



## LABORATORY REPORT

### PREPARED FOR:

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### PROJECT TITLE: Evaluation of DLC coatings.

### INTRODUCTION

The surface chemistry of DLC coatings on two different substrates (yttria-stabilized zirconia, YSZ, and glass slides) were evaluated using Electron Spectroscopy for Chemical Analysis (ESCA). The samples were identified as “Control Group No DLC”, “DLC No Bake”, and “DLC Baked.”

### SUMMARY AND CONCLUSIONS

Both substrates (YSZ and glass slides) show higher concentrations of carbon for those samples containing DLC than found on the Control Group.

### TEST PROCEDURES

The ESCA data were acquired from the shiny, convex side of each sample using a monochromatic Al K $\alpha$  x-ray source, a take-off angle of 65° and an analyzed area having a diameter of ca. 1 mm. Low energy resolution survey scans were obtained from each sample to determine what elements were present. The atomic concentrations and chemistry were determined from higher energy resolution multiplex scans.

### RESULTS

The ESCA data are summarized in Tables 1 and 2. Table 1 lists the atomic concentration summary and Table 2 lists the carbon chemistry.

Table 1a. ESCA atomic concentration summary of YSZ substrates (atomic percent).

Sample	[C]	[N]	[O]	[Y]	[Zr]
Control Group No DLC	36.4	ND	42.5	3.8	17.3
DLC No Bake	88.4	6.3	4.7	ND	0.6
DLC Baked	89.3	5.9	4.6	ND	0.2

ND – None Detected.

Table 1a. ESCA atomic concentration summary of glass substrates (atomic percent).

Sample	[C]	[Ca]	[Mg]	[N]	[Na]	[O]	[Si]
Control Group No DLC	49.1	0.6	0.2	ND	6.3	32.6	11.2
DLC No Bake	86.1	ND	ND	2.5	0.6	7.4	3.4
DLC Baked	87.3	ND	ND	4.9	1.1	6.1	0.7

ND – None Detected.

Table 2a. Carbon chemistry of YSZ substrates (relative percent).

Sample	C-C, C-H	C-O, C-N	C=O	O-C=O
Control Group No DLC	83	11	3	3
DLC No Bake	88	10	2	-
DLC Baked	84	14	2	-

Table 2b. Carbon chemistry of glass substrates (relative percent).

Sample	C-C, C-H	C-O, C-N	C=O	O-C=O
Control Group No DLC	82	7	9	2
DLC No Bake	91	6	2	1
DLC Baked	86	10	3	1

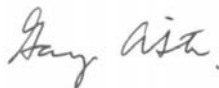
The ESCA data show varying concentrations of carbon (C), calcium (Ca), magnesium (Mg), nitrogen (N), sodium (Na), oxygen (O), silicon (Si), yttrium (Y), and zirconium (Zr) on the six samples that were tested. The survey scans from each sample are shown below.

Both substrate sets show a substantial increase in carbon for those samples containing the DLC coating. In addition, the data show a substantial decrease in the substrate signal for both sets. Given this large of a reduction in the substrate signal, I would say that the coating is approximately 2X the escape depth for a photoelectron in DLC. The escape depths are typically 30 Å to 50 Å.

#### **SAMPLE DISPOSITION AND DATA STORAGE**

The sample from this project will be stored for at least 3 months from the date of this report. The sample may then be discarded unless instructions for return or other disposition are received. All data will be kept on file for 3 years. Additional report copies can be obtained upon request.

Submitted by:



Gary A. Smith  
President and Owner

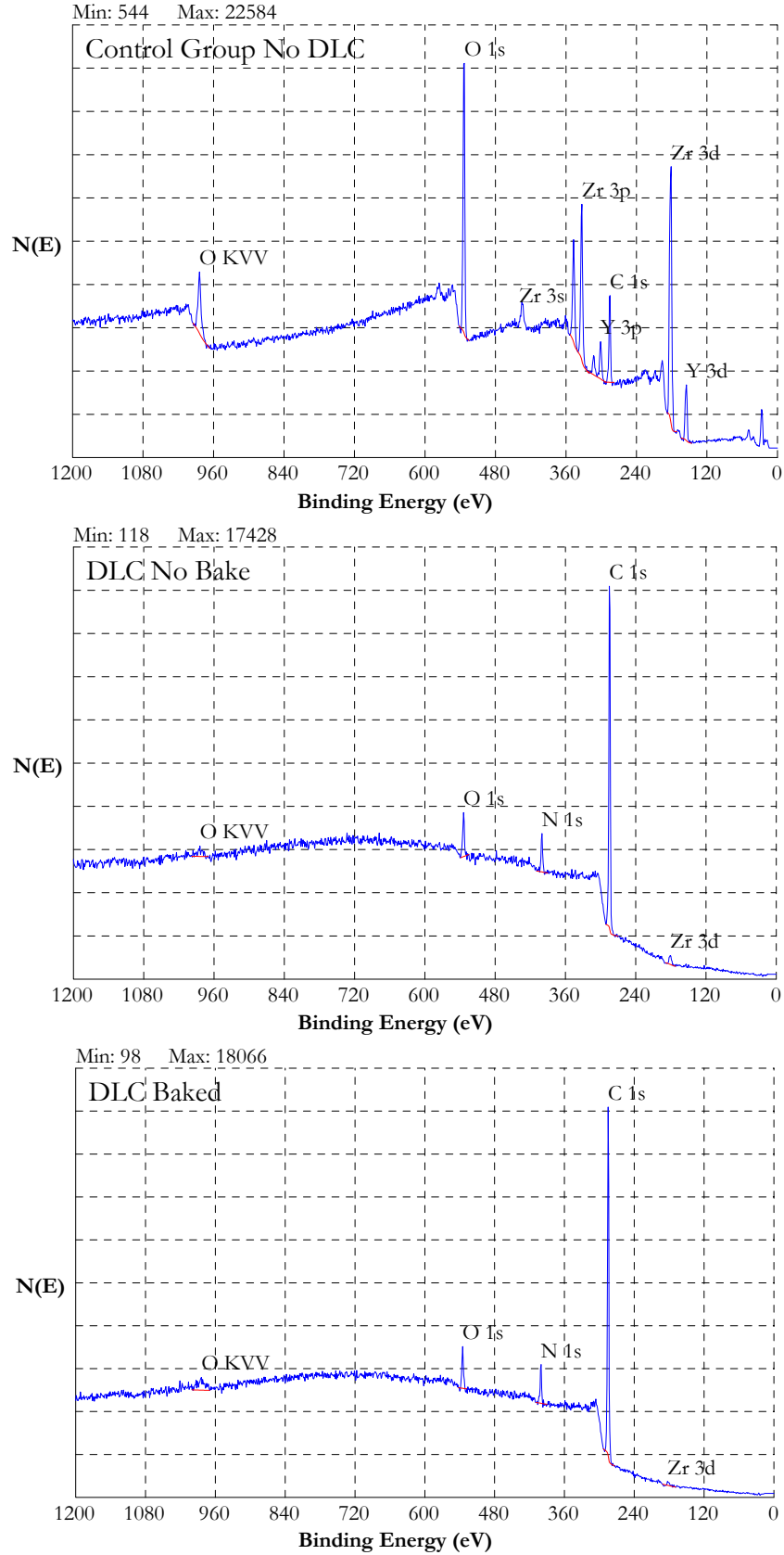


Figure 1. ESCA survey scans of DLC on yttria-stabilized zirconia substrates.

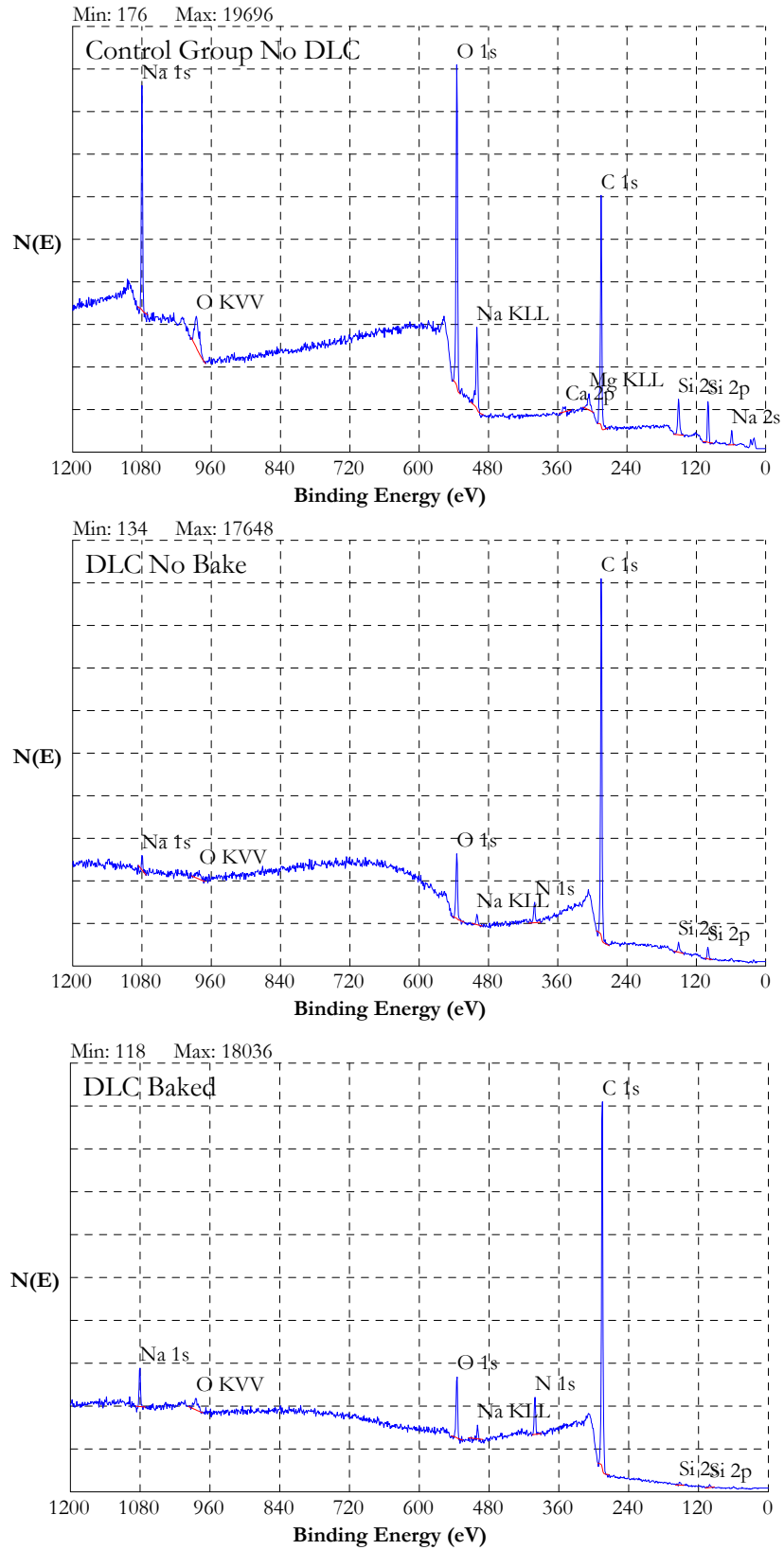


Figure 2. ESCA survey scans of DLC on glass slide substrates.