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**H01S 3/134** (2006.01)

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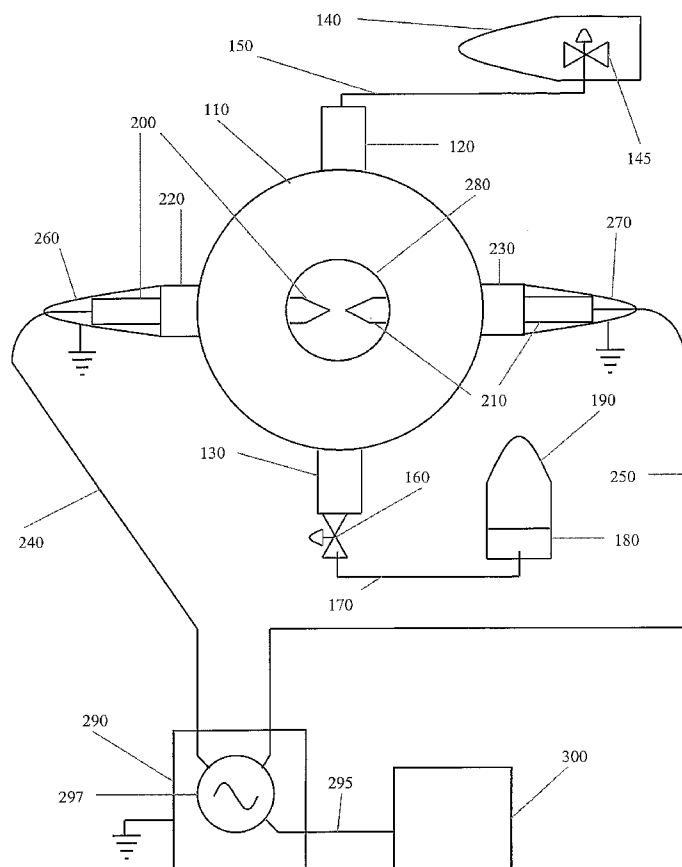
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[Continued on next page]

(54) Title: HIGH FREQUENCY DRIVEN HIGH PRESSURE MICRO DISCHARGE



(57) Abstract: A method and apparatus are provided for generating light such as ultraviolet light from excimer-forming gases. Gases are excited by radio frequency alternating current powered electrodes (200, 210) to form excimers that will decay and emit vacuum ultraviolet light. The halogen concentration is optimized so as to optimize emissions from halogen excimers ( $Z_2^*$ ) or mixed rare gas/halogen excimers ( $RGZ^*$ ). Emissions from rare gas excimers ( $RG_2^*$ ) are maximized by maintaining the gas in the discharge region at a relatively low temperature, desirably below 700 °K, so that the average kinetic energy of gas particles is less than the vibrational excitation energy of the excimer and substantially less than the dissociation energy of the excimer. Relatively large electrodes (202, 204) can be used to cool the plasma.



European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,  
FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE,  
SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN,  
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# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US04/24737

