US005320982A

United States Patent [19]

Tsubone et al.

[11] Patent Number: 5,320,982

[45] Date of Patent: Jun. 14, 1994

[54] **WAFER COOLING METHOD AND APPARATUS**

[75] Inventors: **Tsunehiko Tsubone**, Hikari; **Naoyuki Tamura**, Kudamatsu; **Shigekazu Kato**, Kudamatsu; **Kouji Nishihata**, Tokuyama; **Atsushi Itou**, Kudamatsu, all of Japan

[73] Assignee: **Hitachi, Ltd.**, Tokyo, Japan

[21] Appl. No.: **724,801**

[22] Filed: **Jul. 2, 1991**

[30] **Foreign Application Priority Data**

Jul. 2, 1990 [JP] Japan 2-172757

[51] **Int. Cl.**[5] **H01L 21/465**

[52] **U.S. Cl.** **437/228;** 437/247; 437/248; 156/345; 279/128; 361/233; 118/724

[58] **Field of Search** 118/724; 279/128; 437/20, 248, 247, 228; 156/345; 361/233

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,261,762	4/1981	King	437/20
4,384,918	5/1983	Abe	156/345
4,457,359	7/1984	Holden	118/724
4,615,755	10/1986	Tracy et al.	156/345
4,771,730	9/1988	Tezuka	118/724
4,842,683	6/1989	Cheng et al.	156/345
4,864,461	9/1989	Kasahara	279/128
4,931,135	6/1990	Horiuchi et al.	156/345
4,949,783	8/1990	Lakios et al.	118/724
5,106,787	4/1992	Yen	437/248
5,203,958	4/1993	Arai et al.	156/345

FOREIGN PATENT DOCUMENTS

64-32628 2/1989 Japan .

Primary Examiner—Olik Chaudhuri
Assistant Examiner—Ramamohan Rao Paladugu
Attorney, Agent, or Firm—Antonelli, Terry, Stout & Kraus

[57] **ABSTRACT**

This invention relates to a vacuum processing method and apparatus. When a sample is plasma-processed under a reduced pressure, a sample bed is cooled by a cooling medium kept at a predetermined temperature lower than an etching temperature, the sample is held on the sample bed, a heat transfer gas is supplied between the back of the sample and the sample installation surface of the sample bed, and the pressure of the heat transfer gas is controlled so as to bring the sample to a predetermined processing temperature. In this way, a sample temperature can be regulated rapidly without increasing the scale of the apparatus.

