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The E-Science MOCVD Substrate Heater for Nitride Applications

Abstract

Nitride applications have accounted for the majority of the new MOCVD tool purchases over the past 5 years. These applications have introduced much greater demands on the performance of the MOCVD tools than was required for the more traditional As/P based devices. In particular, growth temperatures for nitrides can reach over 1200 C. These temperature requirements, coupled with the exposure to reactive gasses, put strain on the substrate heater requiring careful design and material selection. In this paper, we present a new heater that has achieved outstanding results and greatly increased lifetimes over other manufacturers' heaters.

Company Background:
E-science has been providing components for MOCVD reactors for over 10 years. Our primary focus is the development and sale of epitaxial components for both MOCVD and MBE systems. The close relationship we maintain with our customers allows us to keep current with existing technologies and the requirements of the marketplace. We have built a solid reputation of delivering working solutions to customers quickly and efficiently.

E-science products include effusion cells, specialty valved sources, accessories for MOCVD and MBE reactors and substrate heaters. Whether it is a specialty designed product or one of our standard products, our knowledgeable sales associates are committed to helping you select the product that is right for you. Once your order is placed, you will be assured that our engineering and manufacturing staff will work quickly to deliver the products to you.

Fig. 1: The E-Science substrate heater for nitride applications utilizes state-of-the-art materials . It's robust design has achieved lifetimes much greater than heaters made by other manufacturers. The flexible design can be adapted to fit a variety of MOCVD reactors from single wafer research reactors to the largest multi-wafer production tools.

Heater Design:
The high growth temperatures used for nitrides has presented many challenges to designers of resistive heaters. Not only does the heater need to simply achieve high temperatures, but many devices require a rapid ramp rate forcing higher powers to be used across the filament. Also, the materials used in the heater assembly must withstand a highly corrosive environment. Finally, to those working in high volume production, stability and longevity of the heater is essential to reduce the cost of manufacturing.

In 1994, E-Science was the first company to address all these concerns. Proper material selection was at the heart of the design and gave the added performance that was needed. To achieve a uniform thermal profile, a multizone heating element was used to tailor the power ratio across the substrate.

As the technology developed, MOCVD growers needed higher performance out of their MOCVD reactors. Capacities also needed to increase to keep up with the high demand for end products.

By maintaining close relationships with our customers, we have been able to anticipate the new demands of the marketplace and have adjusted the heater design accordingly. When necessary, designs were changed to deliver added performance when the devices required it. Scalable design rules were developed to keep pace with the reactors as they became larger and larger.

The design rules developed by E-science take into consideration all the aspects of the heater assembly. The filament supports, contacts and heat shield all play a role in the robustness of the heater. Careful attention to these design elements have contributed significantly to helping us reach the goal of heater lifetimes greater than 1 year.

Experiment:
Samples were grown in a custom 4" epitaxial reactor. For the application described in this note, FET devices were grown on a 4" SiC substrate.

The filament geometry was changed to accommodate the higher powers necessary to achieve the ramp rates required for this process. The filament support was also modified to fix the filament over repeated cycles.

Another enhancement made to the heater was with the contacts which have traditionally been a weak point in the filament design. This is no longer an issue due to E-science's proprietary contact design that has not experienced a failure since its development.

Results:
As in earlier designs, the desired temperature and ramp rate was achieved. However, with its enhancements, this design has a much longer lifetime than the previous heaters with continued operation beyond 18 months. The multi-zone heater was able to achieve a uniform thermal profile across the sample enabling a higher device yield from the wafers.

Conclusion:
E-science has successfully developed a robust MOCVD heater designed specifically for nitride applications. The heater is inert to the nitride process gasses and is capable of short heat up times. To improve temperature uniformity, the heater may incorporate multiple filaments for independent control of input power. The basic design scales easily and can be adapted to fit a variety of different manufacturers systems or custom chambers.

Contact E-Science for more information on this heater or other products for your MOCVD reactor.

E-Science, Inc.
596 Schommer Dr., Suite 100
Hudson, WI 54016
Tel: 715-381-1899;
Fax: 715-381-1866
Email: info@escience.com;
Web: www.escience.com

European Distributor
GEO Semiconductor, Inc.
POB 6262
1211 Geneve 6
Switzerland
Tel: +33 1 45 31 62 84; Fax: +33 1 45 33 39 43
Mobile: +33 680 13 48 95
Email: Ralph_Hananel@compuserve.com