| <b>A. CLASSIFICATION OF SUBJECT MATTER</b><br>IPC: <b>H01S 3/134</b> ( 2006.01)<br><br>USPC: 250/504R;372/85,87,57,58,58;313/637,642,643<br>According to International Patent Classification (IPC) or to both national classification and IPC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                 |                                                                           |                                                                                                                                                                                                                                              |                                                                                    |                       |                                                                                                                                                                                                 |                                                                                                                                      |                                                                                                      |     |                                                                                                                                                                                 |                 |                                                                                   |                                                        |                                                                                                                                                                                                                                              |     |                                                                                                                                                                     |           |                                           |                                                                                                                                  |                                                                          |  |  |     |                                                                                                    |  |  |
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| <b>B. FIELDS SEARCHED</b><br><br>Minimum documentation searched (classification system followed by classification symbols)<br>U.S. : 250/504R;372/85,87,57,58,58;313/637,642,643<br><br>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched<br><br>Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)<br>INSPEC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                 |                                                                           |                                                                                                                                                                                                                                              |                                                                                    |                       |                                                                                                                                                                                                 |                                                                                                                                      |                                                                                                      |     |                                                                                                                                                                                 |                 |                                                                                   |                                                        |                                                                                                                                                                                                                                              |     |                                                                                                                                                                     |           |                                           |                                                                                                                                  |                                                                          |  |  |     |                                                                                                    |  |  |
| <b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b> <table border="1"> <thead> <tr> <th>Category *</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X<br/>---<br/>Y</td> <td>US 20020101902 A1 (ALBRECHT, et al) 01 August 2002 paragraph 0007, paragraph 0012, paragraph 0030, paragraph 0097, Fig. 13a Fig. 14a</td> <td>1, 4, 6-10, 15, 18, 20 and 25<br/>-----<br/>2, 3, 16, 17, 13, 23, 14 and 24</td> </tr> <tr> <td>Y</td> <td>El-Habachi, et al ("Emission of excimer radiation from direct current, high-pressure hollow cathode discharges" Appl. Phys. Lett., Vol. 72., No. 1, pp. 22-24, 5 January 1998).</td> <td>2, 3, 16 and 17</td> </tr> <tr> <td>Y</td> <td>US 6,400,089 (SALVERMOSER, et al) 04 June 2002 Fig. 16</td> <td>13 and 23</td> </tr> <tr> <td>Y</td> <td>US 5,729,565 (Meller, et al ) 17 March 1998 Fig. 1</td> <td>14 and 24</td> </tr> <tr> <td>A</td> <td>Switkes, et al ("Imaging of 1-nm-thick films with 193-nm microscopy" Optics Letters, Vol. 26, No. 15 August 1, 2001 pp.1182-1184</td> <td></td> </tr> </tbody> </table>                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                 |                                                                           | Category *                                                                                                                                                                                                                                   | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. | X<br>---<br>Y                                                                                                                                                                                   | US 20020101902 A1 (ALBRECHT, et al) 01 August 2002 paragraph 0007, paragraph 0012, paragraph 0030, paragraph 0097, Fig. 13a Fig. 14a | 1, 4, 6-10, 15, 18, 20 and 25<br>-----<br>2, 3, 16, 17, 13, 23, 14 and 24                            | Y   | El-Habachi, et al ("Emission of excimer radiation from direct current, high-pressure hollow cathode discharges" Appl. Phys. Lett., Vol. 72., No. 1, pp. 22-24, 5 January 1998). | 2, 3, 16 and 17 | Y                                                                                 | US 6,400,089 (SALVERMOSER, et al) 04 June 2002 Fig. 16 | 13 and 23                                                                                                                                                                                                                                    | Y   | US 5,729,565 (Meller, et al ) 17 March 1998 Fig. 1                                                                                                                  | 14 and 24 | A                                         | Switkes, et al ("Imaging of 1-nm-thick films with 193-nm microscopy" Optics Letters, Vol. 26, No. 15 August 1, 2001 pp.1182-1184 |                                                                          |  |  |     |                                                                                                    |  |  |
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| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Switkes, et al ("Imaging of 1-nm-thick films with 193-nm microscopy" Optics Letters, Vol. 26, No. 15 August 1, 2001 pp.1182-1184                                                |                                                                           |                                                                                                                                                                                                                                              |                                                                                    |                       |                                                                                                                                                                                                 |                                                                                                                                      |                                                                                                      |     |                                                                                                                                                                                 |                 |                                                                                   |                                                        |                                                                                                                                                                                                                                              |     |                                                                                                                                                                     |           |                                           |                                                                                                                                  |                                                                          |  |  |     |                                                                                                    |  |  |
| <input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                 |                                                                           |                                                                                                                                                                                                                                              |                                                                                    |                       |                                                                                                                                                                                                 |                                                                                                                                      |                                                                                                      |     |                                                                                                                                                                                 |                 |                                                                                   |                                                        |                                                                                                                                                                                                                                              |     |                                                                                                                                                                     |           |                                           |                                                                                                                                  |                                                                          |  |  |     |                                                                                                    |  |  |
