



[54] METHODS AND APPARATUS FOR GENERATING PLASMA

Assistant Examiner—Joni Y. Chang  
Attorney, Agent, or Firm—Hickman Beyer & Weaver

[75] Inventor: Robert D. Dible, Fremont, Calif.

[57] ABSTRACT

[73] Assignee: Lam Research Corporation, Fremont, Calif.

A device for generating plasma for use in semiconductor fabrication, which includes a first radio frequency excitation source for outputting a first excitation current having a first phase and a first amplitude. The device further includes a second radio frequency excitation source for outputting a second excitation current having a second phase and a second amplitude and a plasma generating element having a first end and a second end for receiving respectively the first excitation current and the second excitation current. Moreover, the inventive device includes a control circuit having a control input for receiving a user-variable signal indicative of a desired phase difference between the first phase and the second phase. The control circuit, responsive to the control input, outputs a control signal to one of the first radio frequency excitation source and the second radio frequency excitation source for controlling respectively one of the first phase and the second phase, thereby causing an actual phase difference between the first phase and the second phase to substantially approximate the desired phase difference. In so doing, the device becomes essentially an inductive coupling device when the first phase and the second phase are opposite in phase. When the first phase and the second phase are in phase, the device becomes essentially a capacitive coupling device. Finally, when the first phase and the second phase differs by an angle that is between in phase and opposite in phase, the device becomes a combination inductive and capacitive coupling device.

[21] Appl. No.: 536,574

[22] Filed: Sep. 29, 1995

[51] Int. Cl.<sup>6</sup> ..... C23C 16/00

[52] U.S. Cl. .... 118/723 MP; 118/723 E; 118/723 I; 156/643.1; 427/569

[58] Field of Search ..... 118/723 E, 723 ER, 118/723 MP, 723 I, 723 IR; 156/643.1, 345, 627.1; 216/68, 71; 204/298.34, 298.08, 298.06, 298.12; 427/569

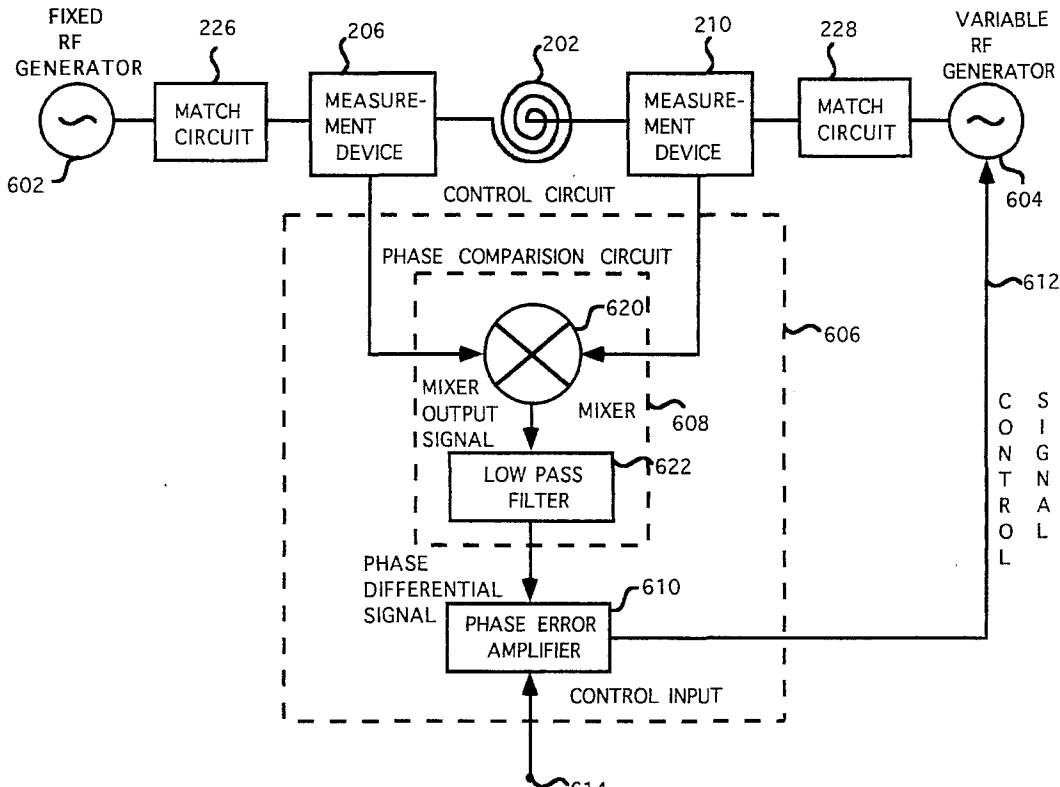
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Primary Examiner—R. Bruce Breneman

