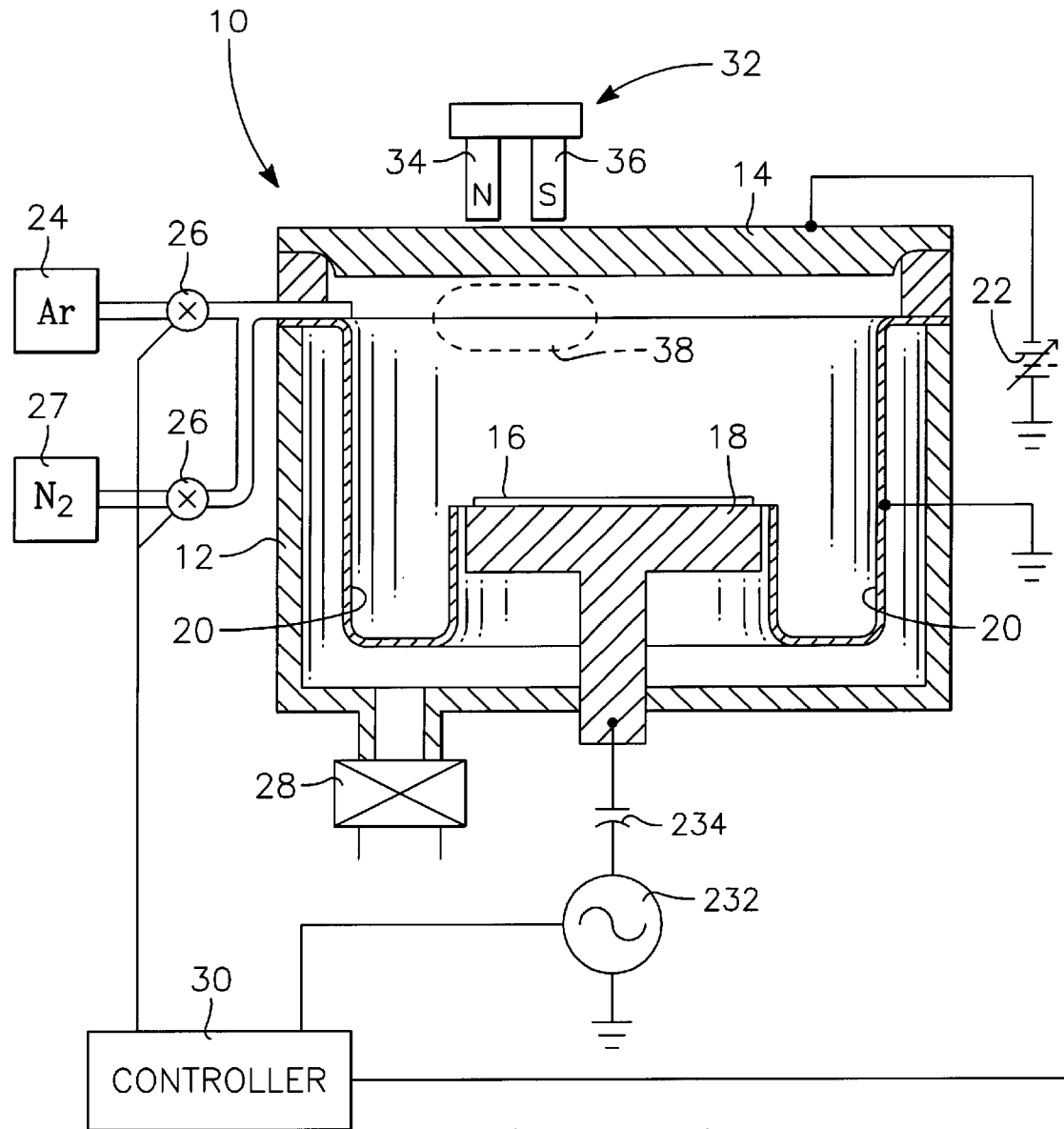
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**22 Claims, 11 Drawing Sheets**



INTEL 1010



(PRIOR ART)