13 Claims, 3 Drawing Sheets

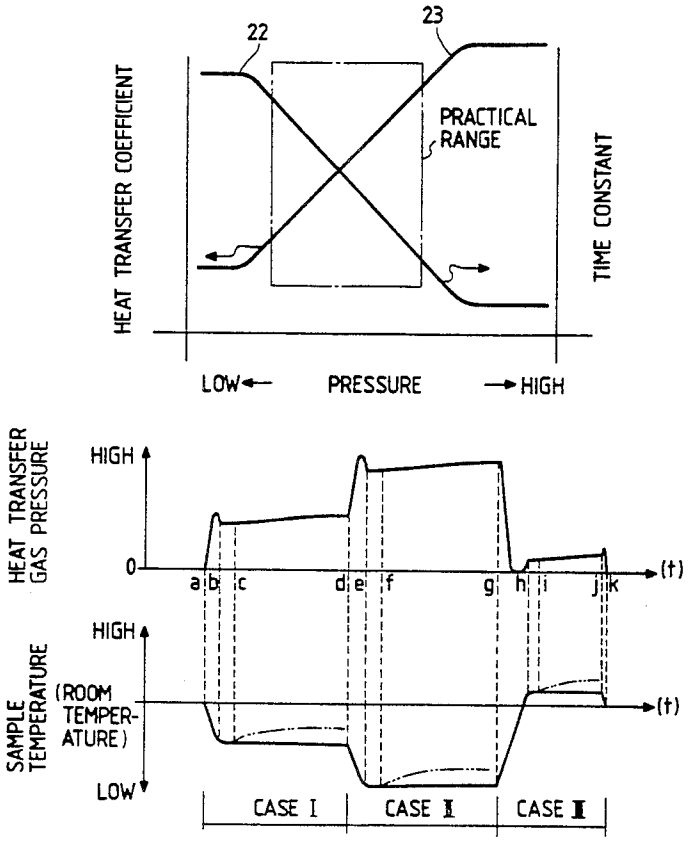


FIG. 1

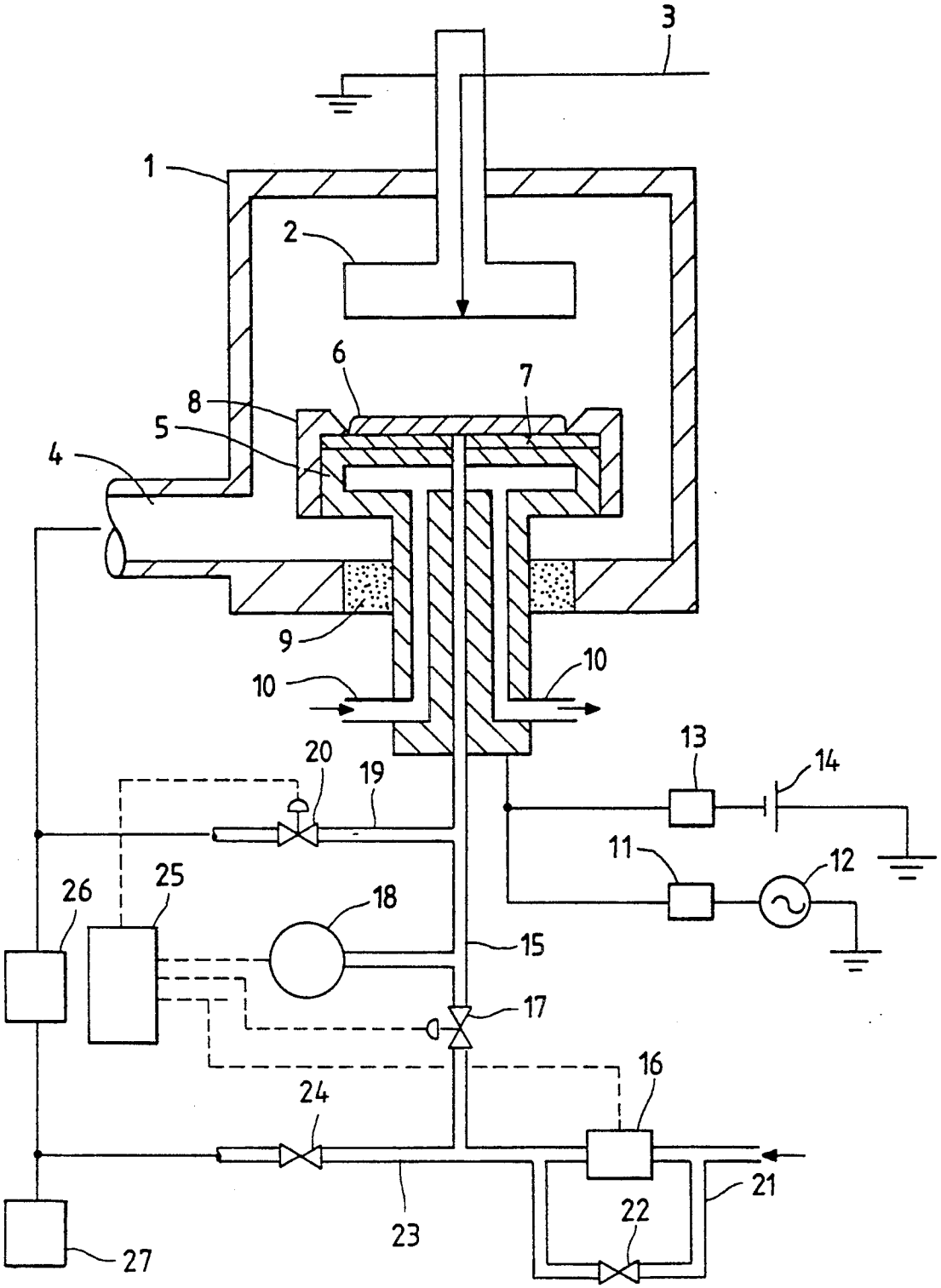


FIG. 2

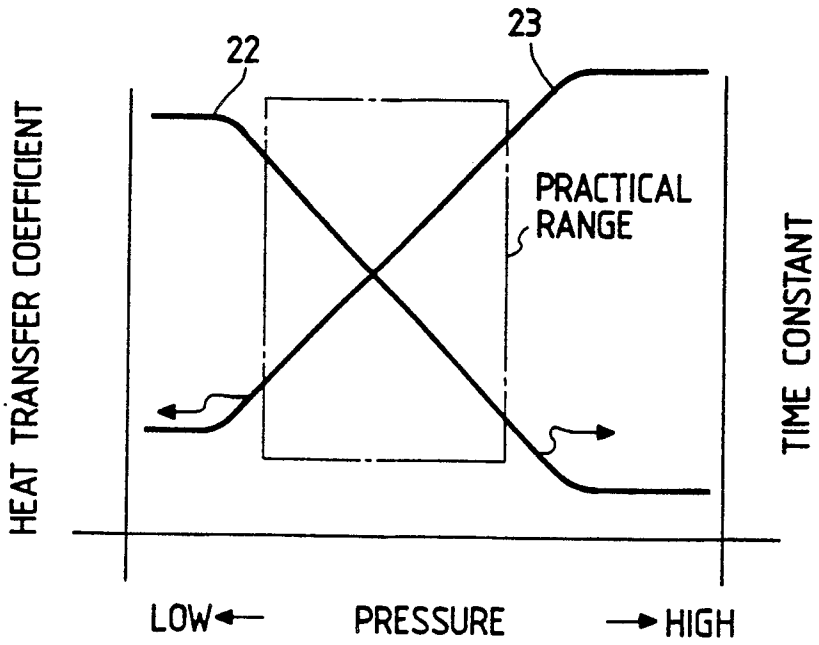


FIG. 4

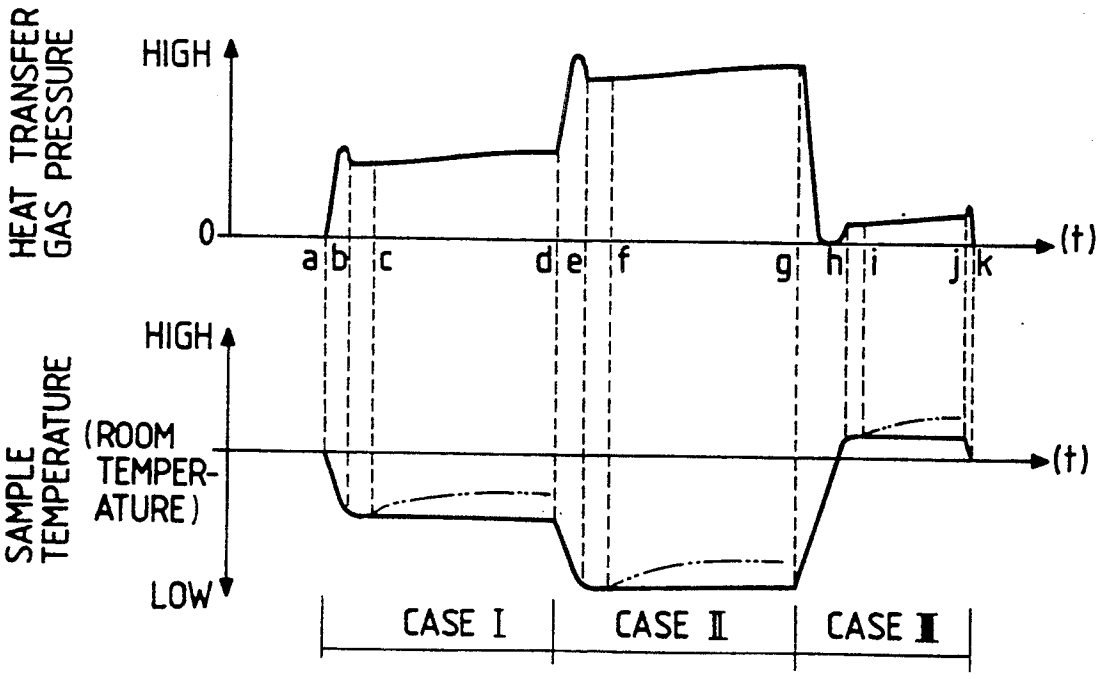
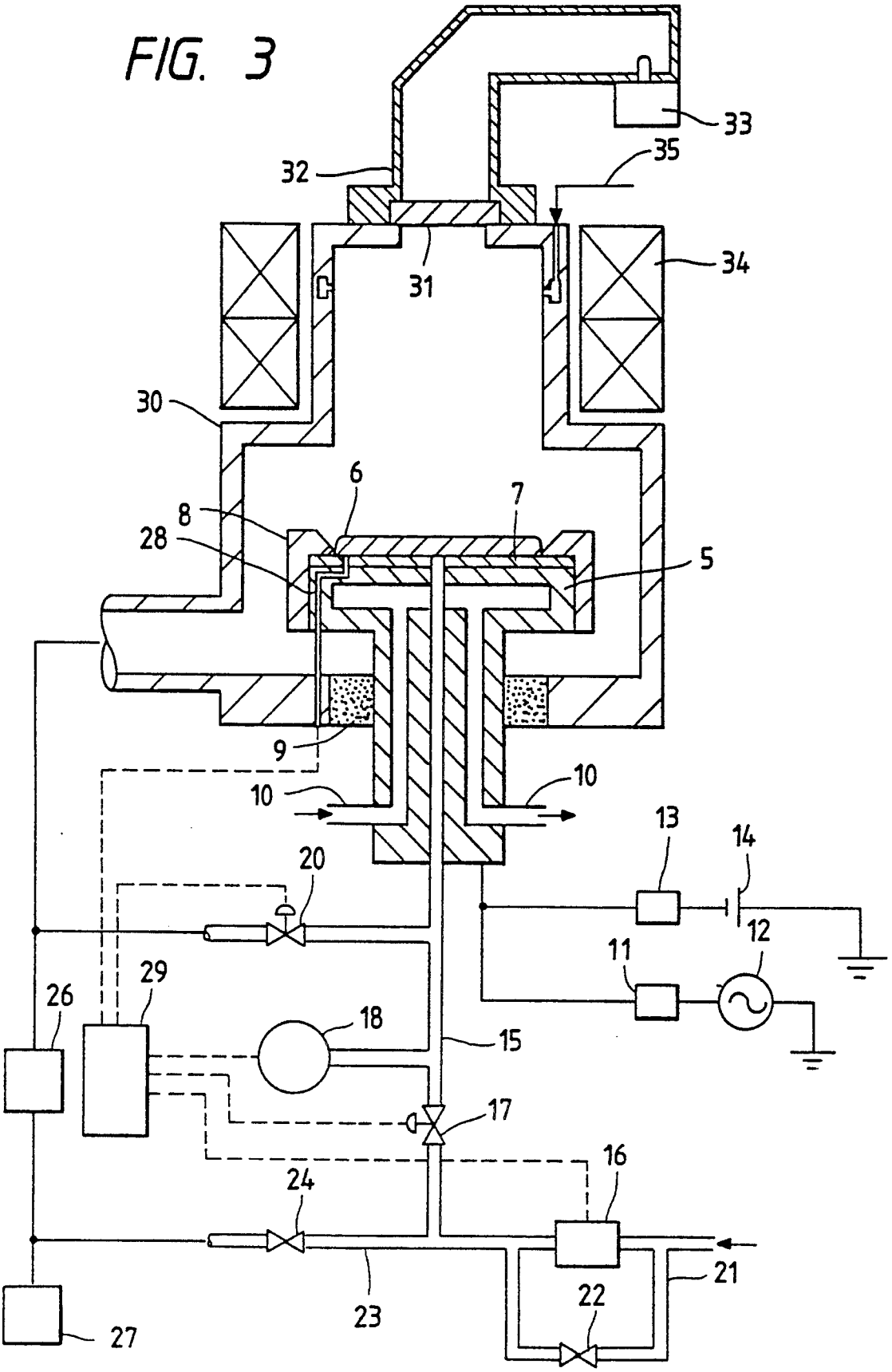


FIG. 3



WAFER COOLING METHOD AND APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a method and apparatus for vacuum processing. More particularly, the present invention relates to a method and apparatus for vacuum processing which is suitable for controlling a sample such as a semiconductor device substrate to different temperatures and vacuum processing the sample.

2. Description of the Prior Art

As disclosed in, for example, Japanese Patent Laid-Open No. 76876/1984, a conventional technology for vacuum-processing a sample by controlling it to different temperatures is such that an object (hereinafter referred to as a "substrate") to be etched is placed on an electrode disposed in a vacuum vessel, a reactive gas is introduced into the vacuum vessel, a voltage is applied to the electrode so as to generate gas discharge and the substrate is etched by this discharge gas at two or more different electrode temperatures.