23 Claims, 7 Drawing Sheets



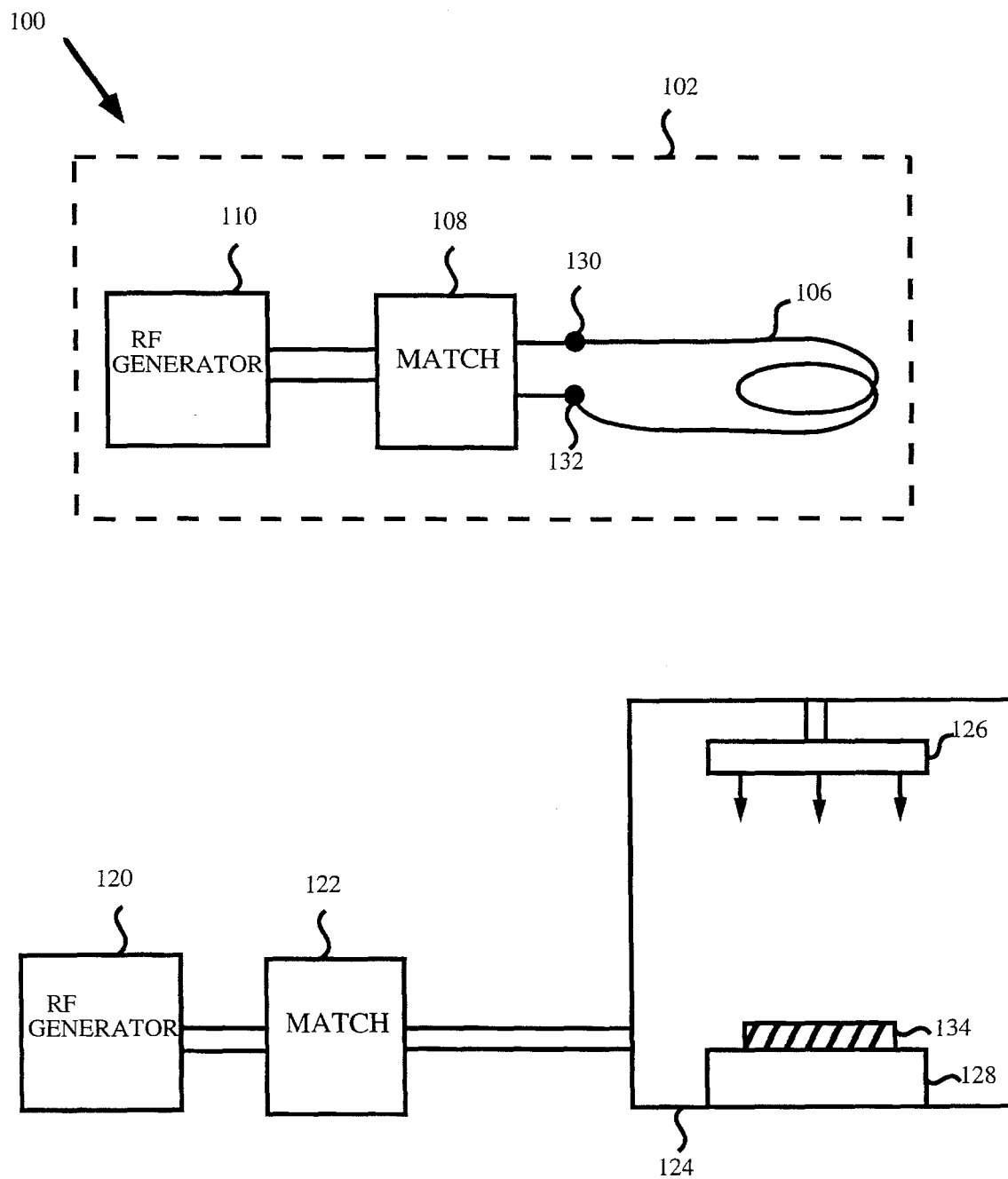


FIG. 1

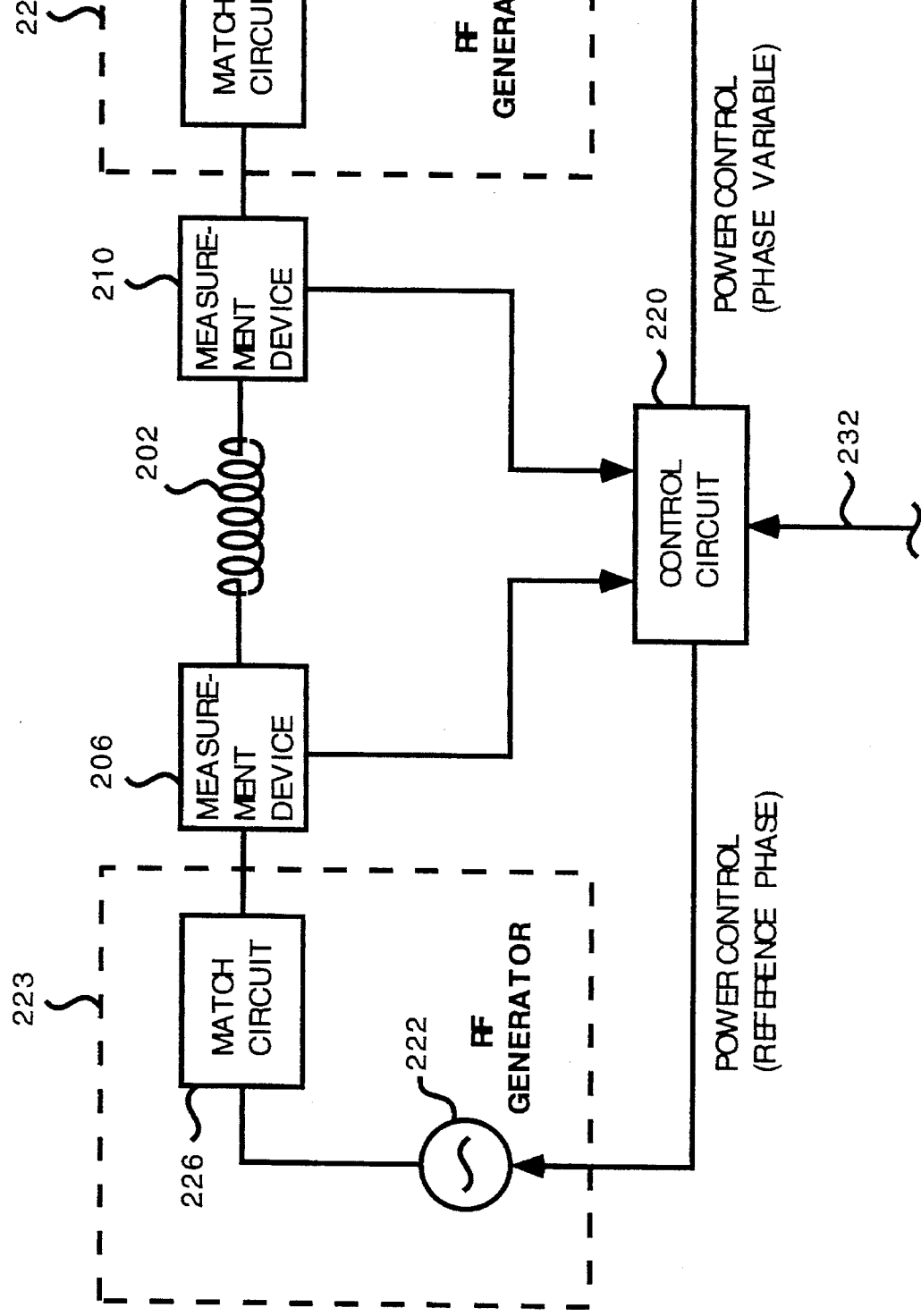