FIG. 1

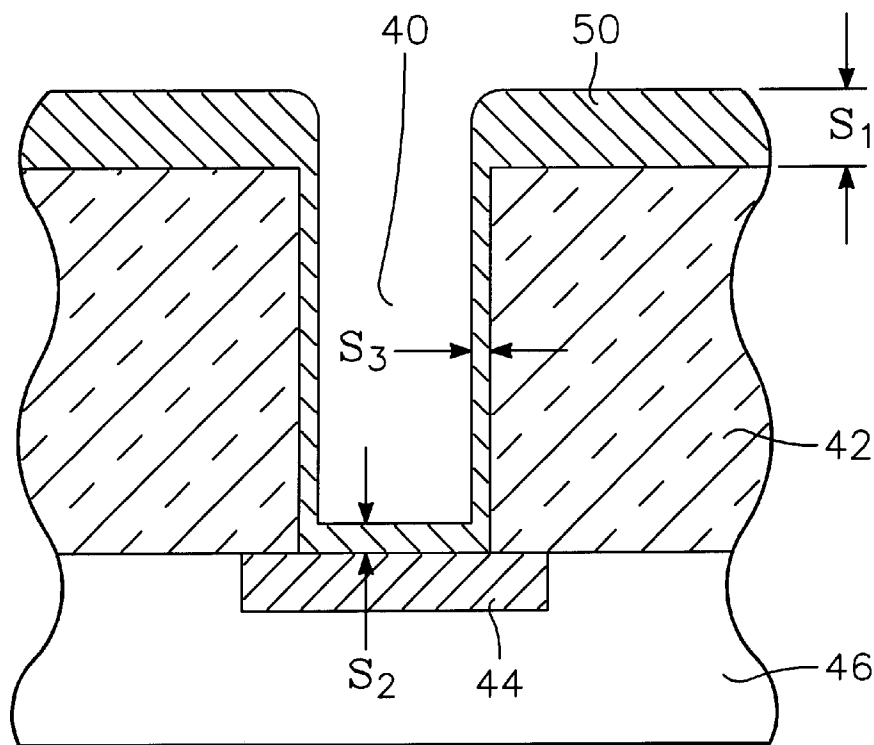


FIG. 2

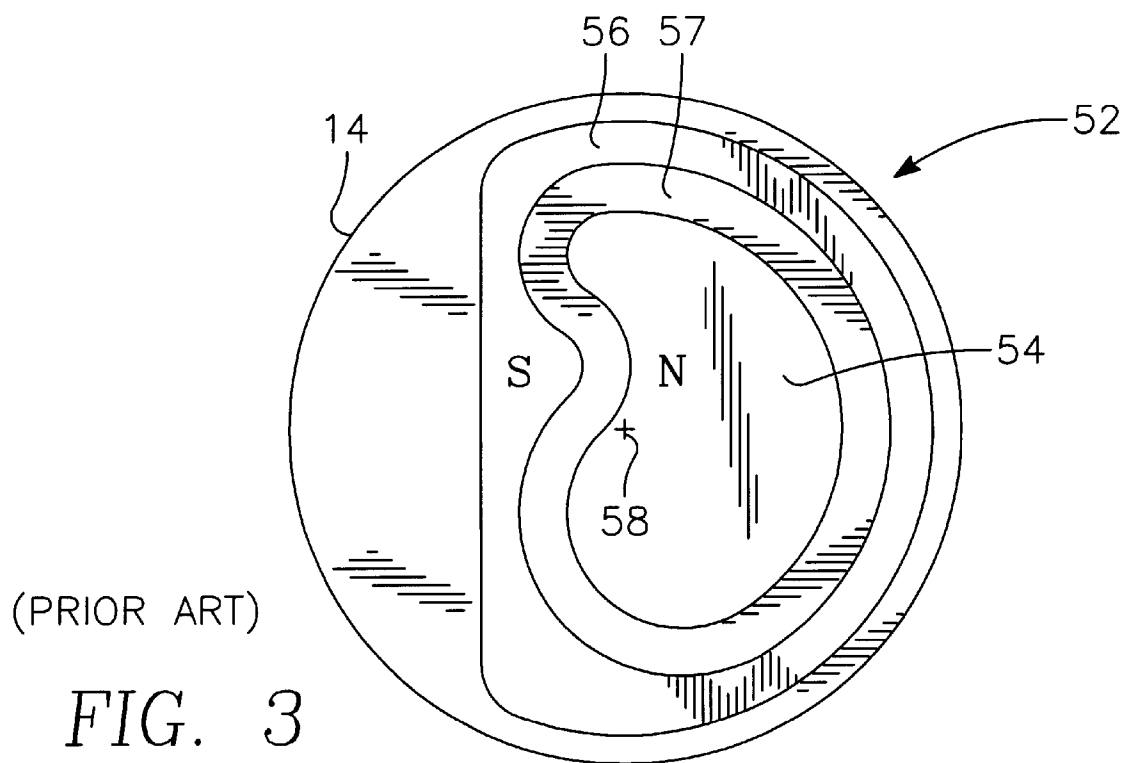


FIG. 3

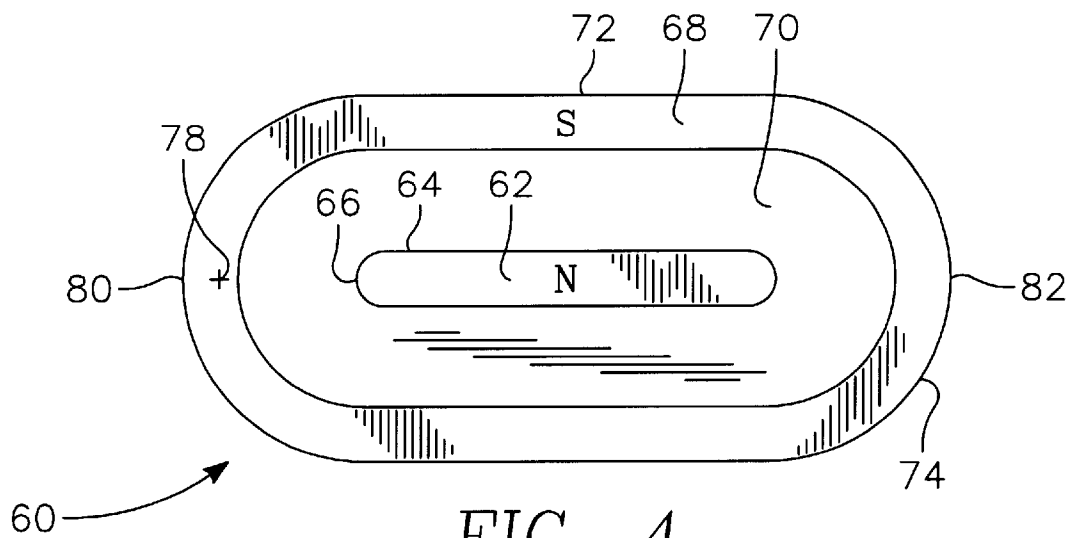


