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Flamm et al.

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[54] **PROCESS OPTIMIZATION IN GAS PHASE DRY ETCHING**

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[52] U.S. Cl. .... **156/643.1**; 156/625.1; 156/346 P; 156/626.1; 156/659.11; 156/646.1; 204/298.31; 204/298.32; 216/58; 216/59

[58] Field of Search .... 204/298.31, 298.32; 216/39, 58, 74, 79, 246 P, 625.1, 643.1, 626.1, 646.1, 659.1, 662.1, 659.11

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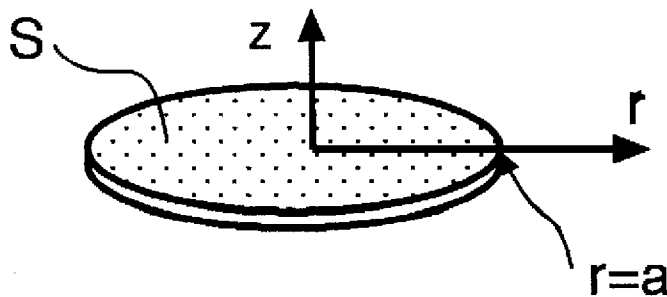Manos et al. "Plasma Etching, An Introduction", © 1989, Academic Press, pp. 91–183.

