LASER-SUSTAINED PLASMA AND ITS ROLE IN METAL SURFACE PROCESSING

时间：2016年3月8日 2:00PM

地点： 电院3-100

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ABSTRACT

Hard, wear-resistant, cutting tools are conventionally coated with titanium nitride (TiN) films, 2.5 to 12 μm in thickness, by physical vapor deposition processes at low pressures and a typical deposition rate of 5 μm per hour. This research investigates the potential for producing low-cost, high deposition rate, functionally graded, TiN coatings on commercially pure titanium using laser-sustained, nitrogen plasma at ambient pressure. Laser nitriding introduces nitrogen into a laser melt pool in a matter of seconds. In this presentation, we will discuss the role of laser plasma by comparing nitriding without plasma, with surface-struck laser plasma, and with laser-sustained plasma. Strategies for control and optimization of melt trail microstructures and morphologies will be discussed. It will be shown how dilution of the nitrogen with argon (1) reduced Marangoni convection in the melt pool, (2) changed nitrogen transport in the melt pool from convection-dominated to diffusion-dominated, (3) reduced nitrogen incorporation into the melt pool, and (4) reduced surface roughness, surface oxidation, and the presence of surface cracks. The implications for depositing multiple overlapping nitride trails to form wide-area titanium nitride surface layers will be discussed.

Dr. Judith A. Todd has served as Department Head, P. B. Breneman Chair, and Professor of Engineering Science and Mechanics at Penn State University since 2002. Prior to joining Penn State, Professor Todd was the Associate Dean for Research in the Armour College of Engineering and Science at the Illinois Institute of Technology (IIT), where she was also an Iron and Steel Society Professor (1996-2002). Professor Todd served as Vice President for Manufacturing, American Society of Mechanical Engineers (ASME) from 2002-2005 and as the 2009 President of the Society of Engineering Science. She is a Fellow of the American Society of Mechanical Engineers, ASM International, and the Association of Women in Science, and has received numerous awards, including the Vanadium Award from the British Institute of Materials. Dr. Todd received the Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring from President Bush in 2007. She received her B.A., M.A., and Ph.D. degrees in Materials Science from Cambridge University and is a Chartered Engineer (professional engineer) in the United Kingdom.