

New development and a challenge of RF power source machines

«Process window expansion which made full use of digital circuit technology and soft treatment technology»

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1. Company brochure

SUNSAY was established as a Hiroshima factory of a fiber enterprise in 1984, and the semiconductor section was also established in 1995.

It's unified to development manufacture of semiconductor associated equipment in 1998, and continues till today.

Major products are RF power supply, RF MATCHING BOX and a gas radical power supply, a process chamber RF interlock system, RF electric power measuring instrument, etc. SUNSAY has measured company deployment focusing on the associated equipment, manufacture development to latest process of semiconductor, and manufacture.

2. Development course

The high frequency apparatus which constitutes a semiconductor device consists of a RF power supply, a RF matching box, a RF measuring instrument, and a RF electrode. Especially in the latest high-density process, 1) a matching system, 2) high stability, 3) high reproducibility are called for. With RF matching box, 4) high-speed control, 5) extension of life-span serve as a big point further especially. Moreover, the process technology of a semiconductor device in recent years follows on forming miniaturization, thinned, and high accuracy, high-speed processing, and density growth of plasma is progressing. And, the functional burden on high frequency apparatus has also been increasing sharply. In a little multiproduct production line, the product in which process conditions differ will be manufactured with the same production equipment. In such a case, since existing high frequency apparatus is analog control technology, the actual condition cannot cope with the subject of the five above-mentioned elements. The method of changing the oscillating frequency of RF power supply is also put to practical use. However, in order to tune finely in the domain where frequency is narrow, a narrow and process window and since an excessive burden is placed on RF power supply, a failure rate will increase certainly. On the other hand, the thorough manufacturing technique correspondence which cost reform and capital investment narrow down is called for strongly future increasingly. The digital circuit technology which does not have SUNSAY until now was introduced to the operation actual condition and the problems of high frequency apparatus in such a factory line. And development manufacture of the high frequency apparatus which made full use of microcomputer technology and a soft processing system is carried out, and the on-site use track record is achieved quickly in the semiconductor or the liquid crystal factory line. The high frequency apparatus of our development corresponds to various plasma systems (Capacitive coupling system, RIE systems, and Inductive coupling system, Hi-Density). In that case, a hardware change of existing use equipment is made the minimum, and the peculiar user process is made inheritable. As a result, compared with conventional high frequency apparatus, very high-speed and highly precise matching performance is realized. And the starting correspondence to the newest process made the minimum cost and a short time possible by extending a process window. In respect of manufacturing efficiency, marked stability and extension of life-span were attained, and the sizable cut of the running cost / maintenance cost were realized.