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[57] **ABSTRACT**

A method of designing a reactor **10**. The present reactor design method includes steps of providing a first plasma etching apparatus **10** having a substrate **21** therein. The substrate includes a top surface and a film overlying the top surface, and the film having a top film surface. The present reactor design method also includes chemical etching the top film surface to define a profile **27** on the film, and defining etch rate data from the profile region. A step of extracting a reaction rate constant from the etch rate data, and a step of using the reaction rate constant in designing a second plasma etching apparatus is also included.
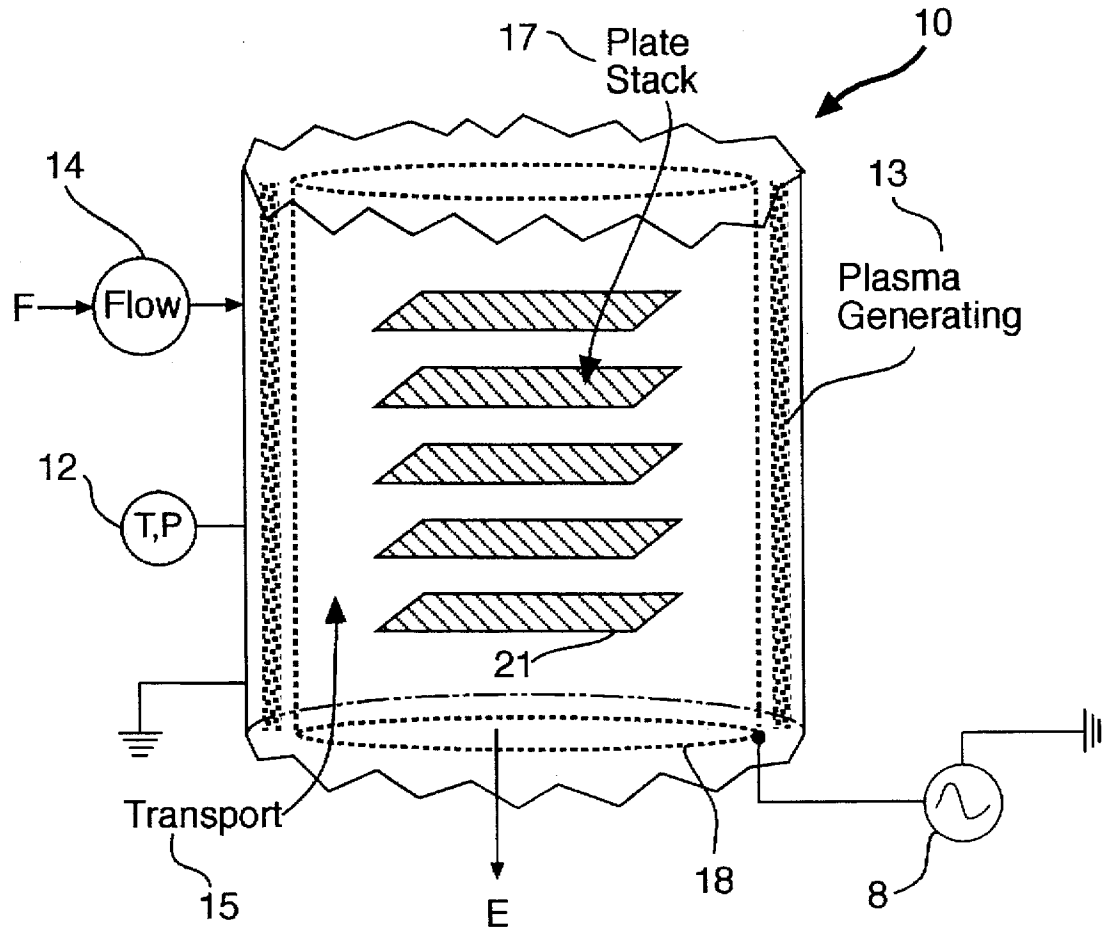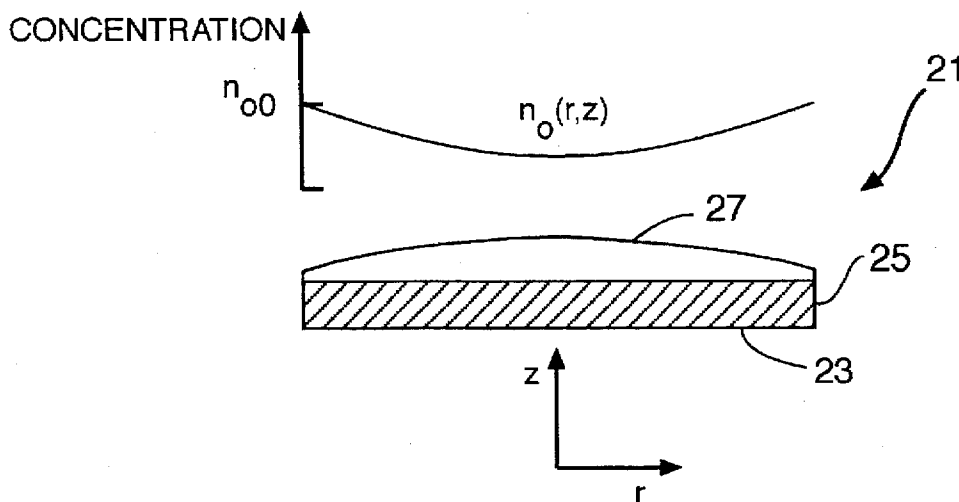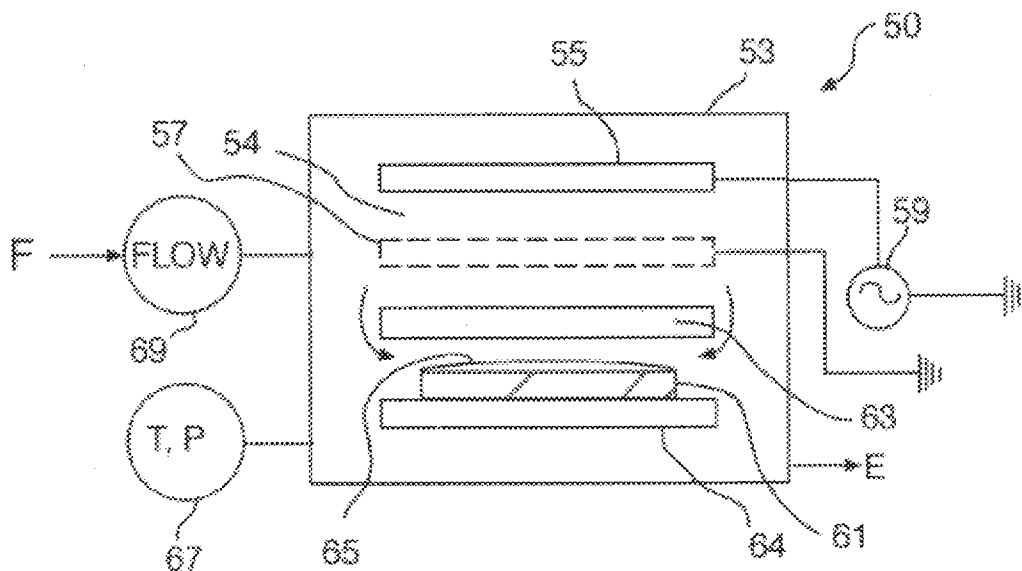
29 Claims, 8 Drawing Sheets