FIG. 4

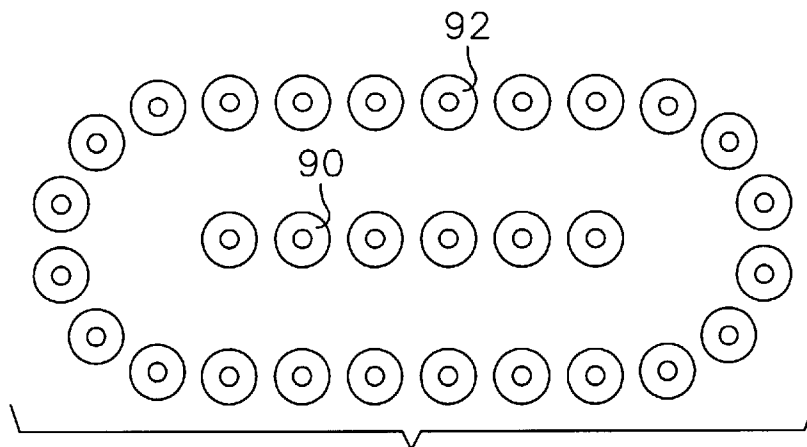


FIG. 5

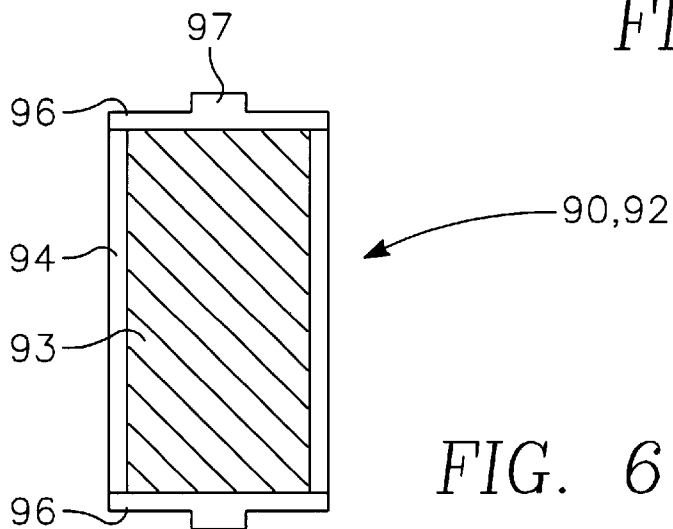