| <table border="0"> <tr> <td colspan="2">* Special categories of cited documents:</td> <td>"T"</td> <td>later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</td> </tr> <tr> <td>"A"</td> <td>document defining the general state of the art which is not considered to be of particular relevance</td> <td>"X"</td> <td>document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</td> </tr> <tr> <td>"E"</td> <td>earlier application or patent published on or after the international filing date</td> <td>"Y"</td> <td>document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</td> </tr> <tr> <td>"L"</td> <td>document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</td> <td>"&amp;"</td> <td>document member of the same patent family</td> </tr> <tr> <td>"O"</td> <td>document referring to an oral disclosure, use, exhibition or other means</td> <td></td> <td></td> </tr> <tr> <td>"P"</td> <td>document published prior to the international filing date but later than the priority date claimed</td> <td></td> <td></td> </tr> </table> |                                                                                                                                                                                 |                                                                           | * Special categories of cited documents:                                                                                                                                                                                                     |                                                                                    | "T"                   | later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention | "A"                                                                                                                                  | document defining the general state of the art which is not considered to be of particular relevance | "X" | document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone        | "E"             | earlier application or patent published on or after the international filing date | "Y"                                                    | document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art | "L" | document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) | "&"       | document member of the same patent family | "O"                                                                                                                              | document referring to an oral disclosure, use, exhibition or other means |  |  | "P" | document published prior to the international filing date but later than the priority date claimed |  |  |
| * Special categories of cited documents:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                 | "T"                                                                       | later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention                                              |                                                                                    |                       |                                                                                                                                                                                                 |                                                                                                                                      |                                                                                                      |     |                                                                                                                                                                                 |                 |                                                                                   |                                                        |                                                                                                                                                                                                                                              |     |                                                                                                                                                                     |           |                                           |                                                                                                                                  |                                                                          |  |  |     |                                                                                                    |  |  |
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| "L"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)             | "&"                                                                       | document member of the same patent family                                                                                                                                                                                                    |                                                                                    |                       |                                                                                                                                                                                                 |                                                                                                                                      |                                                                                                      |     |                                                                                                                                                                                 |                 |                                                                                   |                                                        |                                                                                                                                                                                                                                              |     |                                                                                                                                                                     |           |                                           |                                                                                                                                  |                                                                          |  |  |     |                                                                                                    |  |  |
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| Date of the actual completion of the international search<br>19 June 2008 (19.06.2008)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                 | Date of mailing of the international search report<br><b>09 JUL 2008</b>  |                                                                                                                                                                                                                                              |                                                                                    |                       |                                                                                                                                                                                                 |                                                                                                                                      |                                                                                                      |     |                                                                                                                                                                                 |                 |                                                                                   |                                                        |                                                                                                                                                                                                                                              |     |                                                                                                                                                                     |           |                                           |                                                                                                                                  |                                                                          |  |  |     |                                                                                                    |  |  |
| Name and mailing address of the ISA/US<br>Mail Stop PCT, Attn: ISA/US<br>Commissioner for Patents<br>P.O. Box 1450<br>Alexandria, Virginia 22313-1450<br>Facsimile No. (571) 273-3201                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                 | Authorized officer<br>Robert Kim<br>Telephone No. 571/272-2000            |                                                                                                                                                                                                                                              |                                                                                    |                       |                                                                                                                                                                                                 |                                                                                                                                      |                                                                                                      |     |                                                                                                                                                                                 |                 |                                                                                   |                                                        |                                                                                                                                                                                                                                              |     |                                                                                                                                                                     |           |                                           |                                                                                                                                  |                                                                          |  |  |     |                                                                                                    |  |  |