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Annual Report 3/1/94 to 8/31/94

Title: Plasma Treatments - Textiles

Code Number: S94-13

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Goal Statement:

We are developing a fundamental understanding of how different plasmas change the surface characteristics of textile fibers and the wear surfaces of materials used in textile processing and then to characterize the nature of these changes using surface analytical techniques. Longer term, we hope to see how these changes can be exploited for adding value to textile products and help develop pollution free manufacturing processes for their commercial production.

Abstract:

It is known that plasmas can be used to alter material surfaces by removing surface layers, to activate the surface to become more polar, to passivate surface making them less polar and to deposit thin films. Plasma treatment of textiles was examined in the 1960's without much success; however in response to the electronics industrial need, significant developments have been made in plasma tools since then. For example, processes in the 1960's had 10^9 excited particles /cc compared to 10^{12}/cc in the 1990's. This means there is a great deal more energy available without developing excessively high temperatures. Advances in plasma technology has led to the development of coatings which increase surface hardness and lower the coefficient of friction of metals. We will assess the usefulness of these recent advances for wear surfaces of materials used in textile processing. The project is divided into three tasks focusing on plasma fundamentals for:

- **Removing surface matter,** such as fiber finishes, size, contaminants and the like from fiber surfaces; also the etching of fiber surfaces to reduce fiber diameters.
- **Activating surfaces** to change their polarity. Polar surfaces will be made more non-polar to render them repellent to liquids and reduce adhesion of soil particles, non-polar surfaces will be made more polar to improve water wetting and soil release properties.
- **Depositing thin films** of materials on surfaces to alter their properties. For example diamond-like, ceramic-like or fluorinated surfaces to alter the coefficient of friction and the hardness of wear surfaces and fiber surfaces.

Relevance to the NTC Mission:

The Materials Engineering Department at NCSU has established a Plasma Center known as the CAMP-M project under the direction of Dr. Jerry Cuomo. Cuomo, a Distinguished University Professor, comes from IBM Research Laboratories where he was responsible for their Plasma program. He has brought with him seven Plasma generating units and related equipment worth over 3 million dollars. Four of these units are now operational. He has actively sought partnership with other departments on campus and, in addition to the NTC funded Textile Program, has ongoing activities with Veterinary Science, the Furniture Program, Physics and Chemistry. He is well known and respected in this field and travels internationally to scientific meetings, National Laboratories, University based Plasma research units, and Industrial manufacturers establishing linkages and partnerships which will ultimately impact the Textile initiative. It is important to note that the NTC funded textile effort is but a small part of the overall NCSU effort, and that these funds are being well leveraged in fulfilling the NTC mission of improving the Textile Industry's competitiveness by exploiting emerging technology.

Accomplishments:

This project has been active for only a short period of time, since March, 1994. The accomplishments therefore are typical of start-up projects where the various members are on a steep learning curve. The team members from Textiles are learning the intricacies of plasma generating equipment and plasma physics whereas the members from Material Science are learning about textiles. The accomplishments therefore center around literature survey, establishing communication routes to tap into state-of-the-art knowledge and modifying one plasma generating unit dedicated to the textile initiative. The extent of the accomplishment are highlighted in the paragraphs that follow.

Literature Survey

A thorough literature survey is underway and a large number of references have already been uncovered. These references are being segregated into groupings in order to more easily see the state-of-the-art. As for textile related activities, most of the work has focused on synthetic hydrophobic fibers such as polypropylene and polyester. The objective has been to increase the polarity of the surface for enhanced water wetting and the improved adhesion. There are also many references dealing with reducing the polarity by fluorinating the surface. Here, liquid resistance and anti-stick properties are the focus of this approach. A third segment of literature deals with wool fiber and the removal of surface scales to reduce felting shrinkage. We have also uncovered some references detailing some of the analytical techniques for quantifying the changes brought about.

Plasma Tools

Cathodic Arc Unit

The cathodic arc unit is used for deposition. It also houses an ion beam which is used for etching surfaces of substrates. This setup is currently being used to deposit amorphous carbon coatings on carbon wafers. Often the substrate is first etched with the ion beam to increase adhesion, then the cathodic arc is used to deposit a coating on the surface. The system runs at a mean energy of 22 eV from a 100 amp source. The substrate is cooled to 10°C when using this system.

Magnetron Units

There are two magnetron units, a single and a double setup. The single magnetron unit is working and is currently being used to deposit amorphous carbon coatings. Amorphous carbon coatings are tougher than hydrogenated carbon coatings and require higher energies to create than do the hydrogenated versions.

Radio Frequency Induced (RFI) Units

There are two RFI units, one of which is equipped with a water cooling system for the chamber sides, the RF coil and the vacuum pump. This unit is being used to conduct the textile related research. This unit allows plasmas to be generated using different atmospheres, e.g. air, argon, oxygen methane etc. Relatively thick layers of hydrogenated carbon layers (6.6um) have been created on non-textile substrates with this unit. The incident power of these plasmas vary from 250 to 700 watts and a reflected power in the order of 15 watts. When all of the components are matched, the incident power can be as high as a kilowatt. At this time, the plasma is generated from the top only. To treat two sides of a fabric, a specially constructed holder was devised making it necessary to rotate the fabric 180 degrees. Modifications are underway to outfit the machine so that plasma can be generated top and bottom simultaneously.

Future Plans:

Plans are underway to meet with National Laboratory Researchers to ferret out whatever information they may have. Dr. Cuomo will take the lead on this phase and arrange to include the textile team to increase their level of knowledge of plasmas. Plans are also underway to have the Materials Engineering team visit textile operations to improve their knowledge of this end of the project.

The unit dedicated for the textile initiative will be moved to the College of Textiles as soon as all of the modifications are complete. At the moment it is located in Riddick Hall, Main Campus. The experimental phase and data collection will accelerate along the lines of three tasks outlined in the abstract (removing surface matter, activating surfaces and depositing thin films). In the removal of surface matter task, an industry partner has expressed interest how plasmas might be used to desize fiberglass fabrics for use in PC boards. The miniaturizing of PC boards is placing a higher demand on the cleanliness of fiberglass reinforcing fabrics. This objective seems as a good starting point to start experimental data collection.

Other Contributers: Research Associates: Paul Vernon, Z. Radzimski (Materials Engineering); Graduate Student: Cevin Smith (Textile Chemistry)