Application of Combinatorial Methods for the Testing of Adhesives

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Combinatorial and high-throughput (C&HT) methods combine clever experiment design, instrument automation, and computing tools to form a new paradigm for scientific research. Through this combination of disciplines, combinatorial methods provide a faster and more comprehensive exploration of complex parameter spaces. Given this premise, the C&HT concept is being adapted to study problems in materials science. However, the C&HT methods developed for the pharmaceutical industry often cannot be applied directly to materials research since methods for generating materials libraries and for rapidly measuring properties are often lacking. A vanguard in these endeavors, the NIST Combinatorial Methods Center (NCMC) specializes in the development of C&HT measurement methods for polymer research. Through our efforts and others, an array of novel C&HT approaches and technologies are now available that help make materials research more productive, more rapid, and more thorough.

This presentation will focus on the development and application of novel high-throughput platforms for both adhesion and mechanical property testing. For screening of commercial pressure sensitive adhesives, we are applying C&HT tools to conventional peel tests. This includes the use of continuous gradients in surface energy and temperature along with discrete gradients in peel rate. For the screening of structural adhesives, we are employing the edge lift-off geometry for testing the adhesion between epoxy films and rigid substrates such as copper. Here, we are designing an automated mixing and deposition system for the creation of discrete and continuous gradients in composition of a thermally cured epoxy system. Orthogonal gradients in thickness or quench temperature are used to generate a gradient in the applied stress field. In this geometry, the interfacial adhesion strength can be deduced from the critical stress required to debond each film cell from the substrate. These results can be used to predict the adhesion reliability of epoxy formulations as a function of composition and applied stress. For fundamental adhesion measurements, we are utilizing the JKR contact mechanics approach for quantifying weak interfacial adhesion between symmetric or asymmetric surfaces. For this, we are generating discrete libraries of polymer brush grafted to solid surfaces. The properties of the polymer brush, such as thickness, grafting density and chain length, are systematically varied along the surface. The work of adhesion and adhesion hysteresis between the polymer brushes and contacting hemispherical PDMS lenses are quantified using JKR analysis.