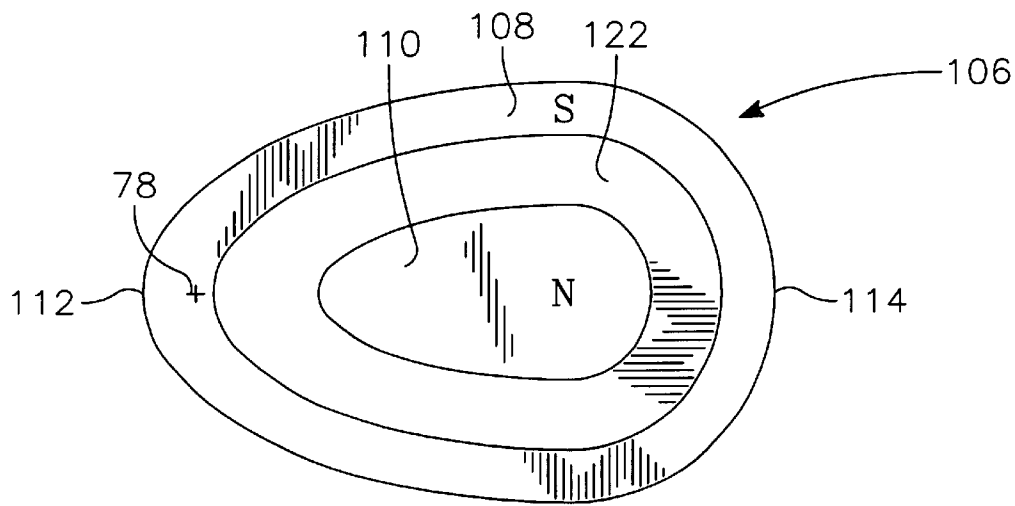
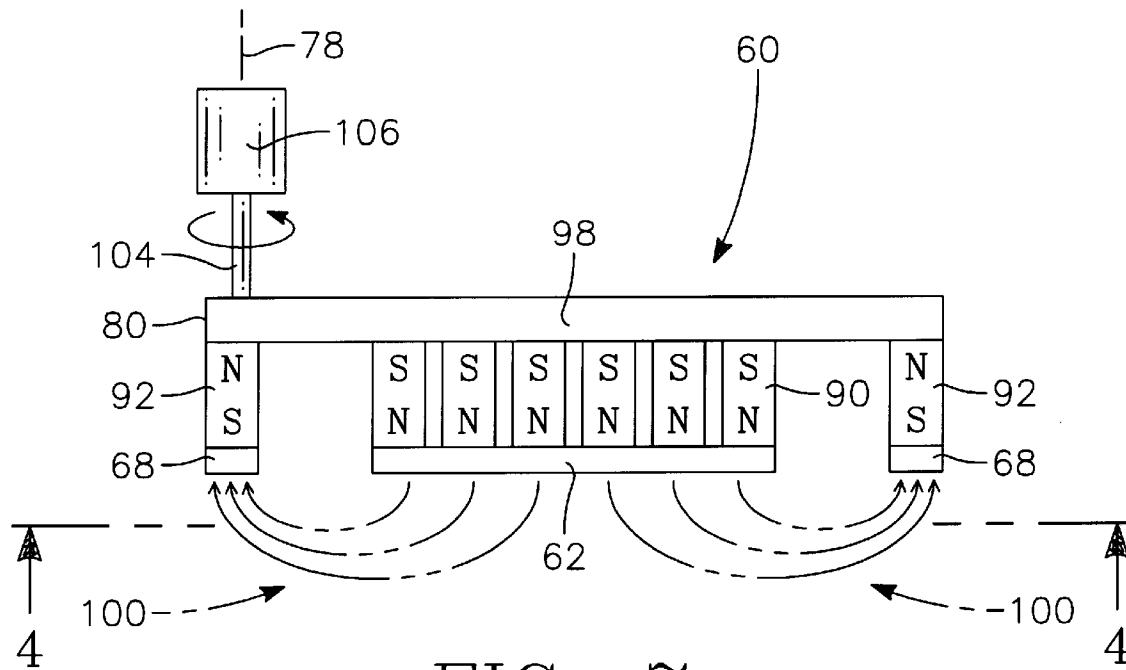


FIG. 6



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