FIG. 2

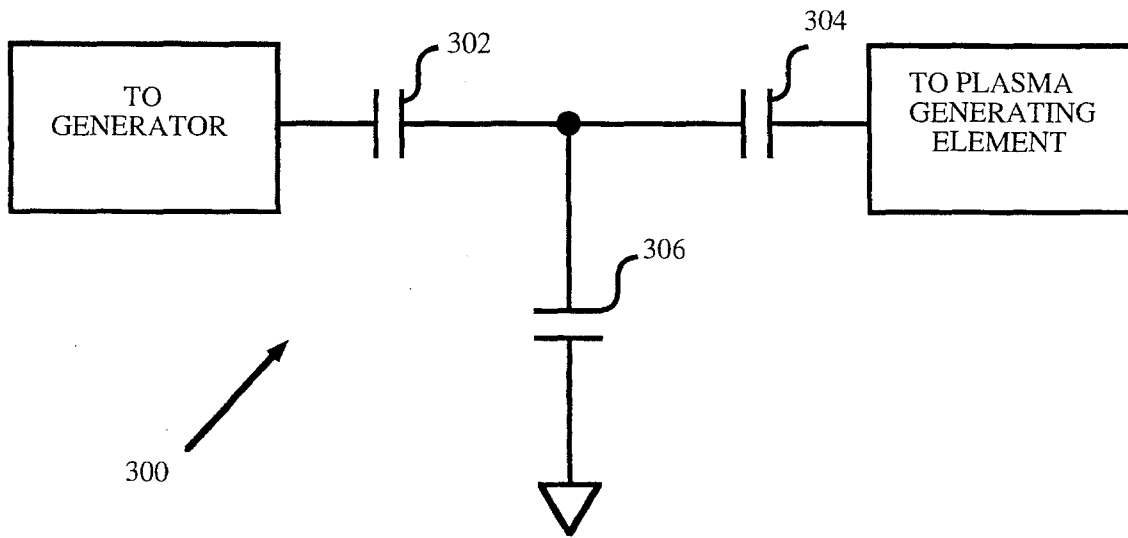


FIG. 3

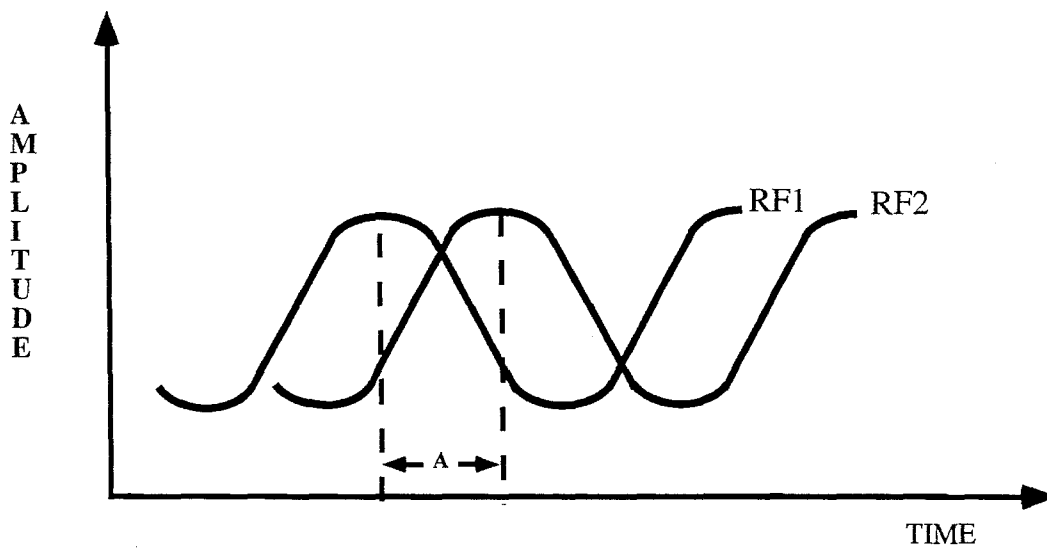
