Mechanics of Materials
Ph.D. Thesis Defense

Speaker: Enrique Escobar de Obaldia

Tittle: *Unveiling the Mechanical Behavior of the Rod-like Microstructure in the Radular Teeth of Cryptochiton stelleri*

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Abstract:

Natural ceramics provided with high volume fractions of mineralized materials that are surrounded by a weak organic interface combine the stiff mechanical behavior of building blocks, like hydroxyapatite or aragonite, and the compliance of the organic surroundings. Unique mechanical properties (e.g. light density and toughness) distinguish biocomposites from common engineering materials. A key example is the highly mineralized shell of the radular teeth of the *Crypochiton stelleri*. Nature has provided the radular teeth with a highly oriented rod-like microstructure of nanoscale dimensions embedded in a matrix of chitin sheaths. Compared to other biological materials, the external iron oxide layer of the mature tooth is characterized with an outstanding abrasion resistance. Studies of the functionality of the tooth have so far been performed with site-specific estimations made by nanoindentation tests and advanced microscopic imaging techniques.

The aim of this work is to analyze the mechanical behavior of the rod-like microstructure of the teeth with biomimetic composites and computational models. The three-dimensional computational model is implemented to unveil the role of the nanoscale features in the response of the microstructure to the penetration of a cube corner indenter. The computational models consider homogenous rods surrounded by cohesive interfaces. The analysis of the damage model indicates a competing mechanism between energy dissipation at the interfaces and rod material. While the localization of damage leads to a higher resistance to penetration, it enhances the probability of failure in the rods. The experimental approach was developed with 3D printed composites, mimicking the mineral/organic composites with strong materials surrounded by weak interfaces. To assess the role of the geometrical features, a detailed set of experiments was used to quantify the effect of rod orientation and aspect ratio in the site-specific properties measured. Both the experimental and computational framework indicate that during indentation the aspect ratio of the rods influences the abrasion resistance and toughness, where the rod deformation plays a critical role in the dynamic response of the microstructure. The findings of this research are applicable to study other biomineralized materials, and to gain insights into the development of wear and tough resistant composites.