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(12) **United States Patent**  
**Chistyakov**

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(54) **PLASMA GENERATION USING MULTI-STEP IONIZATION**

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(73) Assignee: **Zond, Inc., Mansfield, MA (US)**

(\* ) 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**

The present invention relates to a plasma generator that generates a plasma with a multi-step ionization process. The plasma generator includes an excited atom source that generates excited atoms from ground state atoms supplied by a feed gas source. A plasma chamber confines a volume of excited atoms generated by the excited atom source. An energy source is coupled to the volume of excited atoms confined by the plasma chamber. The energy source raises an energy of excited atoms in the volume of excited atoms so that at least a portion of the excited atoms in the volume of excited atoms is ionized, thereby generating a plasma with a multi-step ionization process.

**46 Claims, 13 Drawing Sheets-**

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(51) Int. Cl.<sup>7</sup> ..... **C23C 14/00; C23C 16/00; H01J 7/24**

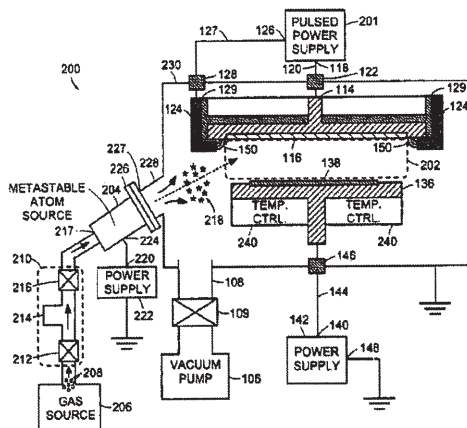
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(58) Field of Search ..... **315/111.81, 111.91, 315/111.71, 111.41, 111.21; 204/298.37, 298.38, 298.36; 118/723 VE, 723 R, 723 EB, 723 E; 250/28, 283, 377, 423, 435, 489**

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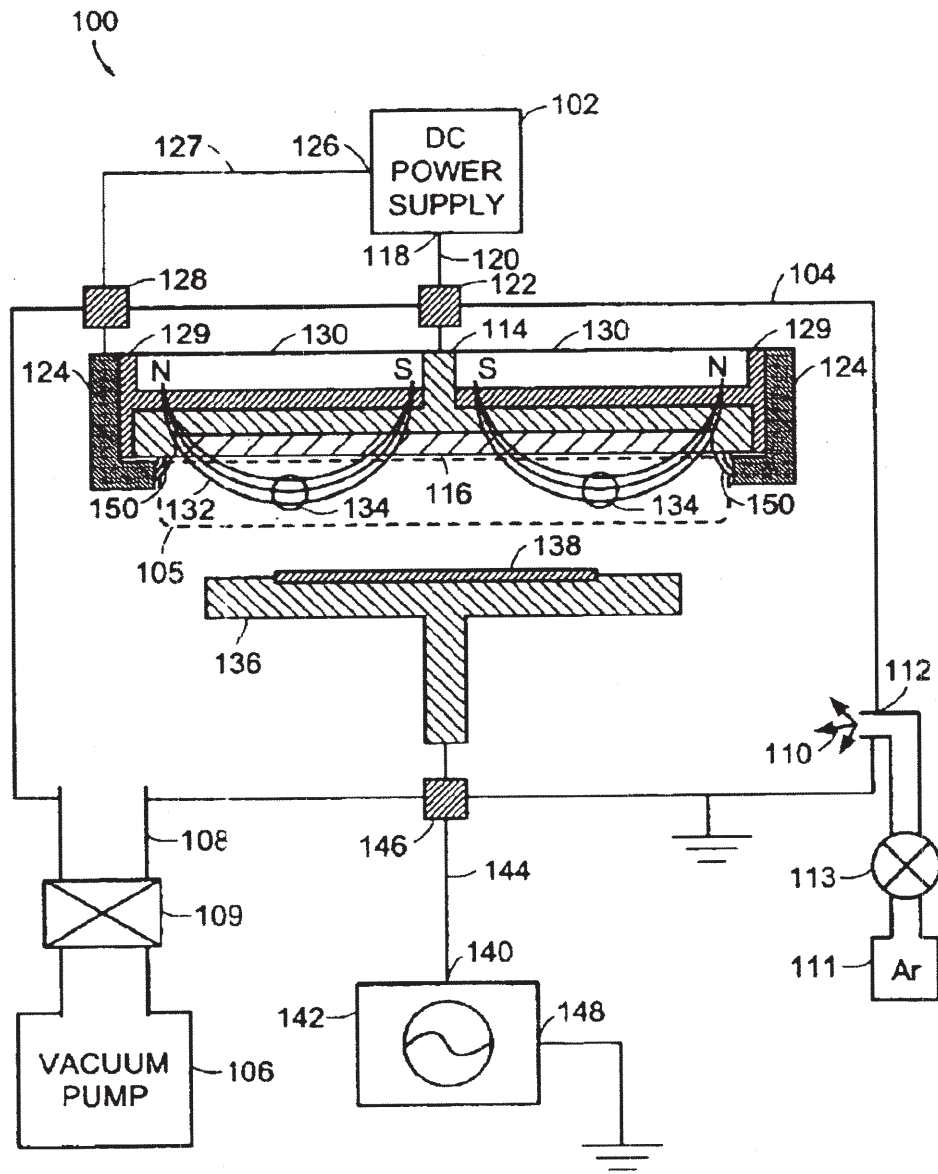