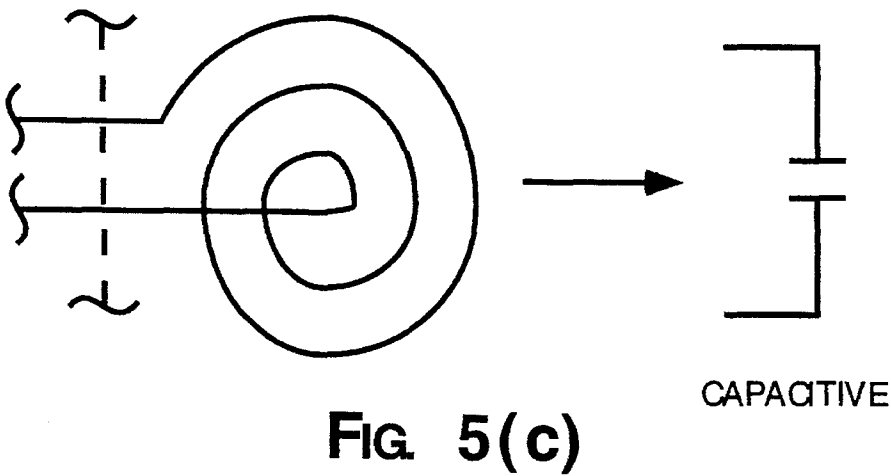
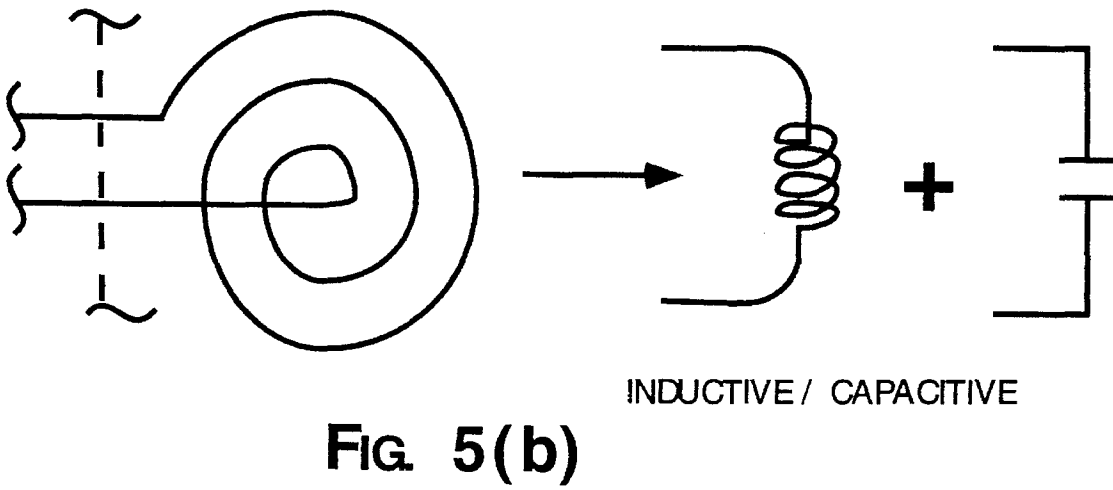
