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

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(54) **HIGH-DENSITY PLASMA SOURCE USING EXCITED ATOMS**

FOREIGN PATENT DOCUMENTS

(75) Inventor: **Roman Chistyakov**, Andover, MA (US)

WO WO 98/40532 9/1998  
WO WO 01/98553 A1 12/2001

(73) Assignee: **Zond, Inc.**, Mansfield, MA (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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This patent is subject to a terminal disclaimer.

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(21) Appl. No.: **10/249,844**

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(22) Filed: **May 12, 2003**

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**Related U.S. Application Data**

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(63) Continuation-in-part of application No. 10/249,595, filed on Apr. 22, 2003.

(51) **Int. Cl.**<sup>7</sup> ..... **H01J 7/24**

*Primary Examiner*—Don Wong

(52) **U.S. Cl.** ..... **315/111.21; 315/111.41; 156/345.44; 118/723 DC**

*Assistant Examiner*—Ephrem Alemu

(58) **Field of Search** ..... 315/111.21, 111.41, 315/111.61, 111.71, 111.81, 111.91; 204/298.07, 298.08, 298.121, 298.161, 298.2, 298.21, 298.22; 156/345.33, 345.35, 345.38, 345.39, 345.4, 345.41, 345.42, 345.43, 345.44, 345.46; 118/723 ME, 723 DC, 723 I, 723 IR

(74) *Attorney, Agent, or Firm*—Kurt Rauschenbach; Rauschenbach Patent Law Group, LLC

(57) **ABSTRACT**

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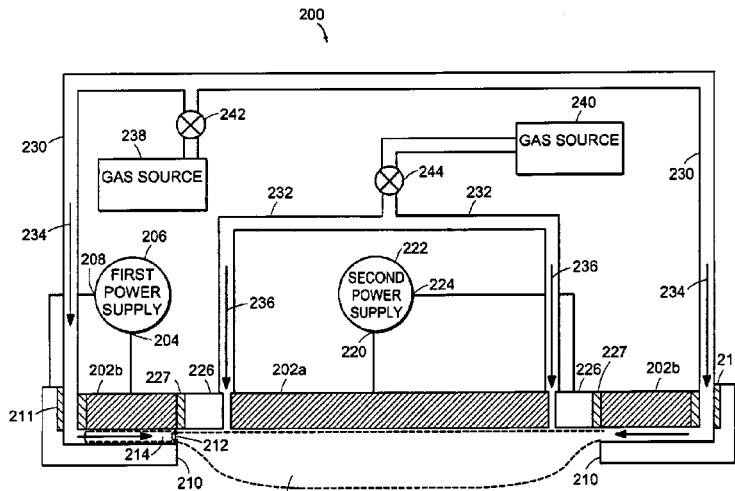
The plasma source includes a cathode assembly. An anode is positioned adjacent to the cathode assembly. An excited atom source generates an initial plasma and excited atoms from a volume of feed gas. The initial plasma and excited atoms are located proximate to the cathode assembly. A power supply generates an electric field between the cathode assembly and the anode. The electric field super-ionizes the initial plasma so as to generate a high-density plasma.

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**35 Claims, 19 Drawing Sheets**



