TECHNICAL REPORT

July 29, 1993

Sponsored by

Defense Advanced Research Projects Agency (DOD)

#BAA#92-20

Issued by Naval Research Laboratory

Contract #N00014-93-C-2026

Applied Science and Technology, Inc.
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Effective Date: December 31, 1992

Contract Expiration Date: December 31, 1993

Reporting Period: April 93 thru June 93

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Title:
"Materials Processing and Manufacturing Technologies for Diamond Substrates Multichip Modules"

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"Materials Processing and Manufacturing Technologies for Diamond Substrate Multichip Modules"

Facilities

The 75kW support facilities have been completed during this period. The house cooling system upgrade (external cooling tower and 200kW capacity) has been completed, and integrated into all operations. The 150 kW electrical power, gas handling, and other laboratory modifications were completed during the previous quarter.

75kW Reactor

The reactor and power supply have been installed and commissioned during this quarter. We successfully achieved first plasma on 4 June, and have run plasmas with up to 35kW power to date. The discharge location and shape vary with microwave power and gas pressure as the prototype operation predicts, verifying the design principles of this reactor type. The gas delivery and pressure control system are fully functional, and we have run plasmas with conventional diamond chemistry recipes for short intervals.

Some additional work is underway to bring the power delivery system up to full specification. We are replacing the circulator and dummy load in the 75kW supply to increase isolation and thus improve stability of the discharge at higher power. We have also replaced both the multi-stub tuner and the sliding short with more rugged designs. We are modifying the control logic in the power supply to provide additional tube protection and to incorporate more accurate calibration coefficients.

All other major subsystems, including gas filled plenum for substrate temperature control, gas delivery, pressure control, water cooling, and mechanical support & chamber lift systems are complete and operational.

Reactor Prototype Studies

We are continuing to study the transfer of high growth rate (HGR) process to our PDS19 reactor, the prototype for the 75kW system. We have been investigating the range of operation of the gas filled plenum for substrate temperature control, and optimizing process conditions for growth on 2", 3", and 4" diameter substrates at 5kW. We have implemented some minor changes in the chamber shape, which have greatly affected the microwave mode structure. This has both improved the power & energetic radical flux onto the substrate, and reduced power loading to critical areas of the chamber walls. We have continued to examine the diamond produced by the prototype by all available means, including FTIR spectroscopy, Raman spectroscopy, and SIMS profiles.

Reactor Modelling

Under DARPA Contract #DAAH01-92-C-R109 for "Computational Modelling of Fluid Flow in PECVD Reactors," we have developed an axisymmetric electromagnetic code to model the power input to the microwave discharge. We have now fully described the boundary conditions of the PDS19 reactor to this code, and have been successfully benchmarking the prototype experiments with reactor shaping, as well as variations in plasma conditions as pressure and power change. This code has already been quite useful in quickly optimizing the cavity shape to achieve large and uniform radical flux on the substrates.

We have recently modified the boundary conditions and microwave frequency for this code to describe the 75kW reactor, and have started initial runs to benchmark existing experimental data. Based on our experience with the prototype, we expect this code to be driving the experimental changes in the near future.

Process Transfer, Ongoing Experiments

We have been able to run diamond chemistry plasmas for only short periods of time, due to the instability of the power supply at higher powers. Under these conditions, we have seen the spectral signature of high growth rate deposition, but were unable to sufficiently heat the substrate nor to hold the discharge stable enough to observe growth. With increased isolation and stable high power operation, we expect to achieve first diamond growth in the near future. An experimental plan to transfer the high growth rate process on 6" diameter substrates will initiate after first growth, and will proceed in parallel with other reactor upgrades.

We are continuing to investigate potential improvements in plasma shape. We have already found a significant flattening of the plasma, indicative of higher growth and uniformity, by minor modifications to the chamber cavity scaled from the prototype experiments. As the modelling passes experimental benchmarking, other more significant changes may be incorporated.

Other chamber design issues that will be investigated early in these experiments include uniformity of gas delivery, diagnostic window location and orientation, and sufficiency of cooling to the chamber walls.