FIG. 1

FIG. 1A

FIG. 2

FIG. 5A

Measure etch profile — 100

Etch film at constant pressure and preferably constant plasma source characteristics and: I. do not etch to endpoint or 2. Etch exactly to first sign of endpoint. Best to do isothermally, but can probably handle complex case if measure temperature-time history. — 101

Get etch rate profile data as (Etch rate,x,y) or (Etch rate, r, θ) triads, an n x 3 array where n is the number of points sampled. If temperature varies it will be average etch rate. — 103

Fit to model with k_{vo}/D and etch rate as parameters

105

Run a least squares fit using differences between the data array and analytical model for etch rate to compute: kv_o/D and the etch rate at edge of the plate or wafer.

Calculate D and with it k_{vo} & k_s

106

New temperatures in order to get $k_s(T_2)$, $k_s(T_3)$ ... — 107

108

Calculate D from Chapman-Enskog kinetic theory formulas (see R. B. Bird, W. E. Steward, E. N. Lightfoot, pp. 510-513, Transport Phenomena, Wiley (1960). Multiply k_{vo}/D by D(T,P) to obtain $k_{vo}(T,d_{gap}) = k_s(T)(Area/Volume)=k_s/d_{gap}$

Separate pre-exp & E_a

109

From $k_s(T_1)$, $k_s(T_2)$... do least square fit to extract E_a and preexponential where $k_s(T)=A(T^{1/2})Ae^{-Ea/kT}$ Or, if E_a is known, just extract preexponential.

111

Use ER(edge)=$k_{vo} n_o$ to deduce n_o, the atom concentration at the edge of the wafer.