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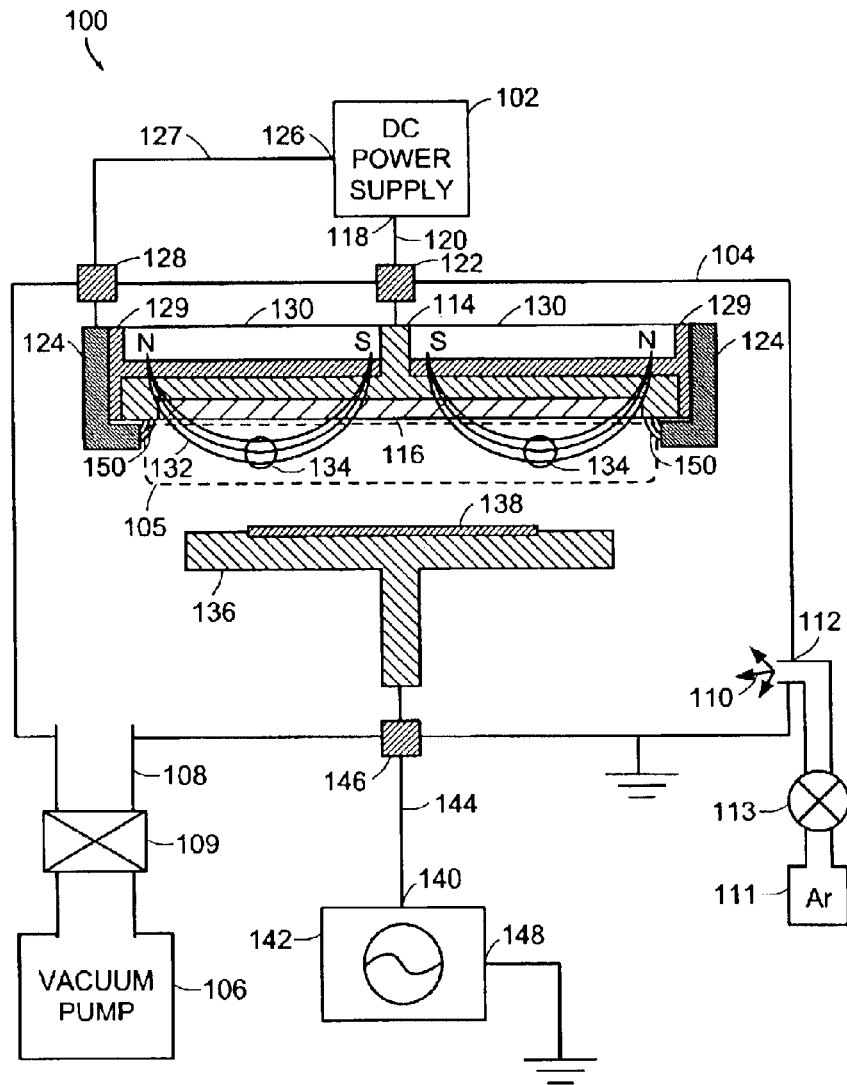