FIG. 1  
PRIOR ART

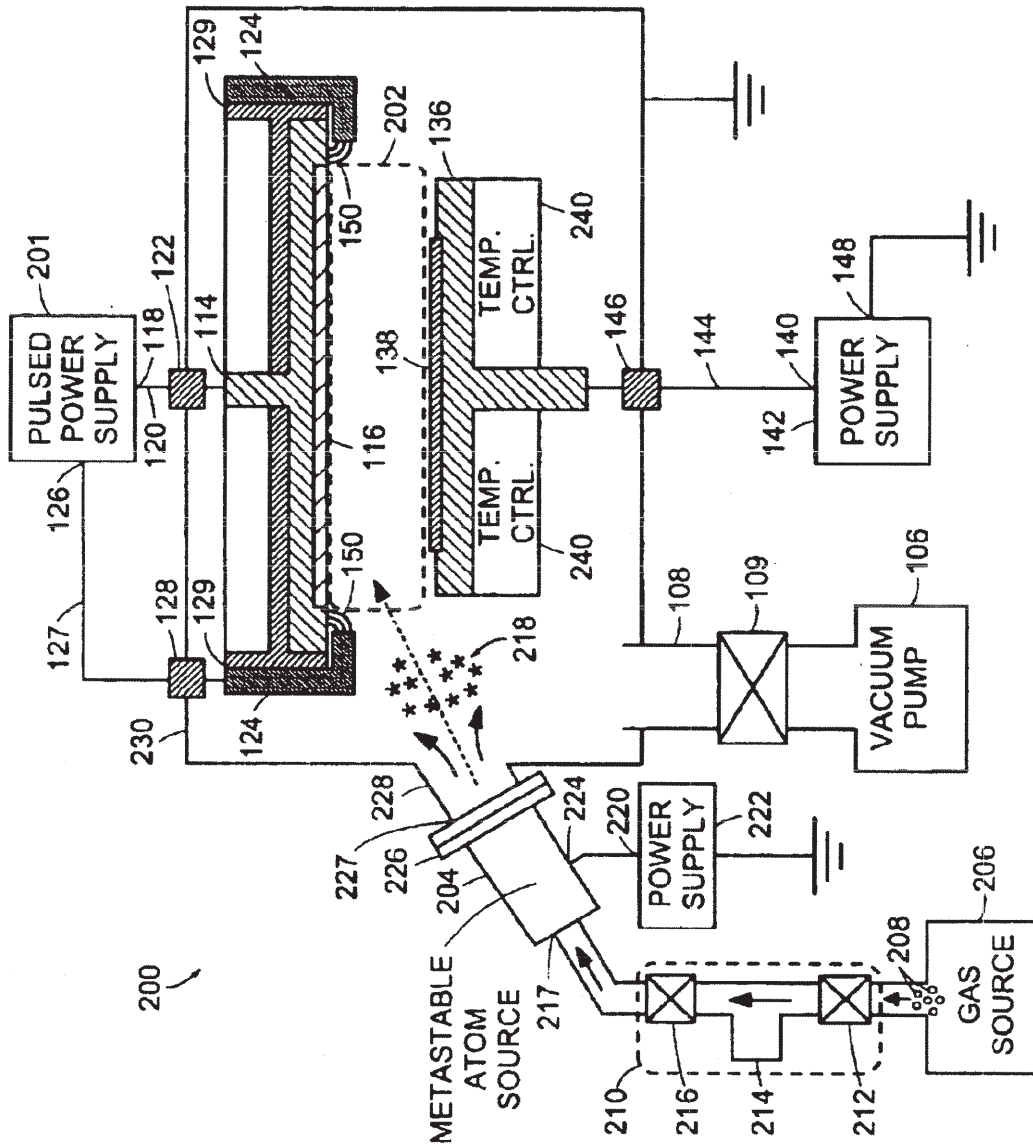


FIG. 2