FIG. 3

FIG. 4

DOCKET ALARM
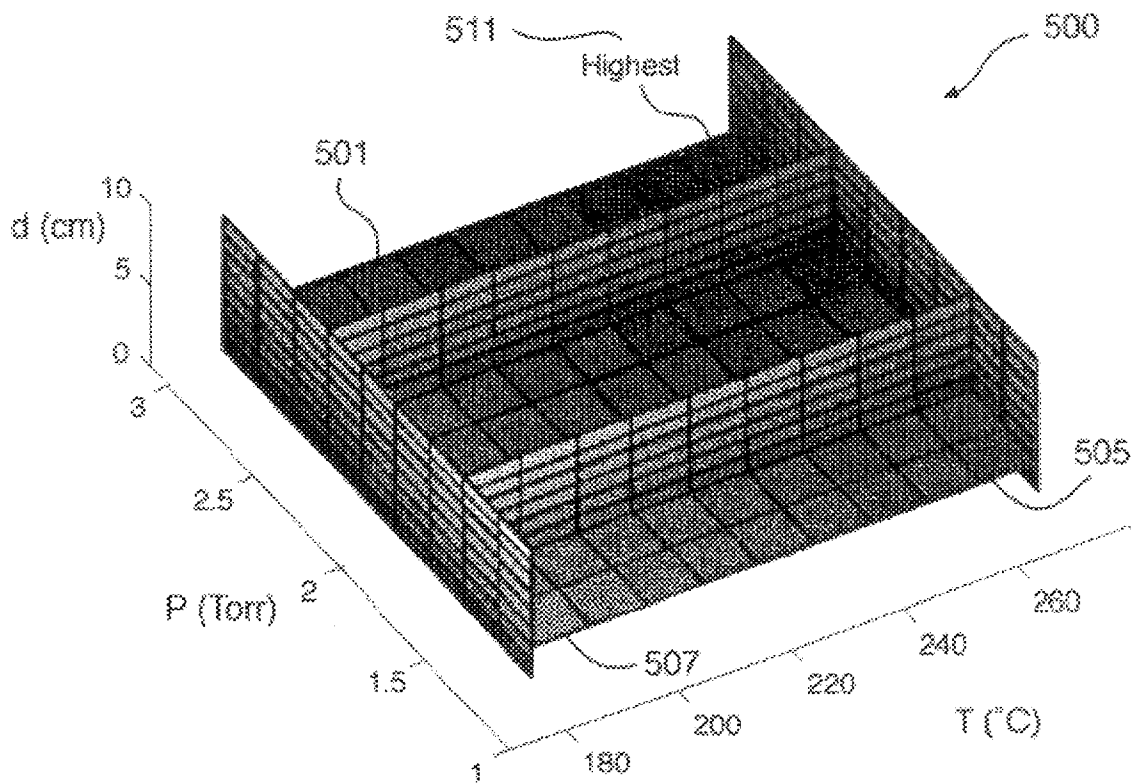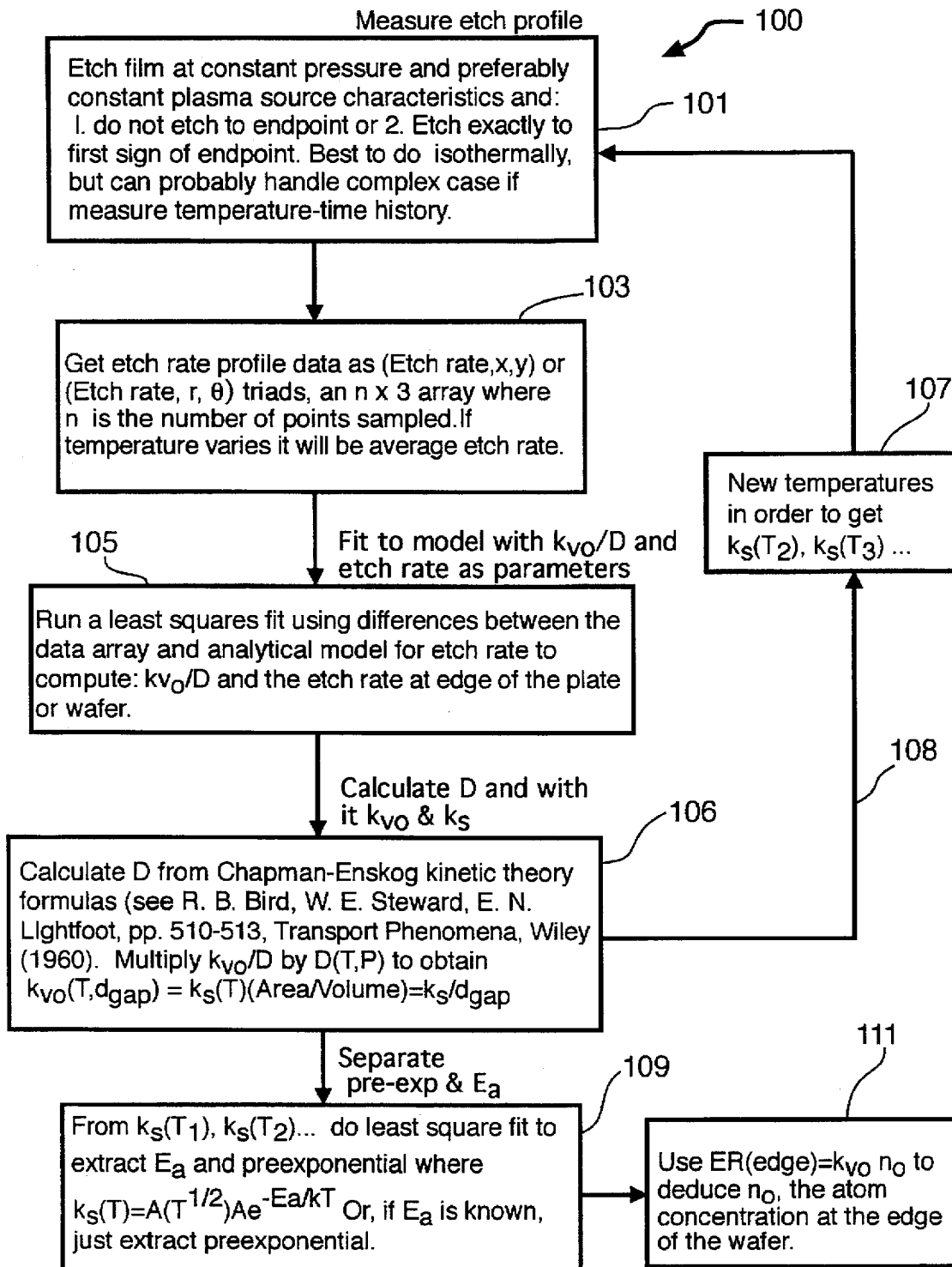