Fig.3 Hi Density PLASMA ETCH

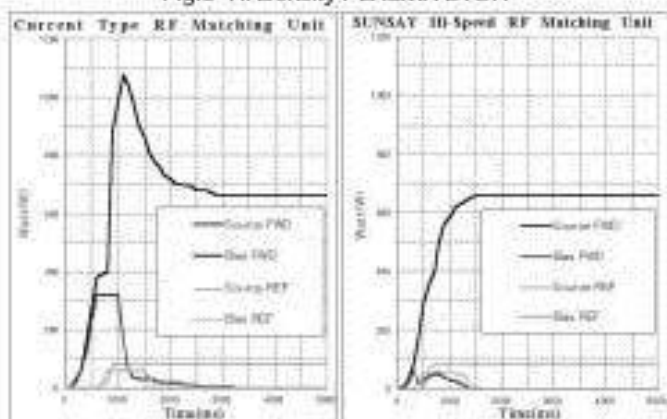


Fig.4 TCP PLASMA ETCH

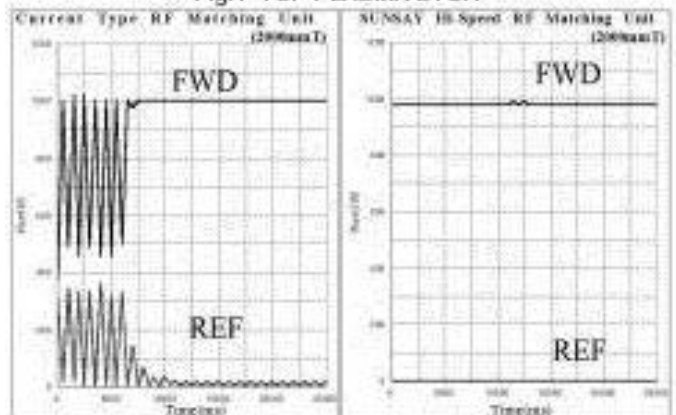


Fig.5 アナログ オープンループ制御 RF Matchingブロック図

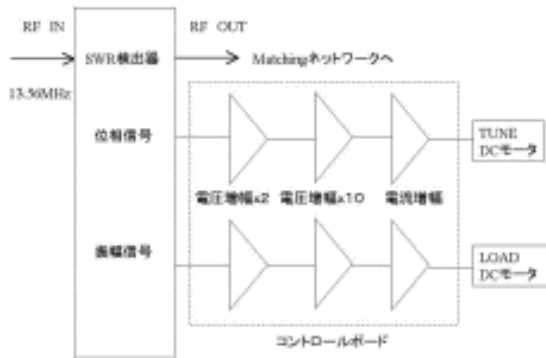
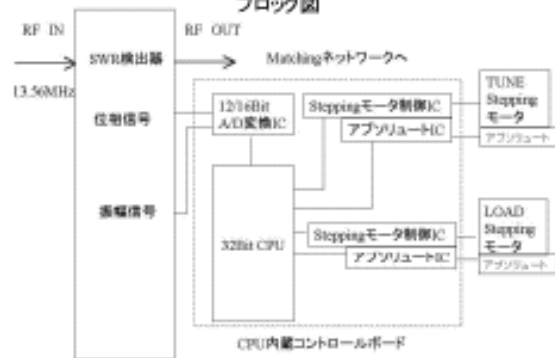


Fig.6 デジタル アbsolute クローズドループ制御 RF Matching ブロック図



●Comparison and an effect

As shown in Fig.1~4 of the last page, the process trouble at the time of the plasma ignition by the conventional Current Type RF Matching Unit and a shutdown, etc. was solved with Sunsay Hi-Speed RF Matching Unit (GENERIC series). Moreover, the failure rate cut down to 3~1/30 and became possible extending reduction process window greatly to 10~200%.

- Fig.1 The reflective wave at the time of RIE plasma ignition, and control of a wafer damage
- Fig.2 Micro arcing at the time of a RIE plasma shutdown, and control of a charge UP
- Fig.3 The reflective wave at the time of Hi Density plasma ignition, and control of a wafer damage
- Fig.4 The reflective wave at the time of TCP high pressure plasma ignition, and control of a charge UP

●The feature of product technology

The example of the new technology which realized the above-mentioned outstanding performance is explained below.

- Fig.5 The conventional analog open loop control RF matching block diagram
- Fig.6 Digital absolute closed loop control RF matching block diagram

In analog control, matching dead zone arises by mechanical load due to the voltage control of DC motor. This phenomenon influences in the matching performance of RF apparatus, flattery performance, and repeat accuracy strongly, and serves as the personnel greatly concerned also with a process window. On the other hand, in digital control, the micro stepping motor drive was adopted for the purpose of the improvement of mechanical precision, and resolution attained 1600 times compared with DC motor. On the experiment level, resolution of 50000 times made possible by using DSP, FTP, and ultra high-speed MPU. The cocking phenomenon at the time of the low speed which is a weak point of a stepping motor obtained the smooth operation near a sine wave by newly changing into 8-bit exciting current control. Thereby, the resolution of stepping motor 1 rotation was raised to 1.8~0.225, and magnetization operation vibration which occurred at the time of a motor stop was solved. Moreover, improvement in repeat accuracy and stability was aimed at by always supervising by an absolute system and carrying out servo control by MPU about the slip of a motor.

●In analog control, since the detection signal of a high frequency phase and amplitude is amplified

and DC motor is driven directly, voltage detection accuracy (It is influenced by the sensor individual specificity of temperature characteristics or a detection element.) is concerned directly greatly for matching accuracy. When the process window became large by this, troubles, such as sending back, were caused under the influence of sensor internal impedance. On the other hand, in digital control, digital conversion of the voltage detection signal is carried out to the numerical value of 12 bits or 16 bits. A matching value is deduced from the current price based on a database, and MPU orders it directly the amount of movements required for matching to a brushless motor drive, and operates to it. The machine different was able to be suppressed very low by having performed digital control, having eliminated the analog adjustment part and having been except the sensor detection part. Also, Compared with the conventional analog control, the about 5~30 times as many improvement in performance was attained by carrying out the digital compound compensation of the output characteristic of temperature, impedance, and a detection element, etc. about signals, such as a sensor assembly.

●Conclusion

The semiconductor industry is developing the survival business in which survival was risked under a very severe market environment. Probably, meanwhile, the greatest point is the quality of technical capabilities and development too. In respect of production, the stable production facility and peripheral equipment with high reliability corresponding to the intense process of change are indispensable. It is called high frequency apparatus even if, quality with high manufacturing efficiency is required at low cost. Our company furthered positively technical development of the high frequency apparatus matched with customer needs, and has always introduced the microcomputer device technology of world's best standards. And we are going to tackle the network technology composition which achieves fusion to production equipment, and unification with a production line system. We would like to offer RF power source machines of simple, toughness and the low cost in including instruction of Omni research institute Co., Ltd. which suit the newest process technology.