Dr. Mark Kastantin obtained his Ph.D. (Chemical Engineering) from University of California, Santa Barbara in 2009. The focus of Dr. Kastantin’s research uses energy transfer phenomena at the single-molecule level to observe the conformations of proteins, peptides, and oligonucleotides on chemically functionalized solid substrates.

TITLE
A Single-Molecule Study of Interfacial DNA Hybridization Dynamics

ABSTRACT
Understanding the dynamic behavior of biomolecules (e.g. peptides, proteins, nucleic acids) at interfaces is an important and open topic in the biomaterial community. For example, how can surfaces be designed to promote double-helix DNA hybridization, thereby enhancing synthesis of nanomaterials that rely on DNA to direct self-assembly? Experimental evidence over the past decade suggests that interfacial effects on macromolecular conformation are significant when answering these types of questions. One powerful way to assess biomolecule-surface interactions is to dynamically measure the conformation of individual biomolecules and correlate that to their interfacial behavior (e.g. adsorption, desorption, diffusion). This goal is accomplished using total internal reflectance microscopy to measure resonance energy transfer (RET) at the single-molecule level. RET reports on molecular conformation, while microscopy allows tracking of a molecule's position from adsorption to desorption.

In this work, single-molecule RET tracking was used to study the effect of surface chemistry on the helix-coil transition of a self-complementary DNA hairpin sequence. Relative to a hydrophilic surface, a hydrophobic surface favored DNA self-hybridization at room temperature but this effect was reversed at elevated temperature. Single-molecule resolution was used to probe the mechanisms behind these observations, identifying potential improvements in surface chemistry to better promote DNA hybridization. Beyond the biophysical insights provided on this specific system, these methods lay the groundwork for a more general technique that can link conformation to interfacial dynamics with unprecedented resolution for a variety of macromolecules at different types of interfaces.