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The following report details the progress on ONR contract number N-00014-86-C-0421 during the period from January 1 to March 31, 1989. This program entails a joint effort between Research Triangle Institute and North Carolina State University.

During this quarter we have made a preliminary comparison of SiO_2 deposited at 1.1 to 1.2 nm per minute and 0.16 to 0.18 nm per minute, both at low pressure. An investigation has been carried to look at the effect of the extension of the glow discharge region using a grounded vs. floating grid between the plasma tube and the sample to control the extent of the plasma.

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TABLE OF CONTENTS

1.0 INTRODUCTION

The following report details the progress on ONR Contract Number N-00014-86-C-0421 during the period from 1 January 1989 to 31 March 1989. This program entails a joint effort between Research Triangle Institute and North Carolina State University. Funding is being provided by the Innovative Science and Technology office of the Strategic Defense Initiative.

During this quarter we have made a preliminary comparison of SiO_2 deposited at 1.1 to 1.2 nm per minute and 0.16 to 0.18 nm per minute, both at low pressure. This work is described in section 2.0. Also, and investigation has been carried out at NCSU to look at the effect of the extension of the glow discharge region using a grounded vs. floating grid between the plasma tube and the sample to control the extent of the plasma. This work is described in section 3.0. Section 4.0 contains the summary and conclusions.

2.0 OXIDE QUALITY VS. DEPOSITION RATE AT LOW PRESSURE

We have made a preliminary investigation of the effect of deposition rate at low pressure on oxide quality. Oxides were deposited at low pressure at rates of 1.1 to 1.2 nm per minute and 0.16 to 0.18 nm per minute. In all cases the substrate was maintained at 300 °C and the pressure was maintained at about 87 mTorr. All samples have aluminum gate electrodes and all received a 30 min 400 °C post metal anneal. The interface state densities measured on all samples were in the low-to-mid 10^{10} eV^{-1} cm^{-2} range. Also the yield (10 to 15 capacitors per sample tested) of the samples were roughly equivalent for all except the thin 10.6 nm oxide deposited slowly. Table 1 shows the deposition rate under which the oxides were deposited and the corresponding electrical characteristics.

TABLE 1: Deposition Rate Under Which Oxides Were Deposited and Corresponding Electrical Characteristics

SAMPLE NO.	DEPOSITION RATE nm/min	MIDGAP D_{it} (cm^{-2} ev^{-1})	CHARGE TO BREAKDOWN (C cm^{-2})
111888-2	1.12	2.9×10^{10}	1.2×10^{-3}
112188-1	0.16	4.3×10^{10}	1×10^{-2}
112188-2	0.18	4.5×10^{10}	Could Not Measure
112288-2	1.24	2.2×10^{10}	3×10^{-2}

This is only a preliminary study of the effect of deposition rate; however, is pes appear that going to the low pressure allows use of faster deposition rates ithout degrading the quality of the oxide. Evidence indicates that OH groups in ie films are responsible for poor breakdown characteristics in the material. OH ·product removal plays a major role in the elimination of OH in the films. The ow characteristics in the reactor will certainly play a major role in the removal of ·product species. These flow characteristics will be greatly affected by both pres- re and reactor geometry. In section 4.0 we describe the construction of a new gh purity reactor at RTI which is being built with swe ping flow characteristics articularly in the vicinity of the sample) and high purity throughout as prime sign concerns.

4.0 SUMMARY AND PREVIEW

During the past quarter we have continued the investigation of the SiO_2 deposition parameter matrix, in particular investigating the effect of deposition rate under low pressure conditions. Data indicates that under the low pressure conditions the deposition rate can be increased without adversely affecting the oxide quality. We believe this is due to enhanced byproduct removal under the low pressure conditions. In addition it has been demonstrated that a grid in the gas flow path can be used to control the extent of the plasma. Furthermore, if the plasma is confined out of the silane introduction region, stoichiometric oxides can be deposited with very low oxygen to silane ratios (as low as 1 to 10). If the plasma extends into the region of silane introduction, suboxides will be formed under low oxygen to silane conditions.

In order to take advantage of the insights we have gathered into the oxide deposition, a second generation remote-plasma reactor is being constructed at RTI. This reactor has an all quartz deposition region for high purity, and a long flow tube-type design to minimize eddie current flows. The all quartz construction of the reaction zone allows us to use external heaters to heat the sample, which greatly simplifies the internal construction of the reactor and eliminates many sources of contamination. The reaction zone will be heated with infra-red lamps. This radiation should couple very well into any water related byproducts and help to drive them off of the reactor walls so they can be transported out of the reaction zone. The gas delivery lines are very short to minimize contamination from the lines, and each gas will be filtered at its injection point with a .05 micron filter. All metal sealed leak valves are used for flow control so that the gas lines are entirely UHV compatible and bakeable. The system provides much latitude for adjustment of sample position and plasma region position. We believe this system will allow us to make major strides in the development of high-quality, highly reliable dielectrics. This system will be operational during the next quarter.