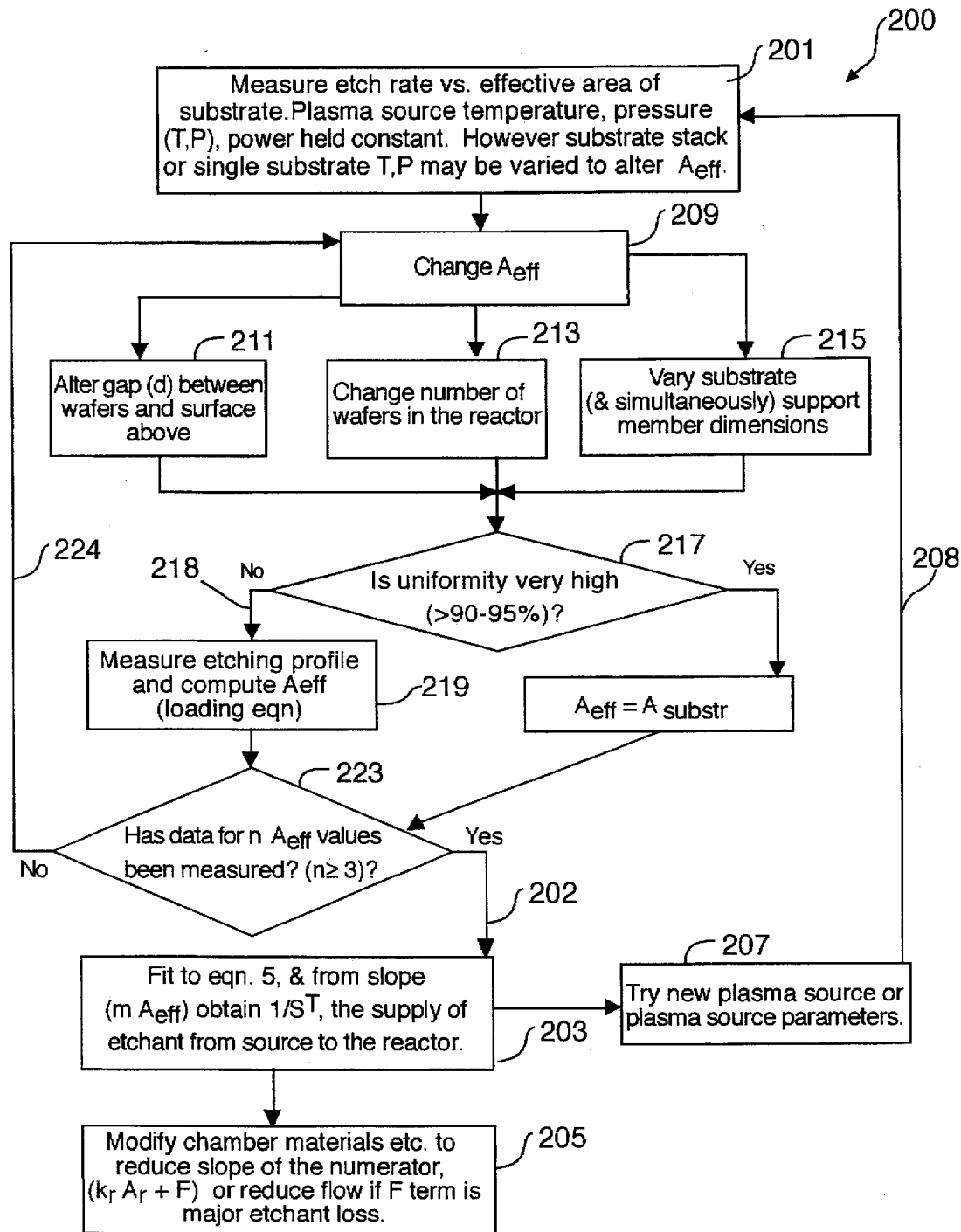
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