In the prior art technology described above, a substrate temperature (to 60° C. in this prior art technology) is raised in view of the etching selection ratio of $MoSi_2$ to a resist and of producibility when an $MoSi_2$ film is etched, and the substrate temperature (to 30° C. in this prior art technology) is lowered in view of over-etching. This prior art technology in the electrode is divided into an electrode on a high temperature side and another on a low temperature side. Etching of the substrate is carried out on the higher temperature electrode side, and after this etching, the substrate is transferred to the lower temperature electrode, and over-etching of the substrate is carried out. Alternatively, only one electrode is provided and the electrode temperature can be changed to high and low temperatures while the substrate is kept placed on the same electrode. The substrate temperature is raised to a high temperature to conduct its etching during processing and is lowered to achieve overetching of the substrate after the etching.

SUMMARY OF THE INVENTION

In the prior art technology described above, the time necessary for raising the substrate temperature to two or more different temperatures and reduction of the scale of the apparatus have not been considered. In other words, if a plurality of electrodes are used, the apparatus becomes greater in scale because of the increase in the number of electrodes. Moreover, the time for attaining a predetermined processing condition or a predetermined temperature becomes long. A long time is necessary, too, in order to change the electrode temperature to predetermined temperatures using a single electrode because the heat capacity of this electrode is great.

One of the references concerning the present invention is U.S. Pat. No. 4,261,762.

In an apparatus for processing a sample under a reduced pressure, so as to rapidly regulate a sample temperature without increasing the scale of the apparatus, the apparatus in accordance with the present invention includes means for cooling a sample bed by a cooling medium kept at a predetermined temperature lower than an etching temperature, means for holding the sample on a sample installation surface of the sample bed, and means for supplying a heat transfer gas into the gap between the back of the sample held on the sample installation surface and the sample installation surface of the sample bed and controlling the pressure of the heat transfer gas in accordance with a predetermined processing temperature of the sample. In a method of processing a sample under a reduced pressure, the vacuum processing method in accordance with the present invention includes the steps of cooling a sample bed by a cooling medium kept at a predetermined temperature lower than an etching temperature, holding the sample on a sample installation surface of the sample bed, supplying a heat transfer gas into the gap between the back of the sample held on the sample installation surface and the sample installation surface of the sample bed so as to control the pressure of the heat transfer gas in accordance with a predetermined processing temperature of the sample, and processing the sample controlled to the predetermined temperature.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a structural view showing a microwave etching apparatus of an embodiment of a vacuum processing apparatus of the present invention;

FIG. **2** is a diagram showing the relation between the pressure of a heat transfer gas and the heat transfer coefficient of the heat transfer gas and the relation between the heat transfer gas pressure and the time constant, when a sample is held on a sample bed by an electrostatic chuck;

FIG. **3** is a structural view showing a parallel sheet-type dry etching apparatus as another embodiment of the vacuum processing apparatus of the invention; and

FIG. **4** is a diagram showing the relation between the temperature of a sample processed by the apparatus shown in FIG. **1** and the time necessary for the processing.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A sample bed is cooled by a cooling medium kept at a predetermined temperature lower than a processing temperature. A sample is held on a sample installation surface of the cooled sample bed by an electrostatic chuck, or the like. The temperature of the sample thus held is controlled to a predetermined processing temperature in the following way.

A heat transfer gas having a ,high thermal conductivity such as helium gas (GHe), etc, is supplied between the sample installation surface of the sample bed and the back of the sample. When this gas is supplied, the gas pressure between the sample installation surface and the back of the sample rises. The gas pressure is regulated by regulating the quantity of the heat transfer gas supplied and is kept stably under a gas pressure at which the sample temperature is kept at the predetermined processing temperature.

When the processing temperature of the sample is to be lowered, for example, the quantity of the heat transfer gas supplied is further increased. Accordingly, the gas pressure in the space between the sample installation surface and the back of the sample becomes higher than the gas pressure that corresponds to the initial processing temperature. Thus, the number of molecules that transfer heat becomes great and the sample can be cooled more effectively. The gas pressure is regulated to the one corresponding to the subsequent processing temperature.

DOCKET ALARM

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS
Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS
Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS
Sync your system to PACER to automate legal marketing.