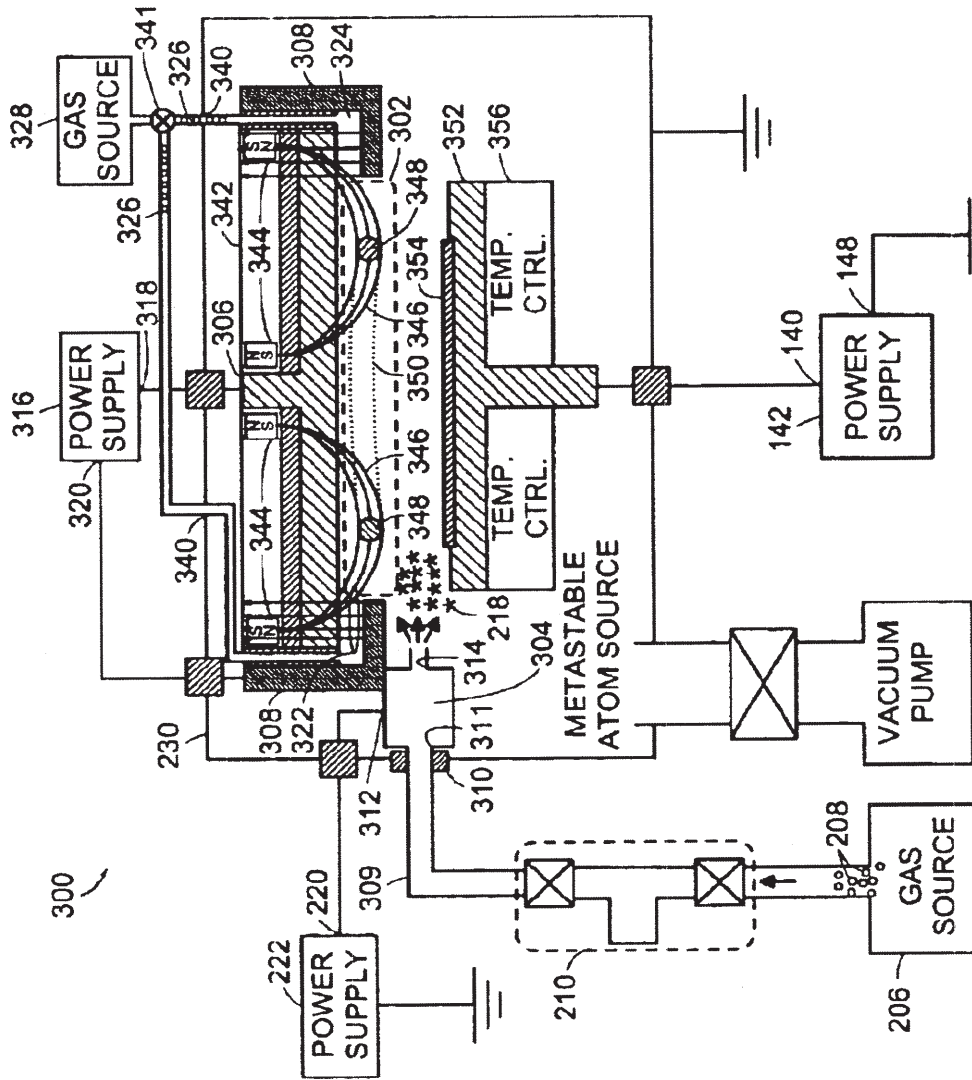


FIG. 3

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