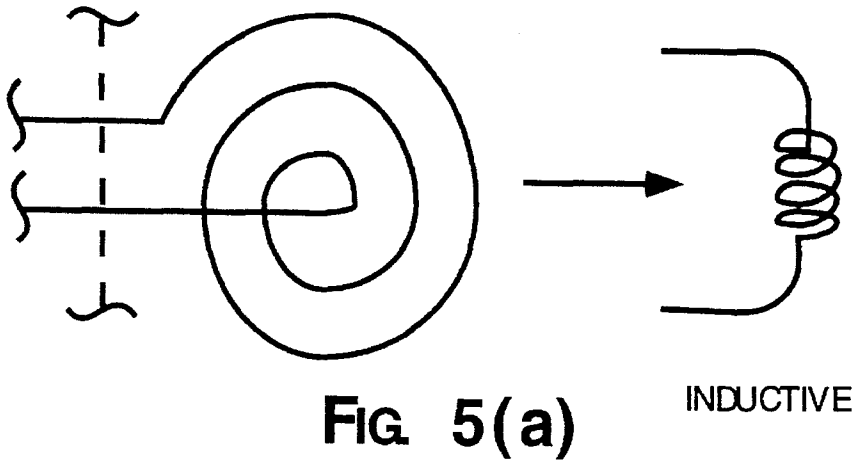


FIG. 4



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