Stress test: A new microscale mechanical testing protocol for metal/ceramic interfaces

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What is the outcome or accomplishment? (1-2 short sentences describing it and why it is transformative; 50-word maximum suggested)*

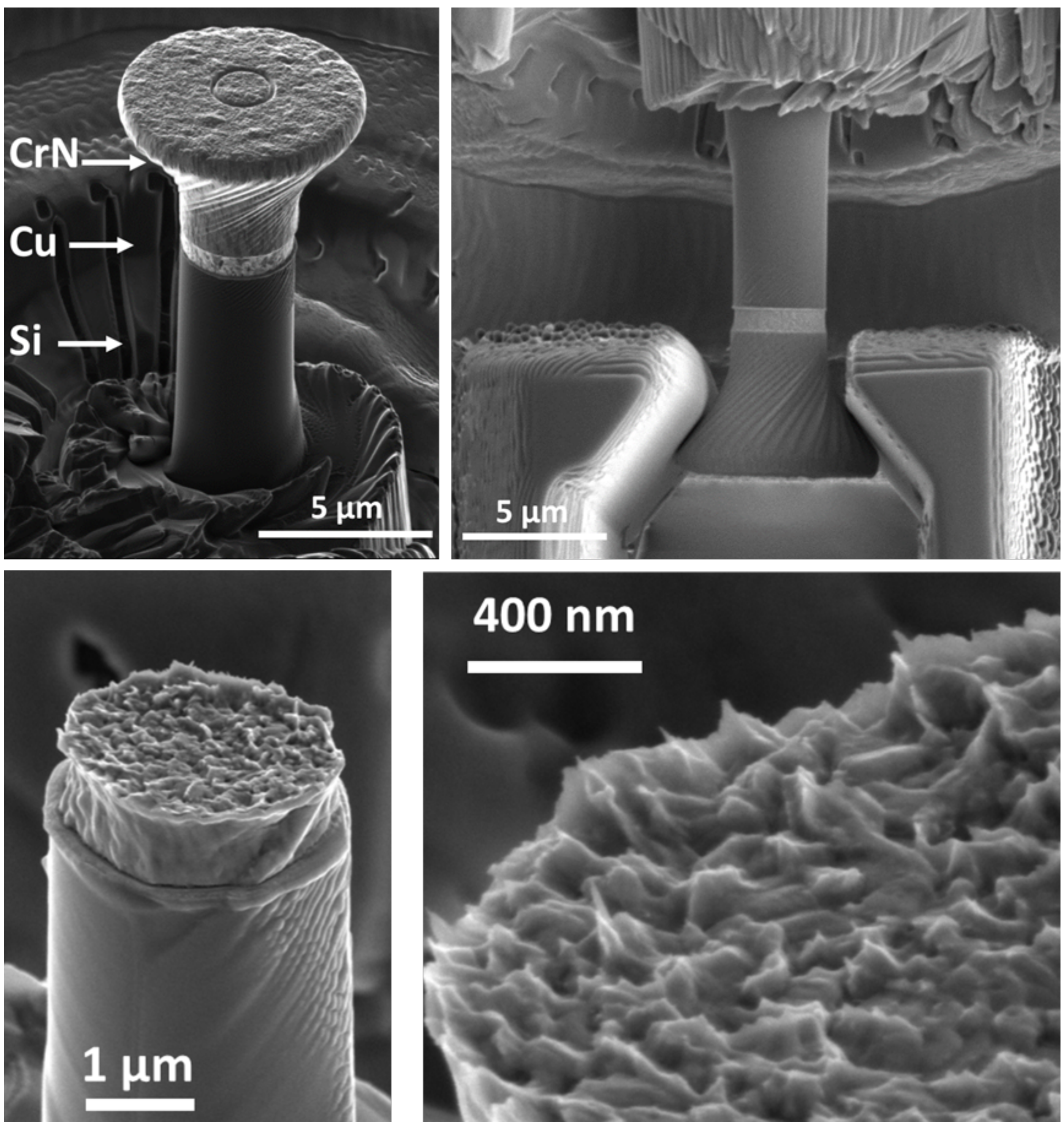
A team of experimental and computational researchers has demonstrated a new microscale mechanical testing protocol for quantitative evaluation of tensile fracture stress of metal/ceramic interfacial regions. The results offer new insight on how metal/ceramic interfaces fail under tensile loading, and provides guidance on how stronger metal/ceramic interfaces can be engineered.

What is the impact? (1-2 simple sentences describing the benefits for science, industry, society, the economy, national security, *etc.*; suggested 50-word maximum)

Mechanical integrity of metal/ceramic interfaces is critical to many industrial applications including ceramic coatings technology and metal matrix composites. Quantitative evaluation of critical stresses for failing metal/ceramic interfaces has remained a challenge. This new micromechanical testing protocol offers such a quantitative evaluation. The accompanying modeling/simulation offers improved understanding of failure mechanisms, and the potential of accelerating engineering developments.

What explanation/background does the lay reader need to understand the significance of this outcome? (1-2 paragraphs that might include, for example, more on who, when, where; NSF's role; support from multiple directorates/offices; what makes this accomplishment unique; additional intellectual merits; or broader impacts such as education, outreach, or infrastructure improvement that are integral to this outcome; suggested 150-word maximum)

Sponsored by the NSF EPSCoR Research Infrastructure Improvement (RII-Track-1) award to the state of Louisiana, a team of experimental and computational researchers from Louisiana State University focused their attention on better understanding of solid/solid interfacial mechanical integrity. The experimental method developed to directly measure the critical stresses for failing interfacial regions between thin ceramic films on top of substrates, to our knowledge, has never been done before. Such measurements offers a quantitative evaluation of the efficacy of different “adhesion-promoting layers” put between the ceramic film and the substrate, thus laying the foundation for a true materials-based design and implementation of better-performing and longer-lasting coating systems, metal matrix composites, etc. Through a tight coupling between experimentation and computation, the team has followed an Integrated Computational Materials Engineering (ICME) approach, and demonstrated the promise of ICME in accelerating design and implementation of next-generation solid/solid interfaces. Through this work, new nano/micro scale machining and microscale mechanical testing capabilities have been added to the arsenal of the Louisiana advanced manufacturing research and development enterprise. Graduate students have been trained on state-of-the-art nano/micro scale mechanical testing and materials characterization techniques. Undergraduate students have been involved in cutting-edge research through the CIMM Research Experience for Undergraduates (REU) program.



Pictured: Micromechanical testing of tensile failure of Cu/CrN meta/ceramic interfacial regions: (upper left) a typical "mushroom shaped" micro pillar specimen containing the ceramic/metal/ ceramic interfacial region fabricated by nanoscale focused ion beam machining; (upper right) the same pillar specimen engaged with an "inverse V" shaped diamond hook for tensile loading; (lower left) tensile fracture near one Cu/CrN interface; (lower right) nanoscale morphology of the tensile fracture surface, indicating extensive plastic deformation in the metal layer.
Image Source: Wen Jin Meng, Louisiana State University.