FIG. 1  
PRIOR ART

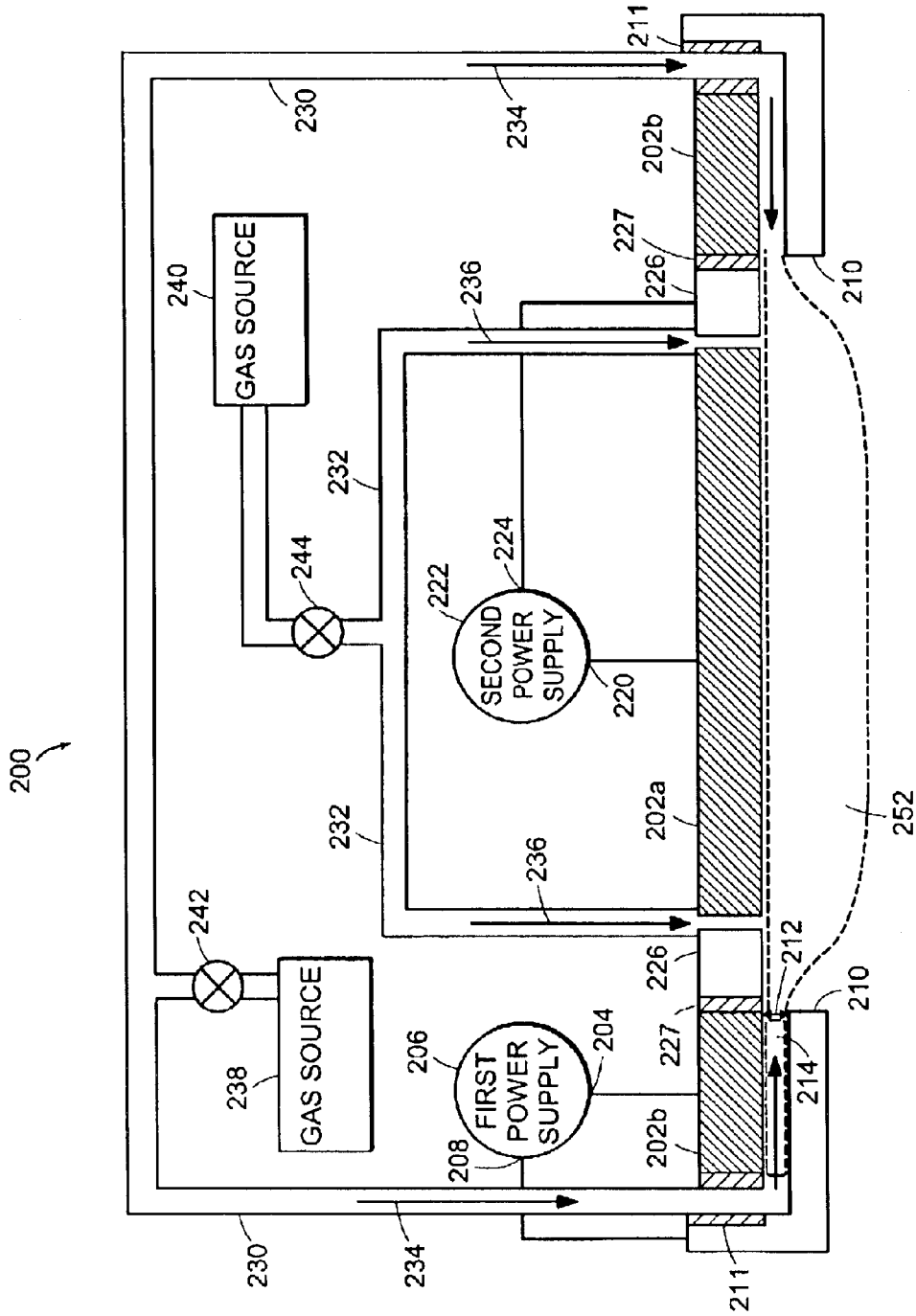


FIG. 2A

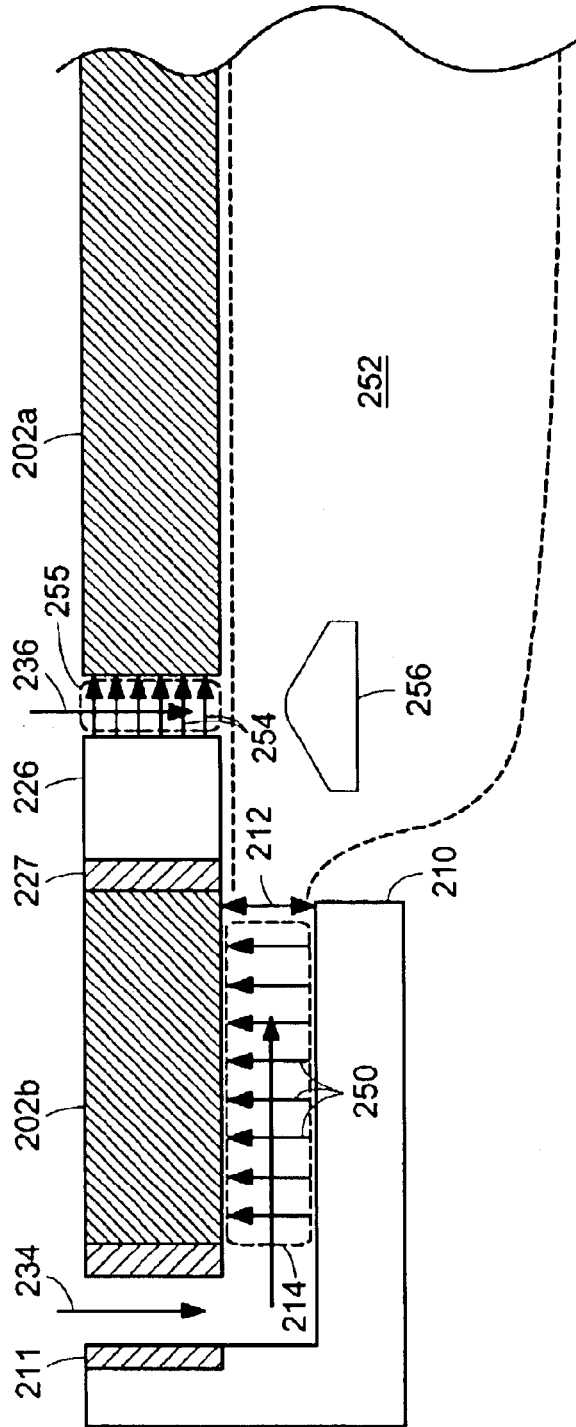


FIG. 2B

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