UNL to improve thin diamond film technology

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A University of Nebraska-Lincoln engineer is leading a team of engineers from UNL and the University of Missouri-Rolla on a project to refine a process that coats surfaces with thin diamond films. The team has received a three-year grant exceeding $3 million from the Department of Defense's Office of Naval Research. There is the possibility of an additional $2 million in out-years four and five.

The grant, awarded in March, was announced April 14 by UNL. The team is led by Yongfeng Lu, associate professor of engineering at UNL. Other members of the team are Hai-Lung Tsai of the Department of Mechanical and Aerospace Engineering at Missouri-Rolla and head project leader for UMR; Lan Jiang, mechanical engineer, UMR; Matthew O'Keefe, metallurgical engineer, UMR; Robert Schwartz, materials science engineer, UMR; and Xinwei Wang, mechanical engineer, UNL.

The process under exploration by the team was developed in the mid-1990s by Michigan-based QCC Inc. That firm used overlapping pulsed lasers to deposit thin coatings of diamond and diamond-like carbon on surfaces. The underlying reasons for the process are unknown -- the technology has preceded the science. That makes it hard to improve the process or extend it to other material systems. Lu's team will attempt to tease out the "how" of the technology.

"If we can understand the science of the phenomenon," Lu said, "and understand the principles behind it, we can use it for other materials

besides diamonds."

The ability to coat surfaces -- making them stronger, lighter and more resistant to corrosion or abrasion -- has many applications. Military hardware is an obvious example, but the ability to coat surgical tools, auto bodies, airplanes or even golf clubs have been posited as potential uses. The diamond coating increases the hardness of the surface and protects it from humidity, abrasion, corrosion or other deformations.

The QQC firm used overlapping light pulses from three types of high-powered lasers -- eximer, yttrium-aluminum-garnet or YAG, and carbon dioxide -- to vaporize a thin layer when scanned across a material such as steel. This creates an electrically charged, superheated plasma of iron atoms that bonds to the surface as a new substance. But the fundamental science of how this works is still unknown.

The UNL-UMR coating technique will be "customized" to specific coating/substrate systems using three laser systems: a resonance absorption laser, a UV laser, and a controlled plasma cooling and coating formation laser. The team will work to establish the knowledge of the physics behind the process and develop a way to do this in "open atmosphere" rather than a vacuum, allowing coatings to be deposited on items like ships or airplanes. The team will test this system both theoretically, using computer models, and experimentally using the lasers.

The grant was one of 33 awarded through the Defense Department's Multidisciplinary University Research Initiative Program. More than 120 proposals were submitted in the competitive grant process. Defense awarded $146 million over the five years to 27 universities. The MURI program is designed to address large multidisciplinary topic areas representing exceptional opportunities for future Defense Department applications and technology options.

The awards provide long-term support for research, graduate students and laboratory instrumentation development. Three post-doctoral scientists will be supported at UNL and two at UMR; each institution will also support four graduate students. In addition, undergraduate students at UNL will work with Lu and Wang.

Lu said UMR's Tsai initiated the proposal effort and realized the joint collaboration would allow the two universities to be more competitive. Lu said two seed grants provided by the UNL Office of Research helped the team prepare its winning proposal.

Prem Paul, UNL's vice chancellor for research, said the proposal is an example of building competitive strength through multidisciplinary collaboration. He noted that only about a quarter of the submitted proposals won funding, and the institutions that received funding are among the nation's most prestigious.

Source: University of Nebraska-Lincoln